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PROCEEDINGS OF THE 5TH ASIAN CONFERENCE ON GEOGRAPHY (ACG5)

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THAI NGUYEN UNIVERSITY

INSTITUTE OF GEOGRAPHY - VIETNAM ACADEMY OF SCIENCE AND TECHNOLOGY

PROCEEDINGS OF THE 5TH ASIAN CONFERENCE ON GEOGRAPHY (ACG5)

5TH - 9TH SEPTEMBER, 2022. THAI NGUYEN, VIETNAM

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FULL PAPER

THAI NGUYEN UNIVERSITY - 2022

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Welcome messages

WELCOME TO ACG 2021

Dear Colleagues and Friends,

It is our great pleasure to offer all of you a warmest welcome to the 5th Asian Conference on Geography to be held in Thai Nguyen University, Viet Nam in 2021 with conference's theme:

GEOGRAPHY IN DYNAMIC ASIA

Thai Nguyen University is nestled in the picturesque city of Thai Nguyen of the Northern Midland and Mountainous region – a strategic region for socio-economic and environmental ecosystem development of Viet Nam with potentials and advantages for the advancement of agriculture, forestry, hydroelectric power, mining, tourism industry, and economy.

Trust that you will enjoy your time here in Thai Nguyen where join efforts from academic research studies, technology, industry and politics come out with actionable and effective solutions for a green and sustainable future of a DYNAMIC ASIA, make new friends, discover new facts and concepts concerning geography and feel part of this important international community.

As you may know, due to the COVID-19's pandemic, many international conferences have cancelled or postponed. With one year ahead, we do hope the coronavirus disappear soon, everything can get back to normal and our conference can be held as expected.

I am certain that Thai Nguyen University will mobilize the necessary experience, expertise and support for one of successful events in the history of the ACG

Wishing all of us a successful and interesting Conference.

ACG 2021 Conference Chairman
Prof. PHAM HONG QUANG, Ph.D.
Chairman of TNU's Board

Dear colleagues,

On behalf of the Asian Geographical Association (AGA), I am honored and delighted to welcome you to the 5th Asian Conference on Geography (ACG2021), to be held from September 05th to 09th, 2022 in Thai Nguyen, Viet Nam.

The Asian Conference on Geography, inaugurated in 2015, aims at providing a platform for geographers, geographical institutions and associations in Asian countries but not limited to them, to facilitate in-depth discussions, the sharing of perspectives in geography and relevant fields.

The theme of the conference is "Geography in Dynamic Asia". Covering a wide variety of disciplines related to geography, the ACG2021 will be a great opportunity to bring together researchers, academics and students from Asia and around the world to explore on current issues and recent developments in geography. I was privileged to have witnessed the founding of the Asian Geographical Association at the 4th Asian Conference on Geography in 2018 and am thrilled to be joining this conference again in 2021. I believe it will be an enjoyable and fruitful conference.

I cordially invite you to participate in this most awaiting event and look forward to seeing you in Vietnam.

Sincerely,

Qin Dahe

Professor Qin Dahe
President of the Asian Geographical Association
Academician of the Chinese Academy of Sciences

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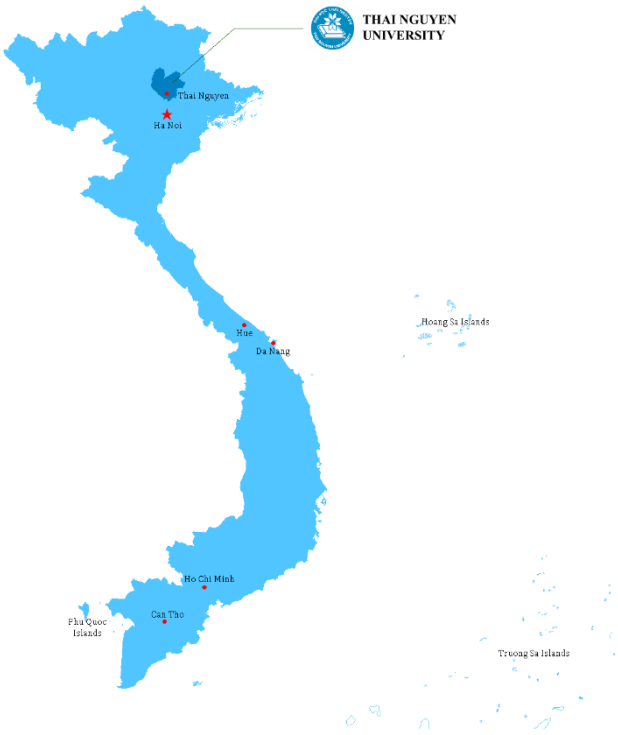
Conference's Venue



Thai Nguyen University is nestled in the picturesque city of Thai Nguyen located in the Northern Midland and Mountainous region - a strategic region for socio-economic, national security, public security, foreign affairs and environmental ecosystem development of the country with potentials and advantages for the advancement of agriculture, forestry, hydroelectric power, mining, tourism industry, and economy.

The Northern part of the country, which includes Red River Delta and Northern Midland and Mountainous Region, is a place where many ethnic minorities live in harmony for a long tradition; said ethnic minorities are accounted for 54.68% - the highest rate in the country with their own cultural identities. This region is noted for its historical, cultural, revolutionary origins and marvelous scenes with a population of approximately 30 million people.

Thai Nguyen is the melting pot of diverse cultures of the Northern Mountain's ethnic minorities, a focal point of cultural and educational activities of the vast northern mountains. With a geographic location as the center of politics and economy of the Northern mountainous region east midlands, Thai Nguyen is also the gateway of socio-economic exchange between the Northern Midlands and Mountainous and the Red River Delta. Considering that Thai Nguyen University is strategically located in Thai Nguyen Province, it appropriately befits as the center of higher education in the northern mountainous region.

Keynote Speeches

Dr Bojie Fu is a distinguished professor of Geography and Landscape Ecology in Faculty of Geographical Science, Beijing Normal University and Research Centre for Eco-Environmental Sciences, Chinese Academy of Sciences (CAS). He is the member of Chinese Academy of Sciences, International Honorary Member of American Academy of Arts and Sciences， Fellow of the Academy of Sciences for Developing World (TWAS) and Corresponding Fellow of the Royal Society Edinburgh UK. His research areas are land use and land cover change, landscape pattern and ecological processes, ecosystem services and management. He has published more than 400 scientific papers and 12 books, including *Science, Nature, Nature Geoscience and Nature Climate change*. His prizes include the Alexander von Humboldt medal of EGU. China National Natural Science Prize, Outstanding Science and Technology Achievement Prize of CAS, The Ho Leung Ho Lee Science and Technology Prize-Geosciences, and Award of Distinguished Service of the International Association of Landscape Ecology.

Promoting geography for Sustainable development

Prof. Bojie Fu

Vice President of IGU
Faculty of Geographical Science, Beijing Normal University, Beijing 100875, China
State Key Laboratory of Urban and Regional Ecology, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100875, China

Abstract

The world is changing at an accelerating pace due to increased human exploitation of the earth's resources and the consequent climate change and biodiversity loss crises. As a transdisciplinary discipline studying the coupled human and nature systems and their interactions, Geography has natural advantages to promote sustainable development. Geography can support sustainable development in many ways, and the key five research areas are: geographical processes, ecosystem services and human wellbeing, human-environmental systems, sustainable development, and geo-data and modelling. The key objective of promoting geography for sustainability is to reveal the mechanisms of human-environmental system dynamics. This depends on understanding the processes in the natural and social systems and their mutual feedback as well as clarifying the relationships between the structures, functional characteristics and interactions in the human-environmental systems at multiple scales. The advancement of geography and its methodologies and technologies will provide a more profound understanding of the future. Geographers have the responsibility of promoting the discipline as the key pathway for carrying natural and social sciences towards sustainability.

Ethnic inequalities in healthcare access among older adults in the Rural Areas in Vietnam: Does travel distance matter?

Prof. Dinh Hong Linh

Thai Nguyen University of Economics and Business Administration, Tan Thinh Ward, Thai Nguyen City, Vietnam

Abstract

Ethnic disparities in access to health services often appear in many countries. According to the previous literature, there are plenty of barriers to healthcare access, in which travel distance is an important estimation of access to health services, since travel distance is linked to travel cost, available transportation, time, and others, it may lead to the delay to go to clinic/hospital or health facilities by the patient in general, and for elderly people in particular. However, so far, most studies have been conducted in developed countries, and there are very few studies in developing countries. Hence, this study is aimed at investigating whether the existing ethnic inequality in healthcare access in rural areas of Vietnam and the role of travel distance affect access to health services among older adults. By using the nationally representative data from the Vietnam household living standard survey, two waves in 2008 and 2018, and employing some basic comparative statistics methods and the multivariate logistic regression model, our findings indicate that existing ethnic disparities in healthcare access in rural areas in Vietnam. And over ten years the travel distance from home to the nearest health facility has been shorted, it remains a significant barrier for elderly people in rural Vietnam in accessing health services. These findings also provide an important evidence for policymakers in designing and promulgating effective health care policies for the entire population in the future.

Key words: Ethnic inequality, healthcare access, travel distance, rural areas, Vietnam

Challenges of Mountain Environments: Land Degradation and Conservation Strategies in the Indian Himalayan Region

Dr. Prabuddh Kumar Mishra

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Abstract

Land degradation in the form of soil erosion is a global phenomenon, and mountains are one of the most vulnerable areas to land degradation. Various studies have reported the increasing intensity of land degradation across the Himalayas. Land degradation, directly and indirectly, impacts flora, fauna, hydrology, climate, Society and economy of the region. Land degradation in the mountainous regions is a significant challenge due to the sensitivity of the mountains to climate change. The Himalayan region encompasses a hill and mountain area of 4,192,000 km^2 in countries (Afghanistan, Pakistan, China, India, Nepal, Bhutan, and Myanmar). The direct impact of land degradation can be seen in the declining forest cover and agricultural productivity in various regions of the Himalayas. Every country in the region is affected by land degradation. Particularly western Himalayas are more affected by land degradation than the eastern Himalayas. Studies conducted by researchers in the Hindu Kush (Afghanistan), Karakoram (Pakistan), and Indian Himalayas suggest increasing land degradation due to deforestation and soil erosion. Similar trends are observed in Nepal, Bangladesh and Myanmar Himalayas. However, the Himalayan kingdom of Bhutan and the Indian state of Sikkim have successfully implemented policies demonstrating how agroecology and organic farming in the Himalayas increase fertile landscapes, safeguard wildlife, and improve livelihood resources for people. This case study attempts to understand the land degradation challenges farmers face in the Rani Khola watershed of Sikkim Himalayas and the low-cost indigenous knowledge-based strategies adopted to reduce the impact of land degradation.

Land use/Land cover dynamics in Houaphan (Laos) and Son La (Vietnam) from 1990 to 2020

Prof. Nguyen Dinh Duong

Institute of Geography, Vietnam Academy of Science and Technology
18 Hoang Quoc Viet Rd., Cau Giay, Hanoi, Vietnam

Abstract

Land use/land cover (LULC) dynamics is a complex process that can be a consequence of many interacting processes ranging from various natural factors to socioeconomic dynamics. In this study, we used the Landsat time series to monitor the dynamics of Land use/land cover in the borderland region, which is composed of the provinces Houaphan (Laos) and Son La (Vietnam). The study area is covered by four Landsat scenes 127045, 127046, 128045, and 128046. The total number of images used for analysis was 1631 after excluding images with high cloud coverage and radiometric noises. Maps of LULC of the study area were established for the periods 1990, 1995, 2000, 2005, 2010, 2015, and 2020. We found out that in Son La, natural forests were changed from 1,076,689 ha in 1990 to 388,550 ha in 2020, and cropland increased from 313,828 ha in 1990 to 555,505 ha in 2020. The situation in Houaphan was the same but with a lower change rate. Natural forests decreased from 1,587,764 ha in 1990 to 966,114 ha in 2020 and cropland increased from 133,901 ha in 1990 to 306,730 ha in 2020. Spatiotemporal maps of LULC dynamics developed in this research are an excellent tool for assessment of driving forces in forest transition in the trans-border region between Laos and Vietnam in the next phase of the study.

The Evolution of Confucian Landscape in the Andong Cultural Region, Korea: Universalism or Particularism?

Prof. Je-Hun RYU

Professor, Korea National University of Cultural Heritage

Abstract

It is generally known that (private) academies are heavily concentrated in the so-called Andong cultural region, or in the upper reaches of the Naktong River. This region is the ancestral home of many yangban families that not only influenced the locality but also the whole country. From the Neo-Confucian perspective, there were many sites in the region suitable for studying Confucianism through self-reflection. The physical (topographical) conditions and the sage named T'oegye were responsible for the relative concentration of academies in the region. Depending on the spatial pattern of diffusion, the developmental process of academies in the region can be divided into three stages: the original, transformative and restorative.

In the original stage, the main way to justify the location of an academy was to infuse the site with meaning by linking the famous scholars both in space and time. The geographical connections of the scholars to the sites of study or retreat often justified the location of academies. It is the enshrined scholars who added sacredness to the site. In the transformative and restorative stages, increasingly, lineage connection rather than geographical connection and scholarly achievement became an important factor in the foundation of academy shrines. In the construction of an academy, therefore, the religious and intellectual justification for shrine-building sometimes became a controversial issue. Instances of contention also occurred among different groups over the same site that eventually led to territorial division.

Neo-Confucianism, as it has been practiced with academies in the Andong cultural region, seems to share characteristics in common with those religions that bind people firmly to a place. The academy has eventually turned from a place open to any lineage groups into a place only open to one or more lineage groups. Neo-Confucianism, originally being claimed to be a universal ideology, has been increasingly practiced as a particularism within regional and local boundaries.

Neo-Confucianism is a place-bound religion that has encouraged love for one's own lineage and hostility to others. The academy is a landscape of high visibility and public significance that has served to enhance a sense of lineage identity. It has encouraged the lineage's loyalty to its own territory.

Key words: private academies, Andong cultural region, Neo-Confucianism, place-bound religion, sense of lineage identity

A data-based approach to the decision-making process

Prof. Bui Quang Thanh

Vietnam National University, VNU-University of Science

Abstract

Data (spatial) - driven approach to decision making is the process of making a decision based on actual data. The increased computational capacity and data collection platforms have made geo-located data overwhelmingly available for spatial analysis (looking for patterns, visualizing the meaning behind the data, classification, and regression) in sustainable resource management, social behaviors, and natural hazard analysis. The amount of information collected has never been greater, but it is also more complex and requires a more sophisticated data analysis approach. This work presents some case studies (using machine learning and spatial analytics) in Vietnam with remarks for future works.

Keywords: Spatial data analytics, machine learning, data-driven approach

FULL PAPERS

Multidisciplinary approach in marine landscape study: A case study of marine landscape mapping scaled at 1/50.000 for remote maritime region of Nam Yet - Sinh Ton cluster, Truong Sa Islands, Vietnam

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Abstract. Studying marine landscapes is a new direction of modern geography to describe the interactive association among maritime physical conditions in a given sea and/or littoral zone. The establishment of a particular marine landscape map contributes to the interpretation of the structure and classification of marine physical components, as well as a scientific foundation to direct resource management, environmental protection and marine biodiversity conservation. Definition of concept and classification system, i.e., criteria and hierarchy is the fundamental component for marine landscape mapping. Based on remote sensing data and field surveillance (including subaqueous and subaerial environments), we established the classification system and marine landscape maps scaled at 1/50.000 and 1/10.000 for the region of the Nam Yet – Sinh Ton islands cluster (Tizard and Union Banks) and Nam Yet Island, respectively. The classification system includes 1 system, 1 sub-system, 4 classes, 7 sub-classes, 13 types and 26 kinds of landscape, of which the bathypelagic/aphotic zone class is the most diverse, with 2 sub-classes, 5 types and 16 kinds. The island landscape contains only 2 kinds of landscapes: pristine and artificial landscapes. The hierarchy of marine landscapes fully represents the physical and artificial components of both biotic and abiotic features in their associated interactions. Depending on the scale level, the marine landscape is visualized at a fluctuating detail that represents the biotic components at the most comprehensive level. The study exhibits the characteristics and the different of the marine landscape of Nam Yet – Sinh Ton islands cluster contributes to the database of the Truong Sa Islands and the scientific foundation for resource management, biodiversity conservation, and marine environment pro-tection, as well as provides a theoretical basis for marine landscape study in the monsoonal tropical maritime domain, which is currently limited in Vietnam in terms of scientific research.

Keywords: Marine-island landscape; mapping; Nam Yet – Sinh Ton cluster; Truong Sa Islands; Multidisciplinary.

1. Introduction

Marine landscape study is an emerging direction of modern geography [1, 2], which handles the issues related to the management and reasonable use of maritime resources and environmental protection. However, theoretical problems and research methodologies on the marine landscape are still being hindered [3, 4]. Globally, the interactions between the spatial model and ecological processes and internal communications are revealed in some littoral and maritime regions [5]. This indicates the necessity of upscaling the details of marine landscape studies in exchange for the role and association of each contributing component.

Although the marine landscape has been prematurely recognized and studied, the concept of the marine landscape is still arguable, principally due to the research approach, application and scale of the study. Polyanov (1956) implied that the marine landscape is a complex of interactive components and elements, including heat, waves, currents, icebergs, coral reefs, islets, climate, and the aquatic flora and fauna of the surface water. L.S. Berg suggested the term 'mershaft' as an equivalence to the 'subaqueous landscape' [6]. Furthermore, the definition of the subaqueous landscape has been mentioned by several USSR scientists, such as Petrov (1971), Poyarkov (1980), and Manuylov (1982) [2, 7-9]. Recently, Preobrazhensky B.V. proposed a new terminology for 'subaqueous geosystems with fundamental 'facies' classified following the seabed morphology, substrate and benthic communities [10]. In Europe and North America, 'marine landscape' is discriminated in usage, research viewpoint on landscape identification, structural units, spatial scale and domain. According to the English Oxford Dictionary, 'seascape' is defined as a picture or view of the ocean a vast', which then afterwards develops into an additional coastal landscape and an adjacent region of open water, including a continuum landscape from terrestrial to maritime and vice versa, and along the coastline [11]. The definition of the marine landscape was developed by Roff and Taylor in their research of Canadian waters, as well as Laffoley et al., in the domain of the United Kingdom [12, 13]. Roff and Taylor assumed that such a definition is applicable to water columns and the seafloor (with the employment of bathymetry, slope, temperature, and light attenuation). The seabed landscape represents the medium extension between sea domains and habitats, which have homogenous physical and ecological conditions and provide a reasonable measurement as a basis for certain anthropogenic activities [14]. The definition of marine landscape is also adopted in the corresponding framework of projects such as UKSeaM or Mesh to characterize the marine environment in terms of geophysical features, including water columns and seabeds [15]. Likewise, marine landscape studies in Europe employed the definition of seascape ecology and marine-island landscap [16-18]. as the marine landscape is specified as the interference effect between land and sea and 3 predefined domains: sea, coast and land [19]. From the viewpoint of seascape ecology, Pittman (2017) defined 'marine landscape as a dynamic heterogeneous space which could be determined on a broad range of time and space».

Recently, island and marine landscapes have attracted many scientists, including studies on the anthropogenic impacts on such landscapes. In his study on anthropogenic influence on Christmas and Cocos Islands on the eastern Indian Ocean, Amstrong noticed impressive changes in the geomorphological, hydrological and ecological processes [20]. Tourism development leads to environmental degradation and pollution, habitat destruction and loss, and shoreline retreat was also recognized on the islands of the Pacific [21]. The internal connection between physical elements and local cultures of the island and sea domain of the Mediterranean Sea was illustrated in a study by Vogiatnakis [22]. The islandic cultural landscape was not only dependent on the recent human civilization but also inherited former landscapes, where interaction with the human-induced landscape heavily depends on the flora and fauna distributed on local islands [23]. In the middle of 2014, Golding and his associates proposed the terminology of 'marine landscape' as the representative level for an intermediate measure between the seas and habitats in a region that has homogenous physical and ecological characteristics, also providing a reasonable measure related to the management of human activities, such as fisheries. The conservation acts as a calibrated tool for such activities according to the relative sensitivity of seabed substrate destruction and the variation or perturbation of the specific water column features (such as a front of a coastal system) [24].

Advantages in the field of remote sensing – GIS and computational technology – are the significant progress in marine ecology study, especially in the domain of island-marine landscape and coastal regions [25]. Zajac (2003) discussed the challenges that researchers have to face in studying seabed landscapes, including benthic habitat mapping and quantification

[26]. Blazhchishin (1992) attempted to establish the marine landscape of the Baltic Sea using a dataset of seabed sediment, but his work was underestimated [27]. The marine landscape map of Barents, Norway was established in 2014 by Elvenes, based on (i) stranflat, i.e., eroded crystallized benches; (ii) continental shelf steepness; (3) morphology: fjords, valleys, plateaus, and mountains [28]. Landscape studies in the southern Black Sea exhibited a landscape map consisting of 5 types and 544 landscape units, which provided a foundation for sustainable coastal urban planning and management [22]. Another example is the BALANCE project, which used 5 large-scale features of a marine environment to establish a seabed landscape map of 21 distinctive units of the Baltic Sea [29]. In 2012, the Natural England project proposed the "Seascape wheel", in which the physical, marine, ecological, social and cultural elements have their role in determining the marine landscape region and making the uniqueness of each single marine landscape unit illustrated in 3-dimensional detail [30].

In Vietnam, marine landscape studies have lagged and remain limited. Nguyen Thanh Long, Nguyen van Vinh (2012) proposed a specific hierarchy landscape classification for a certain maritime region containing 4 degrees: system, class, sub-class and types of marine landscape, and a preliminary classifier of 56 types belonging to 5 sub-classes, 3 classes and 1 landscape system. Pham Hoang Hai (2006) classified the ecological landscape zonation map of the coastal zone of Vietnam scaled at 1/1.000.000 into 3 homogeneous degrees of 1 unified system, including 1 zone, 2 sub-zones, 5 provinces and 17 regions of the ecological landscape. Tran Anh Tuan (2013) suggested a 5-level landscape classification for landscape mapping at the scale of 1/1.000.000, including system, sub-system, class, sub-class, and type. Due to the restriction of the dataset, the criteria for landscape classification were not diversified. Accordingly, the system and sub-system grades use the general climate circulation for the monsoonal tropical domain and humidity-temperature; meanwhile, the class grade solely uses the seabed/island attribute, sub-class grade implies the relative depth (with marine landscape) and proximity (inshore-offshore) between the island and mainland, and landscape types are dependent on marine geomorphology [46]. Ha Quy Quynh [2016] nominated a landscape classification using system/sub-system/class/sub-class/type/sub-type/facies for the ecological landscape of the Tonkin Gulf. A group from the Pacific Geography Institute (Russia) attempted to perform fine-scale research on the landscape of the Cat Ba Island group [31], which produced 4 inequitable landscape units of (i) rock outcrop of upper slope, 0.5-1 m depth, up to 4 m depth; (ii) unclassified coarse sediment, 0.7-2 m depth, 15-30 m width; (iii) coral reefs, 1.5-2 m depth, 20-30 m width; and (iv) soft mud, 4.5-6.5 m depth [32]. In our previous study on Nam Yet Island, a marine landscape map was established and consisted of 32 types for both marine and island landscapes [48]. In general, research on the marine landscape in Vietnam, particularly on offshore waters and islands, is still limited due to poor accessibility and the lack of proper instruments and devices. In this study, we represent the marine landscape map of the Nam Yet – Sinh Ton island cluster using the available dataset of seabed morphology, sediment, island soil and vegetation cover, and the distribution of specific habitats. The study outcomes provide a firm establishment for further use on landscape classification, direct reasonable use of resources and biodiversity conservation of the Nam Yet – Sinh Ton island cluster.

2. Materials and Methods

2.1. Study Area

The study area is the Nam Yet – Sinh Ton island cluster lying in the central region of Truong Sa Islands, which is approximately 560 km southeasterly of Cam Ranh (Khanh Hoa province). The island cluster is under the administrative responsibility of the Sinh Ton commune, Truong Sa district of Khanh Hoa province. This island cluster consists of 2 of the 8 major island clusters of the Truong Sa Islands, lies north–northeastward of the Truong Sa (Spratly Island) – Tham Hiem (Investigator Shoal) cluster, westward of Binh Nguyen (Flat

Island) cluster, southward of Song Tu (North Danger Reef) – Thi Tu (Thitu Island) – Loaita (Loaita Island) cluster. This location is critically significant in terms of geo-economic, as a transition of the Truong Sa Islands and the capability to establish fishery infrastructure and logistics. On the other hand, the Nam Yet – Sinh Ton cluster is a fundamental position in geo-political, national defence and security, as well as a key defence for the northern region and the continuum defensive warfare of the whole Truong Sa Islands region, and a symbolic statue for the marine sovereignty of Vietnam.

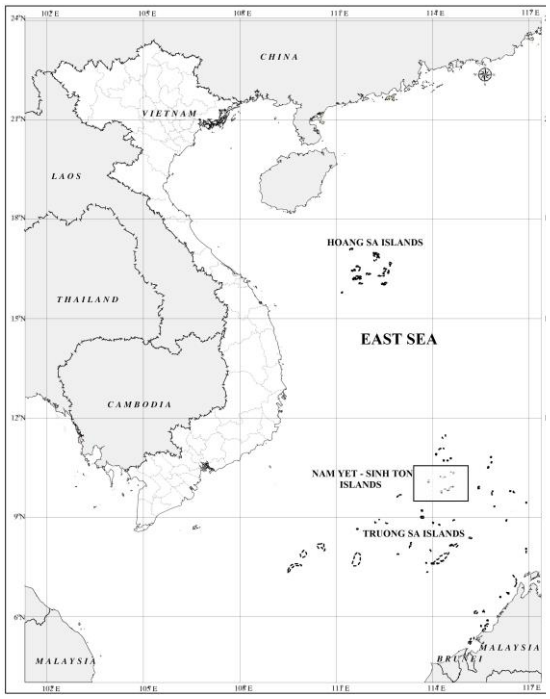

Figure 1. Location of Nam Yet – Sinh Ton islands cluster, Truong Sa islands, Vietnam

2.2. Data Sources

The marine landscape map of the Nam Yet – Sinh Ton island cluster was established using constituent maps from the project KCB.TS03 "Studying the sea-Island landscapes of Truong Sa Archipelago for management and sustainable use of resources based on the application of remote sensing technology and GIS", operation by the Vietnam-Russia Tropic Centre.

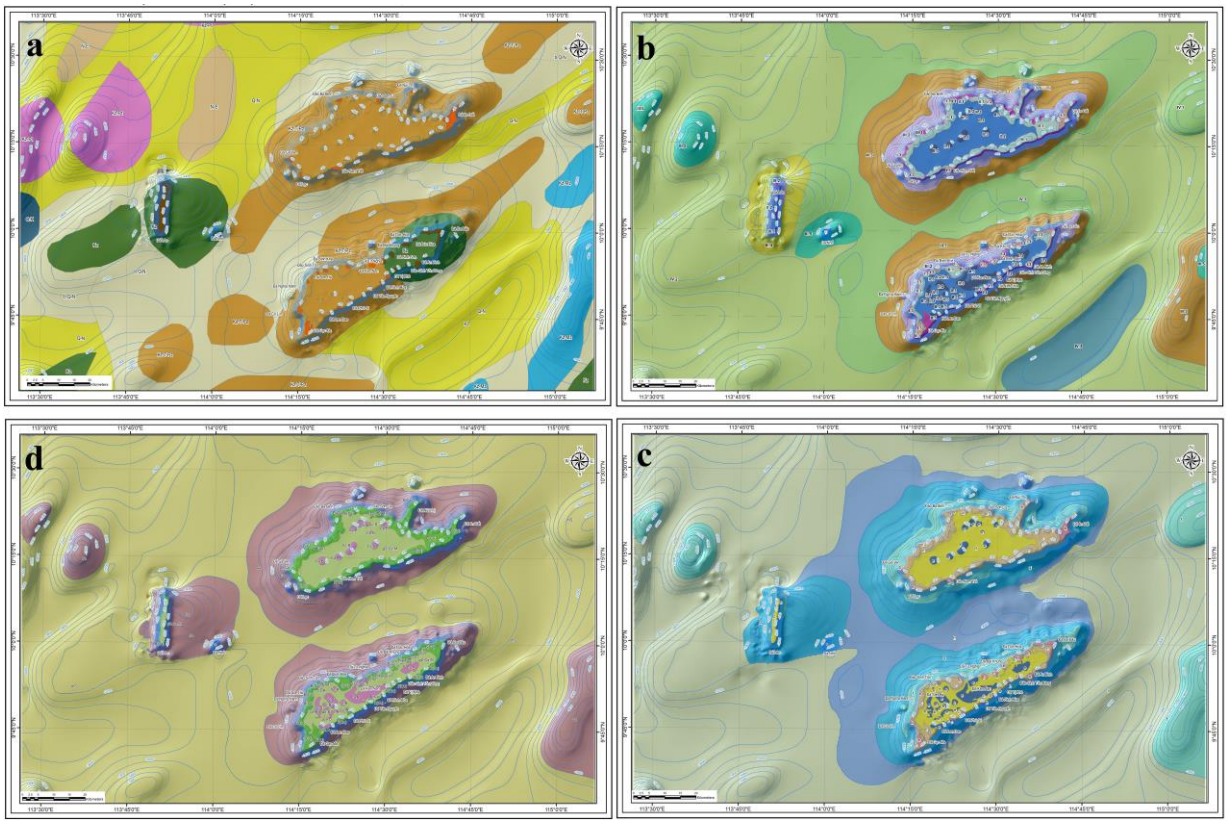

Figure 2. Constituent maps for marine landscape mapping in the Nam Yet – Sinh Ton Island cluster, Truong Sa Islands. a. Geological map; b. Geomorphological map; c. Benthic habitat map; d. Surface sediment/soil map.

2.3. Methodology

2.3.1. Surveillance methodology

Field surveillance in the study area was carried out 4 times over 2 years (Oct – Nov 2020; May – June 2021; Oct – Nov 2021; and Apr – May 2022) on the island domain and adjacent coral reefs of Nam Yet, Son Ca (Sand Cay), Sinh Ton (Sincowe Island), Sinh Tồn Đông (East Sincowe Island), and Đá Lớn (Discovery Great Reef) of the Nam Yet – Sinh Tồn Island cluster. For subaerial biodiversity evaluation on emerged island/cay, vegetation cover assessments were implemented based on predominant species, specific boundaries and featured soils for later landscape mapping. For the submerged environment, multiple dives were performed (up to 42 m depth) to gather information on the benthic communities and habitats, seabed morphology and sediment identification, as well as taking photos and videos along transect and quadrant sites for later use. SCUBA divers were sent to investigate the seabed at a larger depth (up to 40 m) following standard protocols [33]. For each study site, the number and location of dive sites were determined after a pilot survey on-site and using remotely sensed imagery. At each dive site, divers organized 4x25 m-long transects at 15 m intervals and took a series of photos for each consecutive 0.5x0.5 m along the transect, which was equivalent to 25 photos per transect [34]. Species taxonomy was identified during dive time and using photos consequently. Criteria such as coral coverage, seagrass, and predominant sediment were determined based on photos taken afterwards.

Figure 3. Submerged transects were implemented to investigate benthic communities.

2.3.2. Marine landscape mapping methodology

The procedure for marine landscape mapping is established as follows: (i) establish homogenous component maps at a given scale, including geological, current, topological, geomorphological, sediment, salinity, heat and biomes in the water columns and seabed of the Nam Yet – Sinh Ton Island cluster. Then, component maps were layered using the Intersect algorithm in ArcGIS Desktop 10.8 software (Fig. 4). Consequently, each landscape unit would contain the information of each component map, including geological, climatic, heat-salinity, soil-sediment, surface substrate and/or major marine community distribution features.

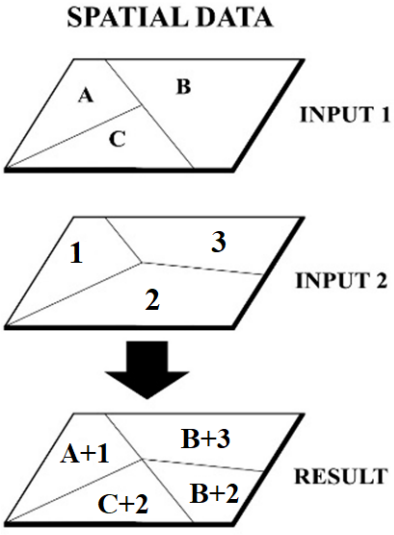

Figure 4. Method of overlaying maps to create landscape maps

3. Results

3.1. Marine – island landscape concept and model

3.1.1. Marine-island landscape concept

In this study, the marine landscape is acknowledged as "a synthetic and unified form of dynamic – genetic origins, in geological – seabed sediment settings, morphology, climatic and oceanographic, biomes, in the integrated association of oceanographic – organism conditions in the shallow water; and of the seabed, water column and featured organism of the deep sea" [48].

The aforementioned definition determines that a marine landscape includes abiotic components (geological setting, terrain, seabed geomorphology, sedimentary, oceanography conditions – currents, tidal regimes, heat-salinity conditions...) and biotic components: marine biomes. Each component of the marine landscape is governed by climate conditions and has interactions and mutual connections with each other. Any variation that happens for a component of the marine landscape may lead to a chain reaction that causes alteration to others.

Abiotic components of the marine landscape, including geological settings, sediment and geomorphological features, are less frequent to change, whereas currents, heat-salinity conditions and marine biomes, in particular, are vigorously changing in the seasonal pattern or are sensitive to anthropogenic influences and turn into momentum for the marine islandlandscape. In the island–maritime domain, synergies of abiotic components occur via material and energy circulations; meanwhile, synergies of biotic components are based on the food web, of which each species is a specific link of the whole. According to the aforementioned definition of the marine landscape, a marine landscape map should contain every configuring component and element of it; hence, it consists of abiotic and biotic components in a specific orderly scheme. Regarding such schemes, featured species elements of biotic components are indicators for a marine landscape system. The case of Nam Yet Island is a clear illustration of which marine landscape features reef-building corals and seagrasses, whereas the island landscape is characterized by artificial technical constructions.

3.1.2. Marine – island landscape model

The marine – island landscape model is the conceptual terminology used to visualize the closed connections among contributed components (Fig. 5).

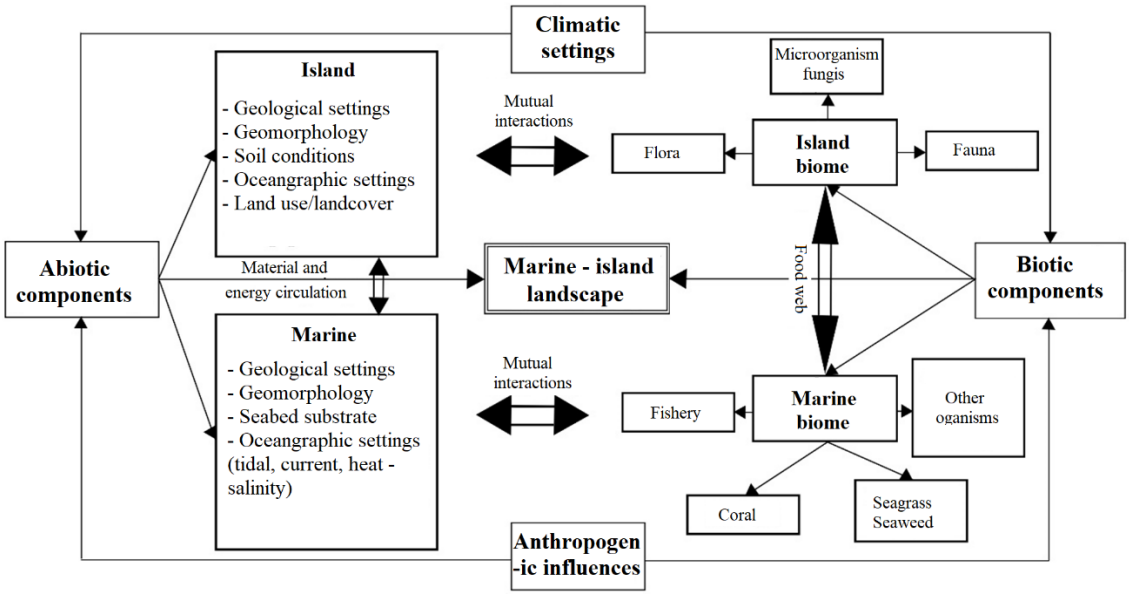

Figure 5. The marine – island landscape model

According to the model, each constituent component of the marine – island landscape belongs to one of two groups: either abiotic or biotic. Climatic conditions and anthropogenic

activities influence the two groups, while the abiotic components are diversified, corresponding to island and marine domains.

On subaerial island/cay, abiotic components include geological settings, island terrain and geomorphology, soil, island hydrology and surface coverages. The island landscape is under the influences of oceanographic settings in particular, of which wave and tidal regimes establish featured landscapes on the seaward portion of the island. Abiotic components aggregate into a growing medium for biomes, including fauna, flora, microorganisms, fungi, etc.

In the maritime domain, abiotic components are geological settings, seabed terrain and geomorphology, seabed substrate, and oceanographic conditions (wave – tidal regime, heat - salinity distribution, currents, etc.). These components are the foundation of a widespread and diverse marine ecology consisting of corals, seagrasses and seaweeds, fish and other organisms (phyto-zooplankton, molluscs, crustaceans, echinoderms, bivalves, etc.). Abiotic components of maritime and island domains interact via material and energy circulations.

Biotic components are the most significant division of marine – island landscape system due to their roles in determining landscape diversity and as indicators of landscape systems. Marine communities and island communities have a closed connection through the food web material – energy flux.

Constituent components of marine- island landscape have their own specific roles and interactive connections with others. As a consequence, a chance made on a given component would alter the structure and attributes of others, hence the overall transformation of a landscape system.

3.2. Marine – island landscape classification system

The landscape classification system for the Nam Yet – Sinh Ton Island cluster covers island landscapes on coral reef cays, shoals and marine landscapes up to 200 m in depth. Island landscape diversity is dependent on the constituent components and anthropogenic influence magnitude. Island landscape classification is based on Nikolaev [35], Pham Hoang Hai [47], Nguyen Dang Hoi [36], which is the System/Sub-system/Class/Sub-class/Type/Kind of landscape. The classification principles for each classifier are represented in Table 1:

Table 1. Classification system and criteria for the marine-island landscape of Nam Yet – Sinh Ton island cluster

№	System	Classification criteria		Note
		Island landscape	**Marine landscape**	
1	System	Predominant temperature, solar radiation, and atmospheric circulations		1 system
2	Sub-system	Terrain – monsoon circulation interactions and redistribution of heat - humidity		1 sub-system
3	Class	Featured by morphology of mega-terrain illustrated by two antagonistic processes: denudation - deposition	Featured by interactive magnitute between hydrosphere and lithosphere with respect to water column characteristics via typical wave process	4 landscape classes: - Island - Euphotic/shallow water/wave transformation - Mesophotic water - Aphotic/bathyal water
4	Sub-class	Physical condition/process divisified according to altitudinal zonation	Physical condition/process according to light	7 sub-classes

№	System	Classification criteria		Note
		Island landscape	Marine landscape	
			attenuation in water column	
5	Type	General bioclimatic conditions determine pristine vegetation cover.	Featured typical communities according to heat-salinity regime	13 types
6	Kind	Vegetation cover and substrated on different soil/hard substratum	Biomes distributed according to morphology features and seabed sediment	26 kinds

3.3. Landscape characteristics of the Nam Yet – Sinh Ton Island cluster

The marine - islandlandscape map of the Nam Yet – Sinh Ton Island cluster was established based on the diversity of physical conditions, cartographic rules and GIS technology at the scale of 1/50.000. The classification system of the study area included 1 system, 1 sub-system, 4 classes, 7 sub-classes, 13 types and 26 kinds of landscapes.

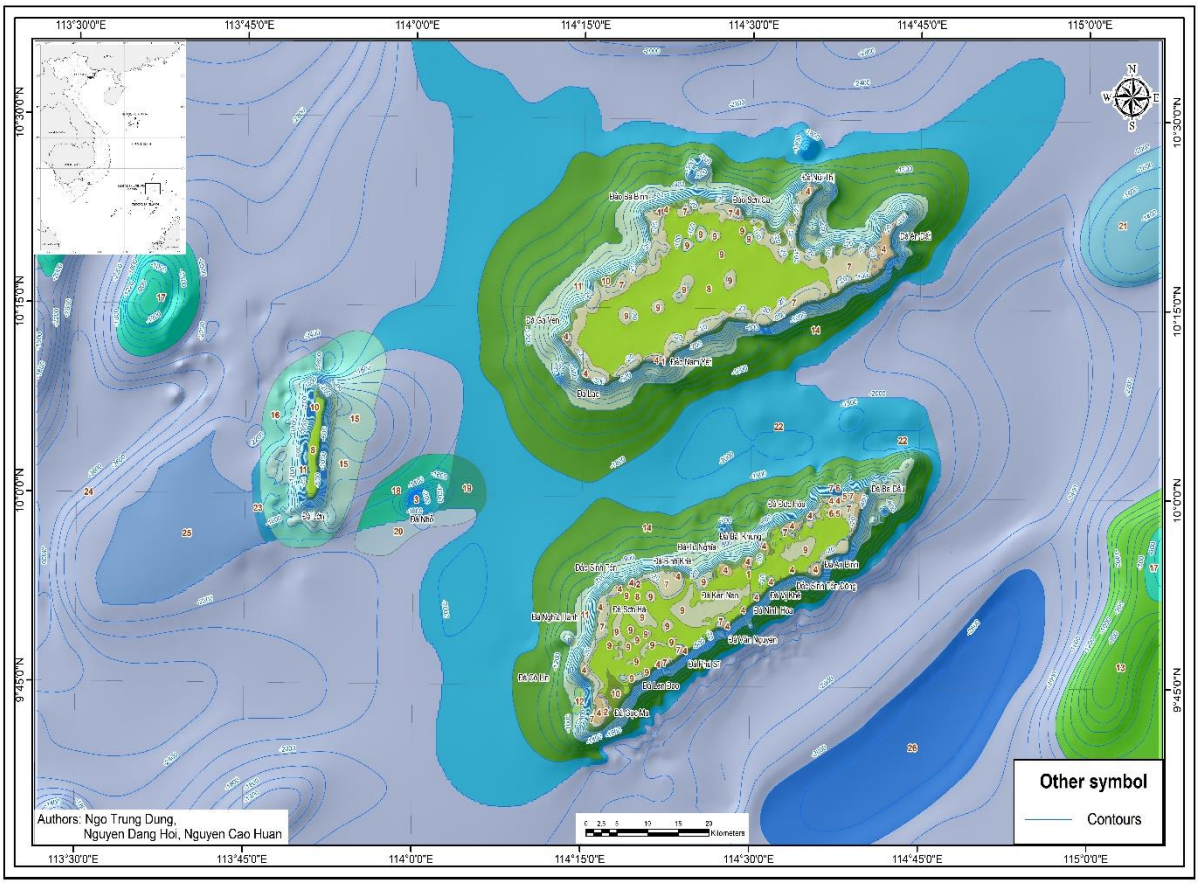

Figure 6. The island-marine landscape map of the Nam Yet – Sinh Ton Island cluster, scaled at 1/50.000

Island landscape class: includes 1 sub-class and 1 type (T.1), 2 kinds of landscapes that cover 131,5 hectares. The vegetated cay landscape appears on the sand-gravel reefal soil contaminated by bird guano (1st kind), distributed on the subaerial part of Nam Yet, Sinh Ton, Ba Binh, Son Ca, Sinh Ton Dong islands. Major vegetation cover is tropical islandic flora, including *Coccoloba uvifera, Barringtonia asiatica, Calophyllum inophyllum, Heliotropium foertherianum, Scaevola taccada, Casuarina equisetifolia*, and other woody and shrub plants. Additionally, there are specific-purpose multirole constructions and civil buildings. The

artificial island landscape (ID 2) is on the reclaimed cays – Gac Ma, Co Lin, Ga Ven. These features are shallow coral reefs formerly reclaimed and transformed into artificial islands and covered with terrestrial plants, such as *Casuarina equisetifolia*.

Table 2. The classified island-marine landscape map of the Nam Yet – Sinh Ton Island cluster, with corresponding unit and characteristics.

Class	Type			Island climate conditions - Annual mean temperature: approx ~27 - Summet (May-Otc) mean temperature ~28.2 - Winter (Oct-Apr) mean temperature ~26.8 - Annual rainfall of 1800-2000mm	Marine conditions - Average temperature of sea surrface: Summer ~28, Winter ~27,5 - Aerage salinity of sea surrface: Summer ~33,75‰, Winter ~ 33,25‰							
	Sub-class	Kind		Tropical island vegetation	Biomes of corals, seagrasses, reef fish in the tidal zone	Coral and reef fish communities in shallow sea areas	Coral biome, reef fish in the awkward area	Independent block coral biome in the lagoon	The marine biome in the coral plateau slopes	The marine biome at the foot of the coral plateau	Economic fish community in the low-lying delta at the foot of the coral plateau	The marine biome in the deep sea area over 2000m
		Geomorphology	Soil /sediment									
Island	Island	Cay/vegetated cay	Cs(Co)	1								
		Artificial island	S(c)	2								
Shallow water/ depth-induced wave transfor-mation zone	Shallow water wave	Reef flat	Co		3							
			B(Co)		4	5						
	Wave transfor-mation (L/20 < h < L/2)	Reef front	B(Co)		6	7						
Mesopho-tic/swell zone (h < L/2)	Upper mesopho-tic	Deep sheltered lagoon	gS.Co.M				8					
		Isolated coral knolls in the sheltered lagoon	Co.B					9				
	Lower mesopho-tic	Steep reef slope, up to 200m	B(Co)			10						
Bathypelag-ic/aphotic zone	Upper bathype-lagic	Reefal talus and reef plateau rise, up to 1000m	Co						11	12		
		Complex atoll plateau rises	Co						13	14		
		Singular atoll plateau rises	Co							15		
			mS							16		
		Platform plateau rises	Co						17	18		
			mS							19	20	
		Intense depressed basin plain	Co							21		
			mS						22		23	
	Lower bathype-	Intense depressed valleys	mS							24		25
		Extreme depressed valleys	mS									26

(*) Cs(Co): sandy gravel soil interspersed with coral; S(c): soil of continental origin; Co: coral; B(Co): boulder and dead; Co. B: coral and boulder; gS.Co. M: Gravelly sand, coral, and mud; mS: mud sand sediment

The shallow water/shoaling wave marine landscape sub-class (under the influence of transformed waves) includes 2 sub-classes and 5 types of landscape. The hydrodynamic characteristic of this sub-class is the dominance of shallow water wave propagation from wave break and refraction on the reef crest, wave shoaling across the reef flat to the sheltered backreef and lagoon. The shallow water marine landscape is distributed on shallow water coral reefs up to 5 m in depth and consists of 2 types (T.2, T.3), which are coral fragments and boulders, and scattered coral colonies on noncohesive reefal sediment. The T.2 type is composed of coral, seagrass and reef fish communities in the intertidal section of the coralgal flat and includes 2 kinds of landscapes (3rd and 4th kind) mainly on the adjacent Nam Yet and Sinh Ton reef flats (Tab.4). Reef-building corals and reef fish show robust growth on the flat, whereas seagrass is distributed only on the reef flat surrounding Nam Yet and Son Ca Islands. The sub-tidal landscape (T.3) consists of 1 kind of landscape (5th kind), distributed on the shallow reef scattered over the rims of Nam Yet – Sinh Ton (Tizard and Union Banks, respectively) atolls, and is featured by reef-building coral and reef fish communities.

Table 3. Landscape specification on the Da Lon (Discovery Great) reef using scuba dives

Landscape unit	Coordinates	Quadrant	Depth	Seabed substrates	Main biological ingredients
6	Da Lon Reef: 10° 4’0.39”N 113°51’16.32”E	1	6.5 m	Living corals: 10%, Reefal sediment: 90%	Few coral colonies and reef fish, scattered gastropods and seagrass
		2	6.5 m	Living corals: 10%, Reefal sediment: 90%	Few coral colonies and reef fish, scattered gastropods and seagrass

		3	6.5 m	Living corals: 10%, Reefal sediment: 90%	Few coral colonies and reef fish, scattered gastropods and seagrass
		4	6.5 m	Living corals: 10%, Reefal sediment: 90%	Few coral colonies and reef fish, scattered gastropods and seagrass
6	Da Lon Reef: 10° 0'31.78"N 113°50'47.71"E	1	2.5 m	Living corals: 2%, Reefal sediment: 98%	Few coral colonies and reef fish, dense seagrass meadow up to 70% coverage, prevailling gastropods
		2	2.5 m	Living corals: 2%, Reefal sediment: 98%	Few coral colonies and reef fish, dense seagrass meadow up to 70% coverage, prevailling gastropods
		3	2.5 m	Living corals: 2%, Reefal sediment: 98%	Few coral colonies and reef fish, dense seagrass meadow up to 70% coverage, prevailling gastropods
		4	2.5 m	Living corals: 2%, Reefal sediment: 98%	Few coral colonies and reef fish, dense seagrass meadow up to 70% coverage, prevailling gastropods

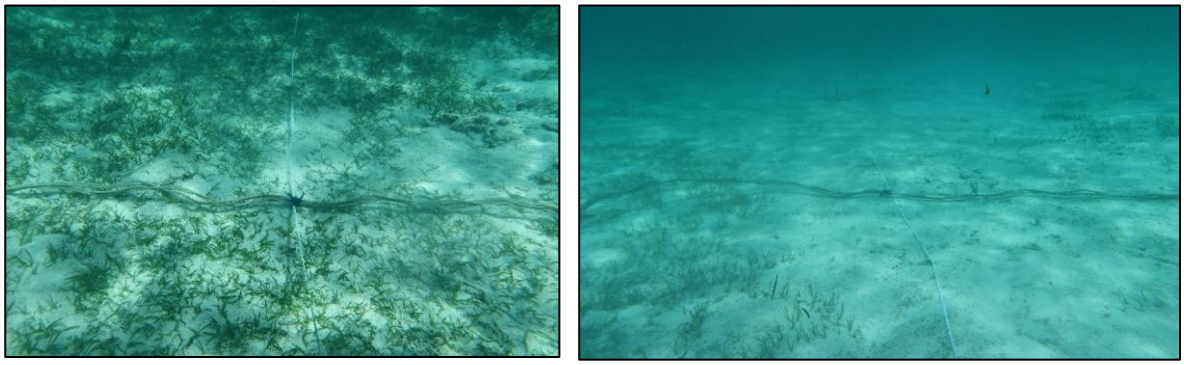

Figure 7. Seagrass biomes in the Da Lon Reef area (depth: 2.5 m)

The shallow water/transformed wave marine landscape sub-class lies in the shallow water zone from depths of 5-30 m, where waves that propagate from the deep sea swell into transformed waves due to the reduction in seabed bathymetry (equivalent to h=L/2 to h=L/20, with h = seabed bathymetry and L = wavelength). It includes 2 types of landscape (T.4, T.5), each containing 1 kind of landscape (6th and 7th, respectively) (Tab.3 and Fig.7). This landscape is a complex of coral, seagrass and reef fish communities on the eroded-deposited coral build-up platform under a transformed wave hydrodynamic regime, with a total area of 1.927,94 ha. It is characterized by the vigorous growth of corals and the highest biodiversity in the study area, with representatives of numerous scleractinian and soft coral families and reef fish, particularly in the adjacent Nam Yet, Sinh Ton, Son Ca, Sinh Ton Dong and Da Lon Reefs.

Table 4. Landscape specification on the NamYet reef using scuba and snorkeling dives

Landscape unit	Coordinates	Quadrant	Depth	Seabed substrates	Main biological ingredients

4	Nam Yet Island: 10°10'43.16"N 114°21'50.76"E	1	1 m	Reefal sediment: 100%	Dense seagrass meadows up to 80% coverage, prevailling gastropods
		2	1 m	Reefal sediment: 100%	Dense seagrass meadows up to 80% coverage, prevailling gastropods
		3	1.5 m	Living corals: 2%, Reefal sediment: 98%	Dense seagrass meadows up to 80% coverage, prevailling gastropods
		4	1.5 m	Living corals: 2%, Reefal sediment: 98%	Dense seagrass meadows up to 80% coverage, prevailling gastropods
8	Nam Yet Island 10°11'6.88"N 114°21'18.71"E	1	10 m	Living corals: 95%, Reefal sediment: 5%	High biodiversity of reef fish and corals, with prevailling schleractinians of staghorn and table corals
		2	12 m	Living corals: 85%, Reefal sediment t: 15%	High biodiversity of reef fish and corals, with prevailling schleractinians of staghorn and table corals
		3	15 m	Living corals: 75%, Reefal sediment: 25%	High biodiversity of reef fish and corals, with prevailling schleractinians of staghorn and table corals
		4	18 m	Living corals: 60%, Reefal sediment: 40%	High biodiversity of reef fish and corals, with prevailling schleractinians of staghorn and table corals

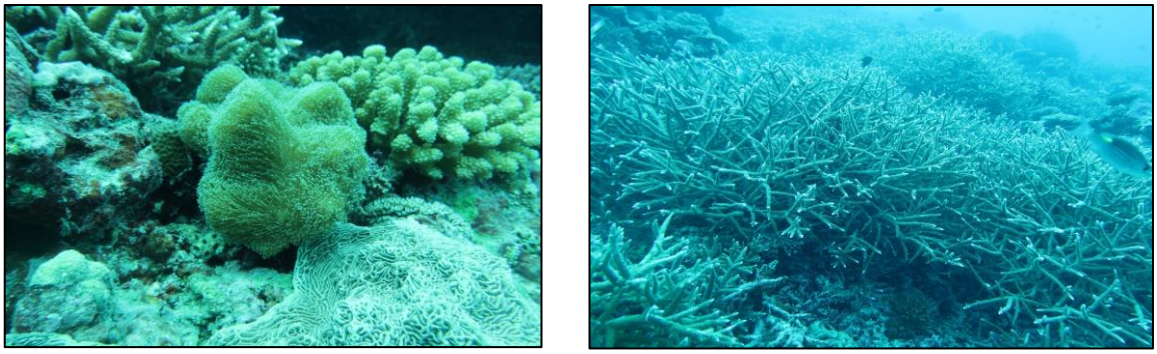

Figure 8. Coral biomes in the Nam Yet Island area (depth: 12-15m)

* The mesophotic marine landscape class includes 2 sub-classes, 3 types and 3 kinds of landscapes.

The upper mesophotic marine landscape sub-class is distributed from depths of 30-100 m (where light gradually decreases to approx. 1% compared to the surface), includes 2 types (T.6, T.7) consisting of living communities in the sheltered lagoon domain of Nam Yet and Sinh Ton atolls (Tab.4 and Fig.8). The featured communities of this sub-class are the isolated coral knolls on the deep depression lagoon bottom dominated by fine to coarse sand-gravel, coral fragments (9th kind), covering an area of 13.162.76 hectares, lie in the Nam Yet and Sinh Ton atolls, and are populated by reef-building corals and reef fish.

The lower mesophotic marine landscape sub-class is from 100 m to 200 m of depth and contains 1 type of landscape (T.8). Representative features of this subclass are the steep escarpments of the coral reef plateau, covering 18.675,80 hectares on the oceanic slope of Nam Yet, Sinh Ton and Da Lon Reef, with a high population of economically important fishes, such as Spanish mackerels, tunas, red snappers, etc (Tab.5).

Table 5. Statistical information of marine landscape diversity on the Nam Yet – Sinh Ton islands cluster.

Class	Sub-class	Type	Kind			Area (ha)
			Geomorphology	Sediment	Symbol	
Island	Đảo Island	T.1	Cay/vegetated cay	Cs(Co)	1	82,83
		T.1	Artificial island	S(c)	2	48,67
Shallow water/depth-induced wave transformation zone	Shallow water wave (h <L/20)	T.2	Reef flat	Co	3	110,73
		T.2		B(Co)	4	8.363,29
		T3		B(Co)	5	1.927,94
	Wave transformation (L/20 < h < L/2)	T4	Reef front	B(Co)	6	1.927,94
		T5		B(Co)	7	33.127,53
Mesophotic/swell zone (h < L/2)	Upper mesophotic	T6	Deep sheltered lagoon	gS.Co.M	8	64.784,60
		T7	Isolated coral knolls in the sheltered lagoon	Co.B	9	13.162,76
	Lower mesophotic	T8	Steep reef slope, up to 200 m	B(Co)	10	18.675,80
Bathypelagic/aphotic zone	Upper bathypelagic	T9	Reefal talus and reef plateau rise, up to 1000 m	Co	11	83.938,70
		T10		Co	12	603,27
		T9	Complex atoll plateau rises	Co	13	47.250,20
		T10		Co	14	194.149,93
		T10	Singular atoll plateau rises	Co	15	21.217,01
		T10		mS	16	16.883,74
		T9	Platform plateau rises	Co	17	28.085,10
		T10		Co	18	10.212,20
		T10		mS	19	4.180,20
		T11		mS	20	5.813,67
		T9	Intense depressed basin plain	mS	21	20.866,73
		T11		mS	22	275.215,75
		T12		Co	23	1.697,12
		T12		mS	24	1.207.800,94

	Lower bathypelagic	T13	Intense depressed valleys	mS	25	38.369,26
		T13	Extreme depressed valleys	mS	26	77.204,09

The marine landscape class of the deep-sea region consists of 2 sub-classes, 5 types (T.9, T.10, T.11) and 16 kinds of marine landscapes for the deep water of 200-2000 m with specific configurations. The class is characterized as the main fishing ground of many economically important fishes, such as Spanish markerels and tunas, in the Truong Sa Islands region (Tab.5).

The upper bathypelagic marine landscape sub-class consists of 4 kinds (IDs 11, 13, 17, and 21) on the slope of atoll plateau blocks. On the plateau slope, the kind 11 landscape is distributed on the upper outcrop up to 1.000 m of depth, whereas the 13th kind populates the lower part rise of the Nam Yet and Sinh Ton atoll plateaus, consisting of partially rock outcrops and reefal sediment with an area of 47.250,20 hectares. The No. 17 kind is distributed on platform plateaus, such as the Den Cay Co (Flora Temple reef) plateau to the west or the plateau group to the east of the study area, with coverage of 28.085,10 hectares. The 21st landscape kind lies on the depressed planes below the plateau rise to the northeast of the study area. The T.10 landscape type includes 7 kinds that lie on the deep-sea sediment of atoll/platform plateau rises, covering 247.246,36 hectares in total and distributed on the deep sea sediment up to 2000 m of depth surrounding the Nam Yet, Sinh Ton, Da Lon and Da Nho plateaus. The 20th landscape kind in the adjacent Da Nho platform plateau and the 22 landscape kind surrounding the rise of Nam Yet and Sinh Ton atoll plateaus (up to 2000 m of depth) feature similar fine sandy silt sediment and economic fish resources, with respective coverages of 5.813.67 and 275.215,75 hectares (Tab.5).

The last marine landscape sub-class is the lower bathypelagic region, which consists of 2 types (T.12 and T.13) and 4 kinds of landscape. The T.12 landscape type is the benthic communities of coral reef plateau rise. It contains two marine landscape kinds: the 23rd kind on the biogenic sediment of the depressed basin to the southwest of Da Lon Plateau and covers a small area of 1.697,12 hectares, and the greatest coverage of the 24th kind (over 1,2 million hectares) covers the deep-sea water column surrounding coral plateaus in the study area at depths greater than 2000 m (hence the name lower bathypelagic). The 24th kind is featured by economic fishes and deep-sea biomes of over 2000 m depth. The T.13 landscape type is the deep-sea benthic habitat on the intense/extremely depressed valleys at a depth greater than 2.000 m with corresponding 25th and 26th kinds, covering 115.573,35 hectares on biogenic sediment (Tab.5).

4. Discussion

The establishment of a marine – island landscape is the fundamental basis of planning for the reasonable use of resources and biodiversity conservation in the maritime domain, especially in remote offshore regions such as the Truong Sa Islands. Priority selection for marine biodiversity conservation attracts more scientific interest due to the global unequal distribution of living organisms [37]. This issue depends on the composition of the marine – island landscape components, such as large estuaries, coastal zones, the shallow sea and the water column characteristics for deep-water maritime domains, which constitute the distribution of marine organisms [38]. Consequently, the study of landscape structure and distribution of marine organisms sets up a scientific foundation for a biodiversity conservation pro [39].

The island-marine landscape map is a visual and effective tool, as it highlights the characteristics of each landscape unit and hence provides an accessible approach to support ecological-based management in the maritime domain [40]. The island-marine landscape map of the Nam Yet – Sinh Ton island cluster scaled at 1/50.000 has been established based on a dataset of its components, showing 26 kinds of landscape. The landscape diversity of the study area is relatively high, equivalent to the Baltic region in the study of Dorokhov (with an outcomes of 21 classified seabed landscape kinds) [41]. In this study, the classification of island-landscape is based not only on the benthic elements but also on the oceanographic conditions and benthic habitat distribution.

Accordingly, the landscape of the Nam Yet – Sinh Ton island cluster is determined by the substratum of the marine landscape (similar to studies of Golding [24], Blazhchishin [27] or Elvenes [28]), as well as the distribution of marine communities following given oceanography settings. Anthropogenic influences should be accounted for and measured simultaneously, alongside substratum conditions [30]. Anthropogenic influences should be accounted for and measured simultaneously with substratum conditions. This might be a limitation of former studies on island-marine landscapes [42, 43]. At present, the concept of marine protected areas (MPAs) is considered the most effective in terms of marine biodiversity management and conservation [44]. Modern warning tools for aerial observation based on GIS technology could be adopted to improve efficiency in management, monitoring, detection and early warning of the change in island-marine landscapes [45].

The maritime domain of Vietnam plays a strategic and essential role in terms of geopolitics, economy, national defence and security, and state diplomacy. In addition to physical and socioeconomic significance, the Truong Sa Islands in general and the Nam Yet – Sinh Ton island cluster in particular have a key role in maintaining national defence and security, as well as an open gate to the east and a multilayered continuum defensive fortress of Vietnam. Therefore, it is essential to construct the potential strength and a continuous defensive battle standoff from the coast to the open sea and island for the task of strengthening maritime defence and security, as well as providing sustainable preconditions for economic development and vice versa. Each stage in maritime economy development should provide a basis for island and maritime sovereignty protection and vice versa. Such cohesive and dialectical connections should be well defined from viewpoints, decisions, policies and projections to promote economic development and strengthen maritime defence and security and linked to a unified strategy for national development and protection. For such purposes, an island-marine landscape study should be an essential foundation in the framework of a long-term strategy.

5. Conclusions

Island-marine landscape studies are the foundation for the planning, development and reasonable use of resource and biodiversity conservation in the island-maritime domain, especially remote offshore regions such as the Nam Yet – Sinh Ton island cluster and Truong Sa Islands of Vietnam. In this study, the interaction links between island-maritime landscape components are recognized based on the island-marine landscape model. The island-marine landscape map scaled at 1/50.000 of the study area is established using the database of constituent components and consists of 1 system, 1 sub-system, 4 classes, 7 sub-classes, 13 types and 26 kinds. Island landscapes have only 2 kinds, whereas deep-water marine landscape is the most diverse, with 2 sub-classessubclasses, 5 types and 15 kinds of landscapes.

Island-marine landscape studies provide a sufficient tool for management, reasonable use and biodiversity conservation, as well as a precondition for maritime economic development and ensuring national defence and security on remote, offshore islands, which are the essential parts of a national defence system. The Nam Yet – Sinh Ton island cluster in particular and

the Truong Sa Islands in general are critical and inseparable components in maritime economy development and affirming the legal sovereignty of Vietnam in the East Sea region.

Acknowledgement

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References

1. Licht F.P., Atlas of underwater landscapes of the Japanese sea Moscow science 1990: p. 224.
2. Preobrazhensky B.V., Z. V.V., and D. L.V., Fundamentals of underwater landscape science, in Dalnauka. 2000: Vladivostok. p. 351.
3. Wiens J., Riverine Landscapes: Taking Landscape Ecology Into the Water. Freshwater Biology, 2002. **47**: p. 501-515.
4. Wu J. and H. R., Key Issues and Research Priorities in Landscape Ecology. Landsc. Ecol., 2002. **17**: p. 355-365.
5. Paine R. and Levin S., Intertidal Landscapes: Disturbance and the Dynamics of Pattern. Ecological Monographs, 1981. **51**.
6. Berg L.S., On sterlet in the White Sea basin, in Priroda 6. 1945. p. 66-67.
7. Petrov K.M., Coastal zone of the sea as a landscape system Izv. VGO., 1971. **T.103**(5): p. 391-396.
8. Poyarkov B.V., Principles of mapping shelf ecosystems in Methods for integrated mapping of shelf ecosystems. 1980: Vladivostok. p. 7-22.
9. Manuilov V.A., Study of bottom natural complexes of the upper shelf of the Peter the Great Bay (to substantiate the location of mariculture farms) Vestn. Moscow University, 1982. **1**(Ser. 5. Geography): p. 48-52.
10. Preobrazhensky B.V., Marine landscape science. , in Technological aspect // Underwater research and robotics. 2006. p. 50-58.
11. Hill M., et al., Guide to Best Practice in Seascape Assessment. 2001.
12. Roff J. and Taylor M., National frameworks for marine conservation? A hierarchical geophysical approach. Aquatic Conservation-marine and Freshwater Ecosystems - AQUAT CONSERV, 2000. **10**: p. 209-223.
13. Laffoley D d'A., et al., An implementation framework for conservation, protection and management of nationally important marine wildlife in the UK, in Prepared by the statutory nature conservation agencies, EHS and the JNCC for the DETR working group on the Review of Marine Nature Conservation. 2000, English Nature Science Report: Peterborough. p. 29.
14. Golding N., V. M., and C. D., Irish sea pilot - a marine landscape classification for the Irish sea. JNCC, 2004. **346**.
15. Connor D.W., et al., UKSeaMap: the mapping of seabed and water column features of UK seas, in Joint Nature Conservation Committee. 2006: Peterborough.
16. Wedding L., et al., Quantifying seascape structure: Extending terrestrial spatial pattern metrics to the marine realm. Marine Ecology Progress Series, 2011. **427**: p. 219-232.
17. Suo A. N., A.D. Z., and G. J., Application of landscape ecology in marine resources and environment: Discussion on oceomscape ecology development. Shengtai Xuebao/ Acta Ecologica Sinica, 2009. **29**: p. 5098-5105.
18. Lianyong, W. and P. Eagles, Some theoretical considerations: From landscape ecology to waterscape ecology. Acta Ecologica Sinica, 2009. **29**: p. 176-181.
19. DTI. Guidance on the Assessment of the Impact of Offshore Wind Farms: Seascape and Visual Impact Report. 2005. London.

20. Armstrong P., Human impacts on Australia's Indian Ocean tropical island ecosystems: A review. The Environmentalist, 1992. **12**: p. 191-206.
21. Minerbi L., Impacts of Tourism Development in Pacific Islands. Greenpeace Pacific Campaign, San Francisco. 1992.
22. Vogiatzakis I., P. G., and M. A.M., Mediterranean Island Landscapes: Natural and Cultural Approaches. 2008.
23. Rackham O., Island landscapes: Some preliminary questions. Journal of Marine and Island Cultures, 2012. **1**: p. 87–90.
24. Golding N., V. M.A., and C. D.W., Irish Sea Pilot - Report on the development of a Marine Landscape classification for the Irish Sea. 2004: JNCC.
25. Hinchey Malloy E., et al., Preface: Marine and coastal applications in landscape ecology. Landscape Ecology, 2007. **23**: p. 1-5.
26. Zajac R., et al., Responses of infaunal populations to benthoscape structure and the potential importance of transition zones. Limnology and Oceanography - LIMNOL OCEANOGR, 2003. **48**: p. 829-842.
27. Blazhchishin A., Underwater landscapes of Kaliningrad region of the Sambian Peninsula area. , in Geoecology of marine landscapes. . 1992: Kaliningrad State University press, Kaliningrad. p. 109.
28. Elvenes S., NGU Report 2013.035: Landscape mapping in MAREANO. NGU Report, 2014.
29. Dorokhov D., D. E., and S. V., Marine landscape mapping of the south-eastern part of the Baltic Sea (Russian sector). Baltica, 2017. **30**: p. 15-22.
30. Natural England, An Approach to Seascape Character Assessment. Commissioned Report NECR105. 2012, England.
31. Lebedev A. M., et al., Research of bottom landscapes of the Katba archipelagus (Tonkinsky bay,). 2020. p. 96-108.
32. Lebedev A.M., et al., Exploration of the bottom landscapes of the Cat Ba archipelago (Gulf of Tonkin,). 2019: p. 8.
33. English S., W. C., and B. V., Survey Manual for Tropical Marine Resources. Australian Institute of Marine Science, 1997.
34. Tkachenko K., H.T.T. Dương, and N.Đ. Hội, Ecological status of coral reefs in the Spratly Islands, (East sea) and its relation to thermal anomalies. Estuarine, Coastal and Shelf Science, 2020. **238**: p. 106722.
35. Nikolaev, V.A., Classification and small-scale mapping of landscapes. Moscow State University, 1978. **62c**.
36. Nguyen Dang Hoi, et al., Transformation and ecological succession of natural – anthropogenic landscapes in Konkakinh – Konchurang conservation territory, Vietnam, in Proceedings of the Karadag Scientific Station named after T.I. Vyazemsky. 2019, Natural Reserve RAS p. 52 - 71.
37. Jinlan L., et al., Identification of the priority areas for marine biodiversity conservation. Biodiversity Science, 2013. **21**: p. 38-46.
38. Spiridonov V., et al., Spiridonov V.A., Gavrilo M.V., Krasnova E.V., Nikolaeva N.G. (Eds.) Atlas of marine and coastal biological diversity of the Russian Arctic. — Moscow: WWF Russia, 2011. — 64 pp. 2011.
39. Grober-Dunsmore R., et al., Influence of landscape structure on reef fish assemblages. Landscape Ecology, 2007. **23**: p. 37-53.
40. Asaad I., et al., An interactive atlas for marine biodiversity conservation in the Coral Triangle. Earth System Science Data, 2019. **11**: p. 163-174.
41. Zyad A.H. and J. R., Towards marine landscapes in the Baltic Sea. BALANCE interim report #10, in Available at *http://balance-eu.org/* 2007.

42. Hogg O., et al., On the ecological relevance of landscape mapping and its application in the spatial planning of very large marine protected areas. The Science of the total environment, 2018. **626**: p. 384-398.
43. Hogg O., et al., Landscape mapping at sub-Antarctic South Georgia provides a protocol for underpinning large-scale marine protected areas. Scientific Reports, 2016. **6**.
44. Lockwood M., et al., Marine biodiversity conservation governance and management: Regime requirements for global environmental change. Ocean & Coastal Management, 2012. **69**: p. 160–172.
45. Elbasiouny H. and E. F., Application of Internet of Things in Marine Biodiversity Conservation. 2019. **1**: p. 38-42.
46. Tran Tuan Anh, Scientific basis and methodology for synthetic assessment of natural conditions and resources serving the orientation of development of offshore seas and islands, applicable to the Truong Sa Islands. Journal of Marine Science and Technology., 2013. **13**(4): p. 324-334.
47. Pham Hoang Hai, Nguyen Thuong Hung, and N.N. Khanh, Landscape basis of rational use of natural resources, environmental protection of the territory of Vietnam. 1997, Hanoi: Education Publishing House.
48. Nguyen Dang, H., et al., Classification and mapping of marine-island landscape in Nam Yet Island, Truong Sa Islands, Vietnam. Vietnam Journal of Earth Sciences, 2022.

Relationship between accessibility and forest cover change in the northern Vietnamese mountains: an application of GIS and principal component analysis

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Abstract. Land use and land cover change (LUCC) models frequently employ different accessibility measures as a proxy for human influence on land change processes. Most studies use straight-line distances to roads or markets as a measure of accessibility. However, distance may not be the most appropriate measure in mountaious areas when the quality of the transport network is highly variable. Using Lao Cai province, the Northern Vietnamese mountains as a case study, we evaluated the coupling of accessibility and forest cover change at the level of communes. A measure of travel time was applied to evaluate accessibility. The cost distance tool of Arcgis 10.2 software was used to calculate travel time along roads and other transportation networks. Forest cover change for the period 1993–2015 was measured using data collected from the Forest Inventory and Planning Institute of Vietnam (FIPI). Then a Principal Component Analysis (PCA) was used to detecte possible associations between forest cover change and accessibility factor. The results show that overall, Lao Cai province experienced net reforestation during the last 22 years (1993-2015). However, the trajectories mask substantial inter-communal differences. Accessible communes experience an increase in plantation forests, while isolated areas are rather characterised by an increase in natural forests. This difference reflects that forest increase in Lao Cai province is not only due to land use policy, but also to other factors such as agricultural intensification, market integration. Forest plantations were most attractive in relatively accessible as there is a growing market for timber products so that planting trees was an economically feasible option. In the poor, remote areas, increases in rice yields due to agricultural intensification led to a reduction of swidden cultivation. Forest regeneration therefore took place in fallow fields.

Key words: Accessibility, Forest cover, Lao Cai province

1. Introduction

Accessibility (distance to roads, market and facilities) is often reported to be a predictor of local poverty [1-4]. Nagendra [5] and the World Bank [6] reveal that geographical isolation is highly correlated to poverty both on a district level and on the sub-district level in Sri Lanka. The relationship between accessibility and forest cover changes is now widely recognized. Castella et al [2] reports that villages with limited accessibility in Northern Vietnam can easily be identified by recent forest deterioration. In such areas, an increase in accessibility can diminish the negative impacts of high poverty levels on forests by encouraging intensive agriculture and off-farm jobs, including migration and therefore reducing pressure on forest [7]. However, other studies from Brazilian Amazon [8], Philippines [9], Honduras [10], and Colombia [11] show that deforestation are highest in accessible places. Nagendra et al [5] shows the mixed effect of accessibility on landscape transformation in western Honduras. At national scale, Meyfroidt and Lambin [12] reported that in areas with better accessibility and growing markets, an increase in plantation forests was observed because households were able to benefit from the conversion of abandoned upland fields to forest plantations. In contrast, in the poor regions with little infrastructure, natural regeneration was taking place as result of agricultural intensification.

The above-mentioned examples show that the relationship between accessibility and forest cover change is dynamic, complex, and often location-specific. In most cases, the studies were conducted at country or district level to assess the association between poverty, accessibility and forest cover change. However, the influence of economic, social and institutional variables on forest cover change is often location-specific [12-15]. Therefore, an analysis at the level of villages or communes might be more appropriate to analyse poverty-environment links [16].

This research aims to make a quantitative analysis of the association between accessibility and forest cover change at the level of communes, the lowest administrative unit of Vietnam (below district and province). The Lao Cai province, located in northern Vietnam is here taken as a case-study as the poverty-environment nexus is often concentrated in the highland areas dominated by ethnic minority populations [16]. In this study, The following research questions will be addressed: Is accessibility a controlling factor of forest cover dynamics?

2. Study area

Lao Cai province is a mountainous area in Northern Vietnam that shares its northern border with China (Figure 9). It covers a surface of 6372km². The landscape of Lao Cai province is diverse with lowlands along the Red River and high mountain ranges in the Southwest and Northeast. Elevation ranges from 180m along the Red River valley to the Fan Si Pan peak (3143m). Lao Cai is one of the provinces with abundant forest resources. Forests covered 56% of the total area in 2018, compared with 45% at the national level [17]. The Hoang Lien National Park is located in the west of the province. It was one of the first areas recognized as a 'special use forest' in Vietnam in 1986. In 1994, it became the Hoang Lien Nature Reserve, and it became a National Park in 2002 under the management of Lao Cai's People's Committee [18].

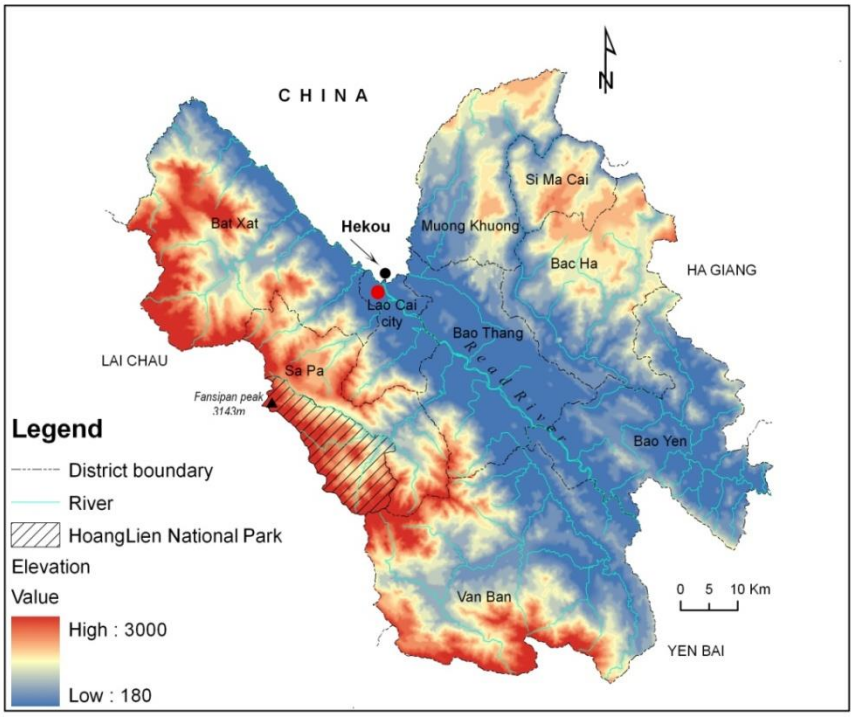

Figure 9. Topographic map of Lao Cai province

The Lao Cai province is home to different ethnic groups. Each of them has his own culture and lifestyle. There is a strong spatial organization of the ethnic groups. The Kinh people (dominant ethnic group of Vietnam) are concentrated in the lowlands and towns, and typically have better economic conditions and accessibility to markets. The remote mountain

areas host a large number of ethnic minorities. These areas are also characterized by lower population density, higher poverty rates and shifting cultivation was important in the past. As one of the poorest provinces in the northern region, it is also targeted by a variety of national and international programs focused on rural development and poverty reduction. The Red River acts as the major transportation and communication axis of the province. In1993, the province opened some destinations (Sa Pa, Bac Ha districts) for domestic and international tourism that boosted the local economy [19]. At the same year, the Hekou Border Economic Cooperation Zone (Figure 9) was instituted to promote trade between China and Vietnam [20].

3. Materials and methods

3.1. Detection of land cover change

The forest cover data were collected from the Forest Inventory and Planning Institute of Vietnam (FIPI) for the year 1993, 2000 and 2015. The FIPI maps were produced by supervised classification of Landsat satellite images that were validated by field inventories [12], and have a spatial resolution of 30m x 30m. For this study, the original land cover classification (13 classes) was generalized into 3 classes: natural forests, planted forests and non-forested area (Figure 10). The land cover maps for 1993, 2000 and 2015 were crossed to produce one single map with the land cover change trajectories. The overlays resulted in a categorical 'change map' where each pixel includes information on forest cover change between 1993, 2000 and 2015. The 27 different land cover change trajectories (3^3) were grouped into 5 classes: No change, Deforestation, Natural forest growth, Increase in plantation forest and other changes (Table 6).

Table 6. Forest cover change trajectories and their descriptions for period 1993–2015 (N is non-forest, NF is natural forest and PF is planted forest)

Order	Category	Change Trajectory			Description	% of change
		1993	2000	2015		
1	N-N-NF	Non-forest	Non-forest	Natural forest	Natural forest growth	20.8
2	N-NF-NF	Non-forest	Natural forest	Natural forest		
3	N-N-PF	Non-forest	Non-forest	Planted forest	Increase in plantation forest	8.1
4	N-PF-PF	Non-forest	Planted forest	Planted forest		
5	NF-NF-N	Natural forest	Natural forest	Non-forest	Deforestation	7.6
6	NF-N-N	Natural forest	Non-forest	Non-forest		
7	PF-N-N	Planted forest	Non-forest	Non-forest		
8	PF-PF-N	Planted forest	Planted forest	Non-forest		
9	NF-PF-N	Natural forest	Planted forest	Non-forest		
10	N-N-N, NF-NF-NF, PF-PF-PF				No change	48.1
11	N-NF-N, N-NF-PF, N-PF-N, N-PF-NF, NF-N-NF, NF-N-PF, NF-NF-PF, NF-PF-NF, NF-PF-PF, PF-N-NF, PF-N-PF, PF-NF-NF, PF-NF-PF				Other change	15.4

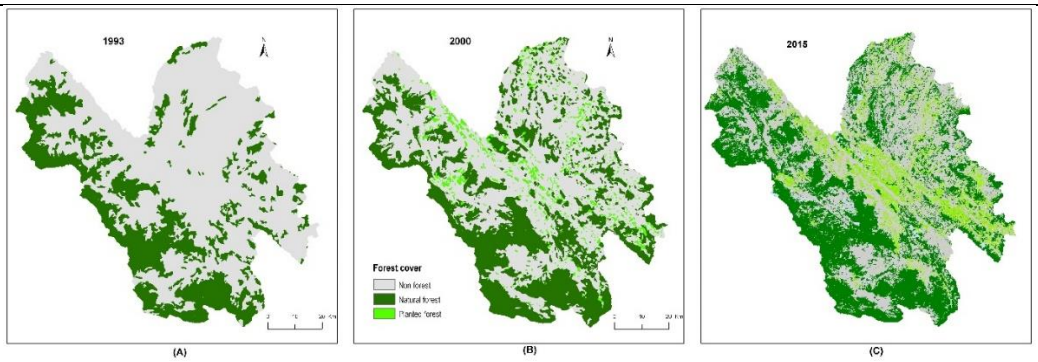

Figure 10. Forest cover maps in the year 1993 (A), 2000 (B) and 2015 (C)

3.2. Accessibility assessment

Accessibility is often defined as the ability for interaction or contact with sites of economic or social opportunity [21]. Accessibility is presumed to initiate and promote rural development [22] and induce land use change [2]. Most studies use straight-line distances to roads or markets as a measure of accessibility [5, 23-25]. However, distance may not be the most appropriate measure when the quality of the transport network is highly variable [26], or where the cost of using public transport must be taken into account [27]. A measure of travel cost or travel time can provide a more realistic measure in the case of highly variable road quality.

Data on road networks and facilities collected from the electronic atlas of Lao Cai province were used to compute accessibility indicators (Figure 11). The cost distance tool of Arcgis 9.3 software was used to calculate travel time along roads and other transportation networks. The transportation network has a total length of about 1500km, of which 65km is railway (travel speed ≈ 60km/h by train), 732km are asphalt roads (travel speed ≈ 50km/h by car), 466km are gravel roads (travel speed ≈ 30km/h by motorbike), and 237km are foot paths (travel speed ≈ 5km/h on foot). Travel speed in off-road areas is 3km/h by foot. The 563 village centers are the points of departure, and the potential destinations are the 163 commune centers, 10 district centers, 1 provincial administrative center, 200 health stations and 83 markets, all represented as points.

At village level, we have used the Gaussian formula [28] that allows for a more gradual fall-off of the distance decay function [27] to quantity anaccessibility indicator at village level:

$$\text{Access}_{village-i} = \sum_{j=1}^{6} e^{(-d_{ij}^{b}/2a^{2})} \qquad (Eq.1)$$

Where

$Access_{village-i}$ is the potential accessibility of village i,

d_{ij} is the distance between the center of the i^{th} village and destination j^{th} (j is the closest market, health station, neighbouring village center, commune center, district center and provincial administrative center (Lao Cai city)),

a is the distance to the point of inflection, and b is the distance exponent.

The parameters a and b were derived from other studies [29]. We used the same parameter values as the ones applied in the Philippines, namely b value of 2 and a of 45 minutes.

In northern Vietnam, the village is very often considered as the most relevant scale level for the analysis of human-environment interactions [30], as village could be considered as a homogeneous unit from ethnical, socio-economic and biophysical point of view. As most of the socio-economic variables were only available at commune level, the accessibility indicator (calculated at village level) was aggregated at commune level to match the spatial scale of the other variables. At commune level, we follow the population potential model to measure accessibility [27, 28]. Accessibility indicators at commune level were calculated using the following formula:

$$\text{Access}_{commune\text{-}k} = \frac{\sum_{i=1}^{n} \text{Access}_{village-i} \times P_i}{\sum_{i=1}^{n} P_i} \qquad (Eq.2)$$

Where $\text{Access}_{commune\text{-}k}$ is the accessibility indicator of the k^{th} commune (k=1 to163),

$\text{Access}_{village-i}$ is the accessibility indicator of the i^{th} village that belongs to commune k,

P_i is the population size of the i^{th} village, and

n is number of villages that belong to commune $k^{th.}$

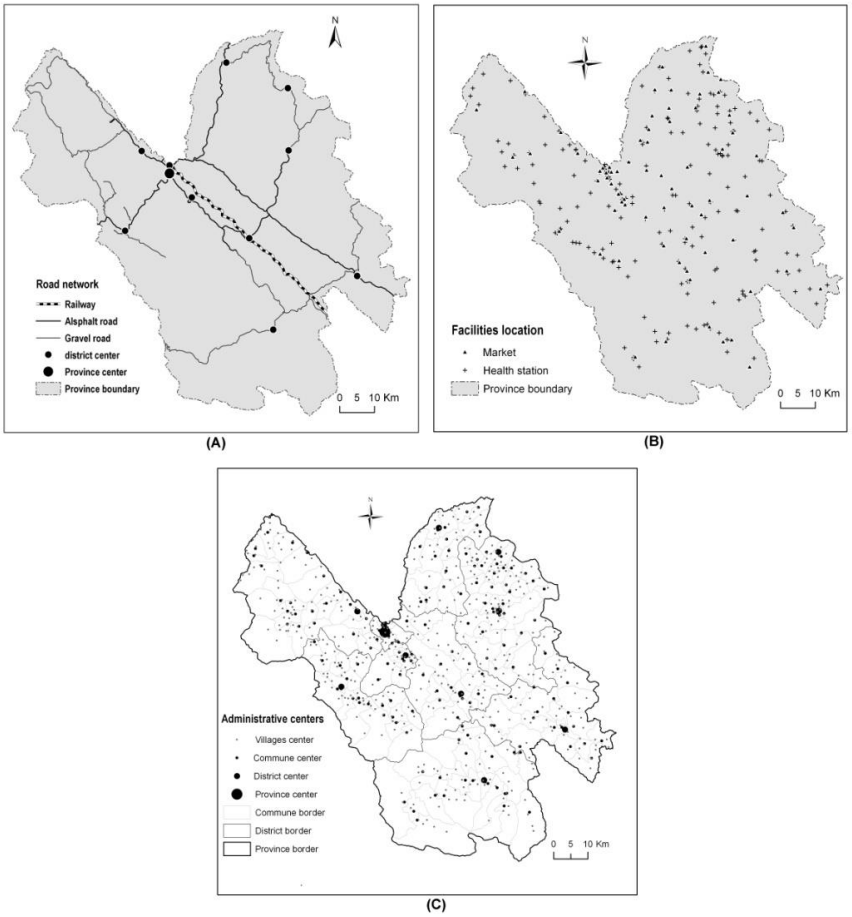

Figure 11. (A) The road network, (B) facilities (health service and markets) and (C) administrative centers (Village, commune, district and province centers) of Lao Cai province

3.3. Analysis of the relationship between accessibility and forest cover change

The statistical analyses were realized at the level of the communes. The commune boundaries were used to extract the forest cover change per commune, and these data were extracted for the 163 communes. Then, a Principal Component Analysis (PCA) was used to analyse the relationships between the sets of variables (Table 7). Principal Component Analysis allows to visualize and analyze correlations between variables, and reduce the number of variables in a dataset by combining the variables into components [31]. In this research, there are 163 observations (163 communes) and 14 numerical variables.

Table 7. List of variables included in the statistical analyses

Sets of variables	Acronym	Description	Unit
Deforestation	DFOREST1993-2015	Area of deforestation in the period 1993-2010 of each commune divided by its total area and then multiply by 100	%
Natural forest growth	NGROWTH1993-2015	Area of natural forest regrowth in the period 1993-2010 of each commune divided by its total area and then multiply by 100	
The increase in plantation forest	PGROWTH1993-2015	Area of increase in plantation forest in the period 1993-2010 of each commune divided by its total area and then multiply by 100	

Accessibility	ACCESS	Accessibility index aggregated at commune level

4. Results

4.1. Forest cover change in Lao Cai province

Across all three dates, forestsare dominant in the high mountains in the eastern and western most parts of the province (Figure 10). Overall, for the period from 1993 to 2015, there is a clear trend of forest increase in Lao Cai province as forest cover increased from 31% in 1993 to 41% in 2000 and 54% in 2015. This trend is consistent with the trend that was reported at the national-scale or other provinces in northern Vietnam [12, 14, 24, 30, 32]. In Lao Cai province, the forest cover has increased through natural regeneration and forest plantations. The data indicate that tree plantations are concentrated in the Red River valley and along the main roads, while natural forest regeneration is mostly observed in the remote areas (Figure 12).

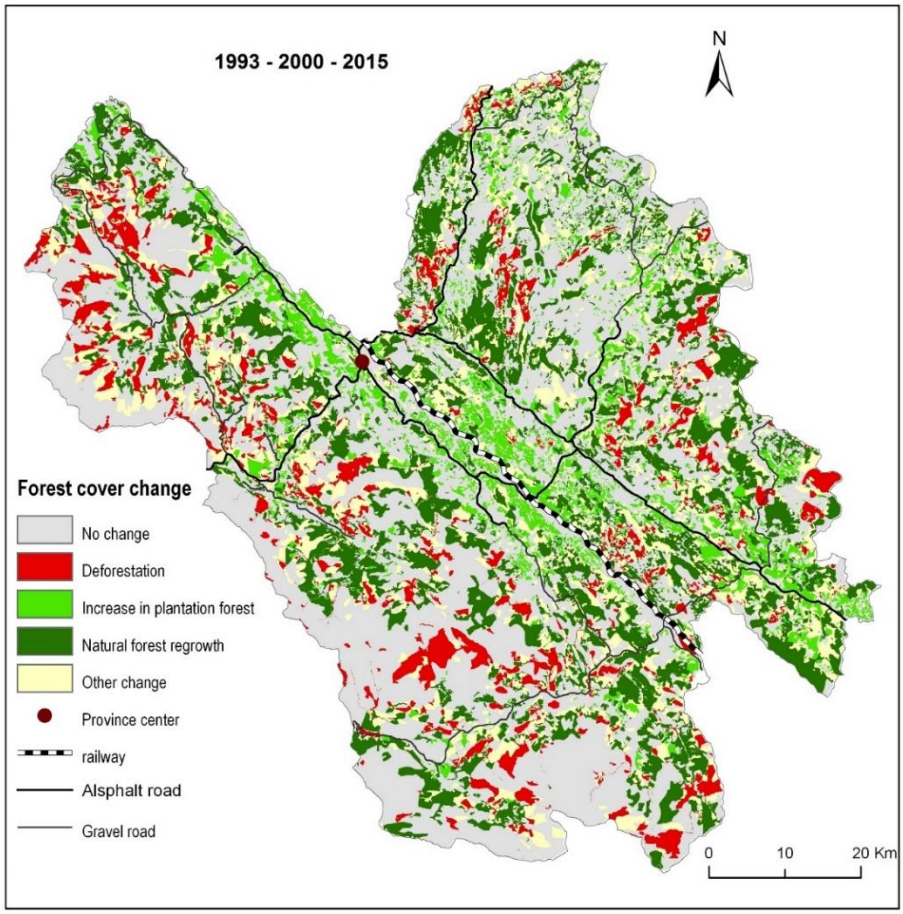

Figure 12. Map of forest cover change between 1993– 2015

The proportion of remaining forest in 1993 is positively associated with deforestation and negatively with the increase in forest plantations (Table 8). It means that deforestation often occurred in the communes that have an abundant forest cover, while forests are more likely to be planted in areas with low forest cover in 1993.

Table 8. Pearson correlation matrix between forest cover change variables and proportion of remain forest in 1993

	Forest area 1993	Deforestation 1993-2015	Increase in plantation forest1993-2015	Natural forest growth 1993-2015

Forest area 1993	1			
Deforestation 1993-2015	**0.705**	1		
Increase in plantation forest 1993-2015	**-0.518**	**-0.469**	1	
Natural forest growth 1993-2015	-0.073	-0.061	**-0.390**	1

In bold, significant values at the level of significance alpha=0.050

4.2. Spatial pattern of accessibility

The spatial pattern of the accessibility indicator highlights geographical disparities in the access of communities to key facilities like market places and health centers as well as the administrative centers (Figure 13). The Red River valley is a major communication axis between the delta and southwest China, and has a high road density. Sa Pa district is well connected to the Red River valley, as it is an important tourism center. The other districts are remote and have a poorly developed transportation network.

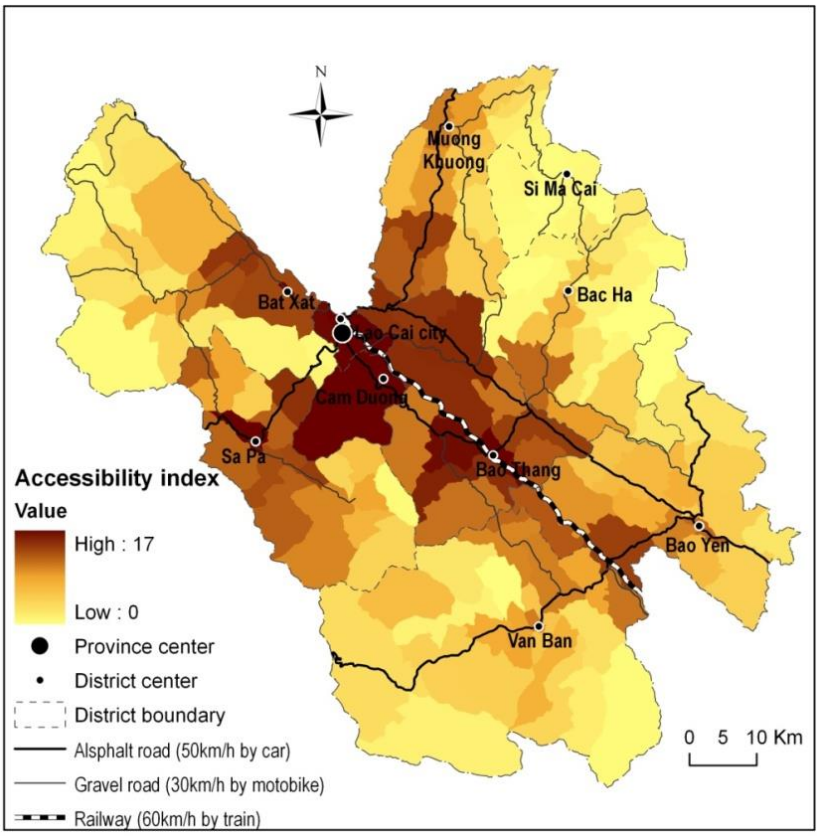

Figure 13. Accessibility indicator at commune level

4.3. Driver of forest cover change

To further understand the mechanisms of forest cover change, we carried out a PCA on a combination of forest cover change variables and the accessibility indicator. The first two principle components, account for 56 % of the total variance. The first component (T1) accounts for 33% of the total variance of the dataset, and represents the accessibility of the communes with higher scores when accessibility are poor. The second component (T2) accounts for 23% of total variance, and represents forest cover change patterns with higher scores for larger deforestation rates.

Figure 14 shows the orientation of quantitative variables in the vector space formed by the first two principle compoments (T1 and T2). The natural forest growth variable are orientated in the opposite direction of accessibility. This suggests that natural forest growth occurred mainly in poor communes with low accessibility (Figure 14). In contrast, the increase in plantation forest and accessibility indicator are grouped in the negative side of axis T1. This suggests that increase in tree plantation is mainly found in the richer communes with high accessibility.

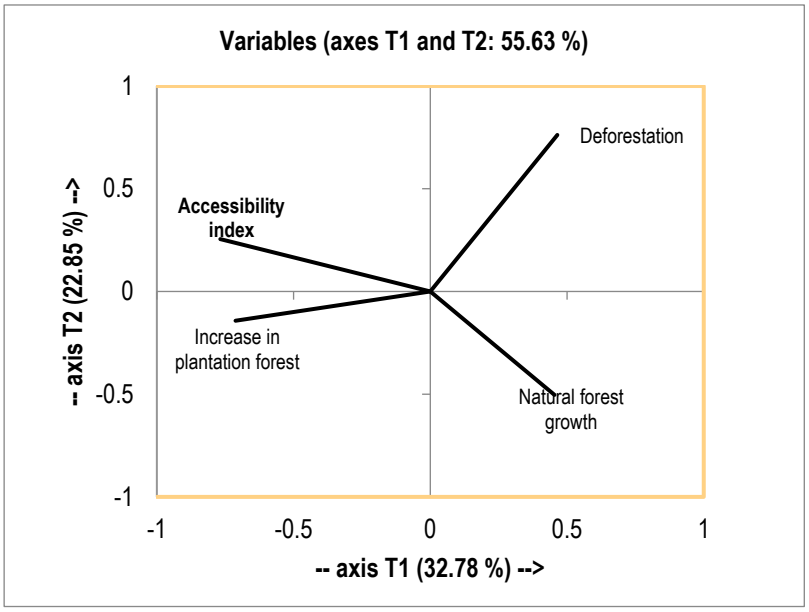

Figure 14. PCA structuring the variability in forest cover change and accessibility indicator

5. Discussion

5.1. Impact of policy on forest cover change

The strong increase in forest plantations that is observed for the Lao Cai province is likely the result of forest policies. The allocation of land to individual households in 1993, the Program 327 in the mid-1990s, and the Five Million Hectare Reforestation Project (5MHRP) (from 1998-2010) were probably very effective in this province, as a large part of the natural forest growth and increase in plantation forest was observed in the period 1993-2010. After the allocation of forest land to individual households, shifting cultivation was legally not possible because all land was allocated to individual households and forest land was protected. This policy inevitably forces rural households to develop new production systems to compensate for the ban on swidden cultivation and it has stimulated people to cultivate their fields more intensively [24, 33]. The program 327 and 5MHRP were intended to stimulate the forestry sector, and to encourage local people to plant trees under the subsidy of the government for reforestation [13]. Following the forest rehabilitation programs, the Vietnamese Government also planned the location of supply regions for timber and wood processing centers. The forestry sector in Lao Cai province is linked to the Viet Tri and Bai Bang paper factories. There is a high demand for forestry products in Vietnam, as 80% of raw materials for furniture manufacturing in Vietnam are from imports [32, 34]. Our research shows that plantation forests were more likely to be planted in areas with a low forest cover. This might be due to the scarcity of wood around timber and wood processing centers, which might have led to an increase in forest plantations to meet the market demand.

5.2. Accessibility, Poverty and forest cover change

Accessibility is a key factor in understanding relationships between the biophysical and socio-economic characteristics of the study area [2]. Rural development depends primarily on accessibility. Research of Castella et al [2] in Bac Kan province, Northern Vietnam, revealed strong relationships between the accessibility of the village, its poverty level and its potential for development. Alther et al [35] revealed that accessible areas benefit from marketing channels for agricultural production and access to development aid projects.

Although forest cover has increased rapidly in the Lao Cai province, the overall forest cover change masks substantial inter-communal differences. By using a principle component analysis, it is possible to unravel the association between forest cover change and socio-economic, variables. Rich and accessible communes are characterised by a strong increase in plantation forests, while poor and more isolated areas are characterised by an increase in forests after natural regeneration. Our results support earlier research of Meyfroidt and Lambin [12] that reported that the occurrence of plantation forests is limited in remote areas. This could partly be due to a lack of infrastructure and market opportunities for timber compared to more acessible areas, as commercial forest plantations are not an economically feasible option for remote areas [36].

6. Conclusion

Overall, Lao Cai province experienced net reforestation during the last 25 years (1993-2015). Forest cover change trajectories are consistent with the trends that are observed at the national scale. However, the trajectories mask substantial inter-communal differences. Accessible communes with better economic development experience an increase in plantation forests, while poverty-stricken and isolated areas are rather characterised by an increase in natural forests. This difference reflects that forest increase in Lao Cai province is not only due to land use policy, but also to other factors such as market integration, and economic growth. Forest plantations were most attractive in relatively accessible and well-developped regions, as there is a growing market for timber products so that planting trees was an economically feasible option. In the poor, remote areas, increases in rice yields due to agricultural intensification led to a reduction of swidden cultivation. Forest regeneration therefore took place in fallow fields.

In Lao Cai province, rural development depends primarily on accessibility. The communes in the Red River valley and district centers have better accessibility, so they can benefit from marketing channels for agricultural products and can have access to development aid projects. In remote, isolated, poor communes with few infrastructureand market opportunities, food security rather than forest plantations remained the first priority. Deforestation was still observed in communes with high land pressure.

References

1. Perez-Verdin, G., et al., *Factors driving deforestation in common-pool resources in northern Mexico.* Journal of Environmental Management, 2009 **90**: p. 331-340.
2. Castella, J.C., et al., *Analysis of village accessibility and its impact on land use dynamics in a mountainous province of northern Vietnam.* Applied Geography 2005. **25**: p. 308-326.
3. Ahlström, A., P. Pilesjö, and J. Lindberg, *Improved accessibili ty mo deling and its relation to poverty e A case study in Southern Sri Lanka.* Habitat International, 2011. **35**: p. 316 -326.
4. Minot, N., B. Baulch, and M. Epprecht, *Poverty and Inequality in Vietnam Spatial Patterns and Geographic Determinants*. 2006, INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE WASHINGTON, D.C. p. 72.

5. Nagendra, H., J. Southworth, and C.M. Tucker, *Accessibility as a determinant of landscape transformation in western Honduras: linking pattern and process.* Landscape Ecology 2003. **18**: p. 141-58.
6. World Bank, *Sri Lanka poverty assessment: engendering growth with equity: opportunities and challenges*. 2007.
7. Deininger, K. and B. Minten, *Determinants of forest cover and the economics of protection: an application to Mexico.* American Journal of Agricultural Economics, 1997. **84**: p. 943-960.
8. Laurance, W.F., et al., *Predictors of deforestation in the Brazilian Amazon.* Joural of Biogeography, 2002. **29**: p. 737-748.
9. Liu, D.S., L.R. Iverson, and S. Brown, *Rates and patterns of deforestation in the Philippines: applications of geographic information system analysis.* Forest Ecology and Management, 1993. **57**: p. 1-16.
10. Ludeke, A.K., R.C. Maggio, and L.M. Reid, *An analysis of anthropogenic deforestation using logistic regression and GIS.* Journal of Environmental Management, 1990. **31**: p. 247-259.
11. Etter, A., et al., *Regional patterns of agricultural land use and deforestation in Colombia.* Agriculture, Ecosystems & Environment, 2006. **114**: p. 369-386.
12. Meyfroidt, P. and E.F. Lambin, *The causes of the reforestation in Vietnam.* Land Use Policy 2008. **25**(2): p. 182-197.
13. Clement, F. and J.M. Amezaga, *Linking reforestation policies with land use change in northern Vietnam: Why local factors matter*. Geoforum, 2008. **39**: p. 265-277.
14. Clement, F., et al., *Drivers of afforestation in Northern Vietnam: Assessing local variations using geographically weighted regression.* Applied Geography, 2009. **29**(4): p. 561-576.
15. Sowerwine, J., *Territorialisation and the Politics of Highland landscapes in Vietnam: Negotiating property relations in policy, meaning and practice.* Conservation and Society, 2004. **2**(1): p. 98-117.
16. Dasgupta, S., U. Deichmann, and D. Wheeler, *Where is the Poverty–Environment Nexus? Evidence from Cambodia, Lao PDR, and Vietnam.* World Development, 2005. **33**(4): p. 617–638.
17. GSO, *Vietnam statistical year book 2010*. 2021, Hanoi: Statistical publishing house.
18. Le, V.L., *Hoang Lien National Park*. 2004, Hanoi, Vietnam: National Culture Publishing House.
19. Truong, V.D., C.M. Hall, and T. Garry, *Tourism and poverty alleviation: perceptions and experiences of poor people in Sapa, Vietnam.* Journal of Sustainable Tourism, 2014.
20. Tugault-Lafleur, C. and S. Turner, *The price of spice: Ethnic minority livelihoods and cardamom commodity chains in upland northern Vietnam.* Singapore Journal of Tropical Geography, 2009. **30**(3): p. 388-403.
21. Deichmann, U., *Accessibility indicators in GIS*. 1997, United Nations Statistics Division Department of Economic and Policy Analysis: New York.
22. Odoki, J.B., H.R. Kerali, and F. Santorini, *An integrated model for quantifying accessibility-benefits in developing countries.* Transportation Research 2001. **35**: p. 601-623.
23. Meyfroidt, P., V.T. Phuong, and H.V. Anh, *Trajectories of deforestation, coffee expansion and displacement of shifting cultivation in the Central Highlands of Vietnam.* Global Environmental Change, 2013. **23**(5): p. 1187-1198.
24. Vu, K.C., et al., *Land Transitions in Northwest Vietnam: An Integrated Analysis of Biophysical and Socio-Cultural Factors.* Human Ecology, 2013. **41**(1): p. 37– 50.

25. Getahun, K., et al., *Factors controlling patterns of deforestation in moist evergreen Afromontane forests of Southwest Ethiopia.* Forest Ecology and Management, 2013. **304**: p. 171–181.
26. Vanacker, V., et al., *The effect of short-term socio-economic and demographic change on landuse dynamics and its corresponding geomorphic response with relation to water erosion in a tropical mountainous catchment, Ecuador*. Landscape Ecology, 2003. **18**(1): p. 1-15.
27. Verburg, P.H., K.P. Overmars, and N. Witte, *Accessibility and land-use patterns at the forest fringe in the northeastern part of the Philippines.* The Geographical Journal, 2004. **170**(3): p. 238–255.
28. Ingram, D.R., *The concept of accessibility: a search for an operational form.* Regional Studies, 1971. **5**: p. 101-107.
29. Bigman, D. and U. Deichmann, *Spatial indicators of access and fairness for the location of public facilities*, in *Geographic targeting for poverty alleviation: methodology and application*, D. Bigman and H. Fofack, Editors. 2000, World Bank: Washington DC. p. 181-206.
30. Castella, J.C., N.R. Tronche, and V. Nguyen, *Landscape changes in Cho Don District during the doi moi era (1990-2000) and their implications for sustainable natural resource management in Vietnam's mountainous provinces* in *Doi Moi in the mountains*, J.C. Castella and D.Q. Dang, Editors. 2002, The Agricultural Publishing House: Hanoi, Vietnam. p. 149-173.
31. Bryant and Yarnold, *Principal components analysis and exploratory and confirmatory factor analysis*, in *Reading and understanding multivariate analysis*, Grimm and Yarnold, Editors. 1995, American Psychological Association Books.
32. De Jong, W., D.D. Sam, and T.V. Hung, *Forest rehabilitation in Vietnam: histories, realities and future*. 2006, Bogor Barat 16680, Indonesia: Center for International Forestry Research (CIFOR).
33. Castella, J.-C., et al., *Impact of forestland allocation on land use in a mountainous province of Vietnam.* Land Use Policy, 2006. **23**(2): p. 147-160.
34. Meyfroidt, P. and E. Lambin, *Forest transition in Vietnam and displacement of deforestation abroad.* PNAS, 2009. **106**(38).
35. Alther, C., et al., *Impact of accessibility on the range of livelihood options available to farm households in mountainous areas of northern Vietnam*, in *Doi Moi in the mountains. Land use changes and farmers' livelihood strategies in Bac Kan province, Vietnam*, J.C. Castella and D.Q. Dang, Editors. 2002, The Agricultural Publishing House: Hanoi, Vietnam. p. 121-146.
36. Clement, F., et al., *The impact of goverment policies on land use in northern Vietnam: an institutional approach for understanding farmer decisions*, in *IWMI Research Report, Technical Report*. 2007, International Water Management Institute: Colombo.

Application of gis and remote sensing for monitoring land cover change over the last 60 years: case study in the Sa Pa district, Lao Cai province, Vietnam

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Abstract. Trajectories of land cover change often reflect common underlying socio-economic processes. This study used very high resolution remote sensing images to resume the historical land cover dynamics for 5 sellected communes of Sa Pa district, Lao Cai province, Vietnam over the last 60 years. The land cover maps derived from aerial photos (1952, 1993, 2002) and very high resolution SPOT images (2012) were compared to calculate land cover changes. This was done by performing an overlay of two raster maps so that a cross-tabulation can be carried out by the raster calculator tool in ArcGIS 9.3. The results show that over the last 60 years, the major changes were the reduction of the forest area and the expansion of arable land. Between 1952 and 2012, the overall forest cover decreased by 9% in favor of shrubs, arable land and residential area increased by 11%, 20% and 42%, respectively. However, trajectories of land cover change in Sa Pa district are multiple and sometimes contradictory between time periods. Forest has a large size in terms of annual losses during the first (1952-1993) and second interval (1993-2002) but this trend was reversed in the third interval (2002-2012). Arable land gained during the first interval while lost in the third interval. Residential area has annual gains during the all time interval. This difference reflects that land cover change in Sa Pa district is not only due to land use policy, but also to other factors such as agricultural intensification, market integration, and economic growth.

Key words: Land cover change, GIS, Remote sensing, Vietnam

1. Introduction

As many tropical countries, Vietnam was characterized by a net deforestation during the period 1950s-1990s [1]. Since the 1990s, Vietnam has experienced a net increase in forest cover as a combination of economic and political responses to forest and land scarcity, economic growth, and market integration [2]. However, forest cover dynamics vary locally, and national-scale inventories mask disparities that might exist at local scales [2-5].

The integration of multi-source data is necessary to monitor land cover change for long time period. Aerial photographs and Very High Resolution SPOT images (VHR-SPOT) are known to be highly accurate for investigating historical land cover, but cover only limited area. Aerial photos are therefore often used to detect long-term land cover change (spanning 50 to 60 years) at local scale, covering individual villages or clusters of households. This approach has been successfully applied in previous studies by [6, 7].

In this paper, land cover data from different sources were compared to resume the historical land cover dynamics (1950s-2012) at local scale. Sa Pa district (ca.700 km^2, located within Lao Cai province in NW Vietnam) was selected for the analysis at the district and village level. The study relies primarily on very high resolution remote sensing images (VHR-SPOT4, 5) and aerial photographs. The following three research questions are addressed: (1) What are the major trends of land cover change over 60 years?, and (2) How do recent land cover changes (10-20years) fit with longer term trends (50 years)?

2. Materials and methods

Table 9 gives an overview of the data that were used for the land cover analysis. The data span a time period of 60 years, and data are available at relatively regular time intervals.

Table 9. Characteristics of the data used for the land cover analysis

Characteristics	**Aerial photographs**	**VHR-SPOT**
Year	1952, 1993, 2002	2006, 2012
Type	Black and white	4 bands
Size	60km^2	1569 km^2
Scale (or resolution)	1/38,180; 1/47,500; 1/47,500	5m x 5m; 2.5m x 2.5m
Image quality	Good	Good
Covering	5 communes (Trung Chai, Ta Phin, San Sa Ho, Lao Chai and Nam Cang)	Sa Pa district
Land Cover categories	Closed canopy forest, Open canopy forest, Shrub, Paddy field, Upland field, Water body, Residential area, Road.	Closed canopy forest, Open canopy forest, Shrub, Paddy field, Upland field, Water body, Residential area, Road,

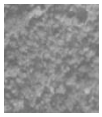
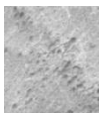
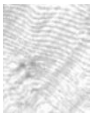
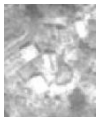
2.1. Land cover classification on very high resolution images

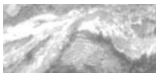
At small spatial scale, very high-resolution satellite images (VHR-SPOT) and aerial photographs were used. The time series spans the period from 1952 to 2012, and covers part of Sa Pa district (Table 9). The aerial photographs were obtained as scanned files from the Agency for Survey and Mapping, Ministry of Natural Resources and Environment, Vietnam [8-10]. The three sets of aerial photographs were extracted for five communes within the Sa Pa district: (1) Trung Chai, (2) Ta Phin, (3) San Sa Ho, (4) Lao Chai and (5) Nam Cang (Figure 15). The first set of aerial photographs was taken between 1952 and 1954 and its printing scale is approximately 1/38,180. The second and third sets were taken in 1993 and 2002 respectively, and their printing scale is approximately 1/47,500. The photographic quality of the three series of photos is acceptable. The aerial photos were orthorectified and georeferenced using Photomod software [11].

The land cover maps of 2006 and 2012 were based on visual interpretation of VHR-SPOT satellite images of 2006 and 2012 with a resolution of 5 by 5m and 2.5 by 2.5m, respectively. All SPOT images were obtained in orthorectified and georeferenced format from the Ministry of Natural Resources and Environment, Vietnam [12, 13].

For all images (three sets of aerial photographs and two VHR-SPOT images), image segmentation was carried out with the eCognition Professional 6.0 software. As such, the digital image was segmented into a set of non-superimposable, discrete regions on the basis of their internal homogeneity criterion [14, 15]. Land cover maps were produced by grouping manually the segments based on a visual interpretation. Eight categories were used (Table 10): (1) closed canopy forest, (2) open canopy forest, (3) paddy field, (4) upland field, (5) shrub, (6) residential area, (7) water body, and (8) road.

Table 10. Short description of the eight land cover types, as they were detected on aerial photographs and VHR-SPOT images

Land cover type	Terrestrial picture	VHR-SPOT image	Aerial photograph	Characteristics
Closed canopy forest				Closed canopy forests are distinguished on the aerial photos and VHR-SPOT by a dark tone, the 'cauliflower' texture, and most of the time by their specific location on steep slopes, at high altitudes and/or in gullies [16].
Open canopy forest				Open canopy forests have a more open cauliflower texture than closed canopy forests
Shrub				Shrub is distinguished by a lighter tone than forest. The texture still shows some patterns, but does not show the 'cauliflower' pattern typical of a continuous cover of trees [16].
Paddy field				Paddy fields are recognized by their light (almost white) tone, by their steps and by their location in the valleys near rivers.
Upland field				Upland fields are recognized by the light, homogeneous tone and the texture. Upland fields often have angular forms.
Residential area				Residential areas were easily distinguished by the shape of the houses, by their location near infrastructure and by their non-uniform pattern [16].

Water body				Water body (rivers) and roads are easily recognized through their curved lines and light color. Roads are typically more smooth and uniform than rivers
Road				

2.2. Land cover change analysis

The land cover maps derived from aerial photos (1952, 1993, 2002), VHR Spot images (2006, 2012) were compared to calculate land cover changes. This was done by performing an overlay of two raster maps so that a cross-tabulation can be carried out by the raster calculator tool in ArcGIS 9.3. After the cross-tabulation matrix was created for each time interval, the change in terms of size and intensity at three levels was analyzed following the procedures described by Aldwaik and Pontius [17]. First, the interval level examines how the size and speed of change vary across time intervals. Second, the category level examines how the size and intensity of gross losses and gross gains in each category vary across categories for each time interval. Third, the transition level examines how the size and intensity of a category's transitions vary across the other categories that are available for that transition. This procedure also allow us to measure which part of observed changes is real changes and which part is just map errors.

3. Results

3.1. Land cover change based on VHR data

The land cover maps obtained from aerial photographs and VHR-SPOT images for the years1952, 1993, 2002 and 2012 are shown in Figure 15A, B, C, D. Table 11 presents land cover changes between 1952 and 2012 in 5 selected communes. The area of forest has decreased by 9% between 1952 and 2012 while shrubs, arable land and residential area increased by 11%, 20% and 42%, respectively (Table 11).

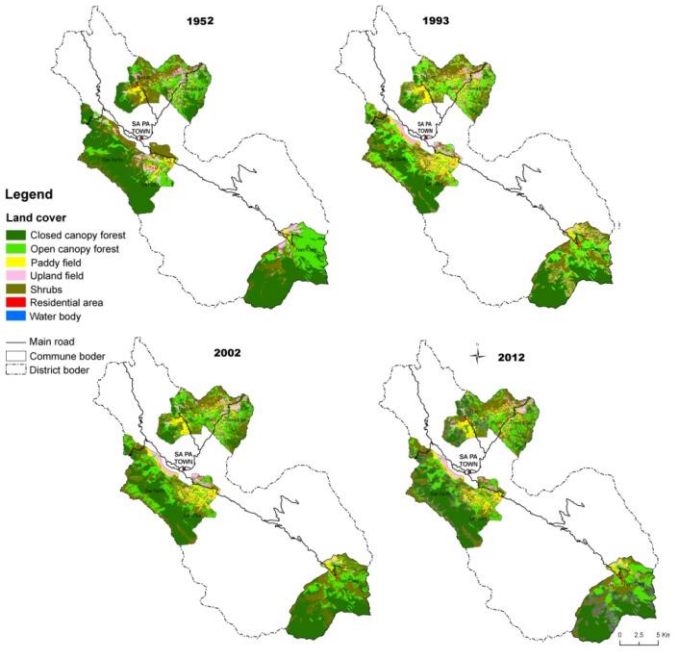


Figure 15. Land cover maps of 5 selected communes in 1952, 1993, 2002 and 2012 (from aerial photographs and VHR-SPOT image)

Table 11. Land cover and land cover changes in the period 1952 –2012

Land cover	Area (ha)				Change 1952-2002		Change 2002-2012		Change 1952-2012	
	1952	1993	2002	2012	Differences	%	Differences	%	Differences	%
Forest	14602	12712	12583	13232	-2019	-14	649	5	-1370	-9
Arable land	2127	2657	2656	2367	529	25	-289	-11	240	11
Shrub	5264	6535	6719	6332	1455	28	-387	-6	1068	20
Residential area	149	181	184	211	35	23	27	15	62	42

3.2. Time intensity analysis of land cover change

Figure 16 gives a graphical approach to present the results at interval level. The central vertical axis shows time interval. Each horizontal bar that extends to the left of the vertical axis shows the size of the total change for an interval in terms of percentage of the landscape. However, when we examine only the total change, we fail to account for the fact that different intervals have different durations, which is why we need to consider also the intensity of the rate of annual change [17]. Each bar that extends to the right of the vertical axis shows the rate of annual change. The vertical dashed line in the right side is uniform line. If an intensity bar ends to the left of the uniform line, then the change is relatively slow for that time interval. If an intensity bar extends to the right of the uniform line, then the change is relatively fast to that time interval.

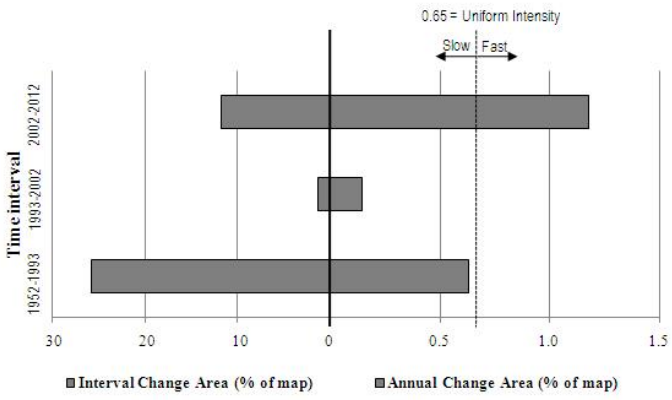


Figure 16. Time intensity analysis for three time intervals: 1952-1993, 1993-2002 and 2002-2012. Bars that extend to the left of zero show gross area of overall changes in each interval, while bars that extend to the right of zero show intensity of annual area of change within each time interval.

The left side of Figure 16 shows that the size of change during the first time interval (1952-1993) is the biggest (26% of map) while the size during the second interval (1993-2002) is the smallest (1% of map). However, the right side of Figure 16 shows that the annual rate of change was actually fastest in the third time interval (2002-2012) (1.2% of map) and slowest in the second interval (1993-2002) (0.1% of map). This can be explained by the fact that the duration of the third time interval is shorter than the duration of the first time interval. The rate of change is not perfectly stationary at this interval level of analysis because the bars on the right do not all equal the uniform line.

At the interval level, the results show that omission of change error accounted for 3% and 48% of the observed change during the first and second interval, respectively. While commission of change error accounted for 15% of the observed change during the third interval.

This means that observed changes during the first and second interval are less than the real changes while the observed changes during the third interval are greater than the real changes. In addition, land cover changes observed in the first and third interval were real changes while in the second interval the changes were just error.

3.3. Category intensity analysis of land cover change

At the category level, the left side of Figure 17 shows that shrubs has the largest size in terms of annual gains during the first (1952-1993) and second time interval (1993-2002) while in the third time interval (2002-2012), this class was characterized by the net annual loss. Forest has a large size interms of annual losses during the first and second interval but this trend was reversed in the third interval. In overall arable land gained during the first interval while lost in the third interval. Residential area has annual gains during the all time interval. Forest and shrubs are involved in the largest changes as they account for a large percentage of the landscape at all time points. Therefore it is helpful to examine the right side of Figure 17 to see whether the large size of the annual transition is due to simply the large size of the categories, or to the intensity of activity within the categories. The right side of Figure 17 shows that the bars for gain and loss of shurbs extend to the right of the uniform line in all time intervals, which indicates that shurbs experiences gains and losses more intensively than the landscape in general. While the bars for forest changes extend to the left of the uniform line in all time intervals, which indicates that forest experiences both gain and loss less intensively than the landscape in general. Residential area experiences gain more intensively than forest. However the size of the gain of residential area is smaller than the gain of forest because residential accounts for a smaller percentage of the landscape than forest.

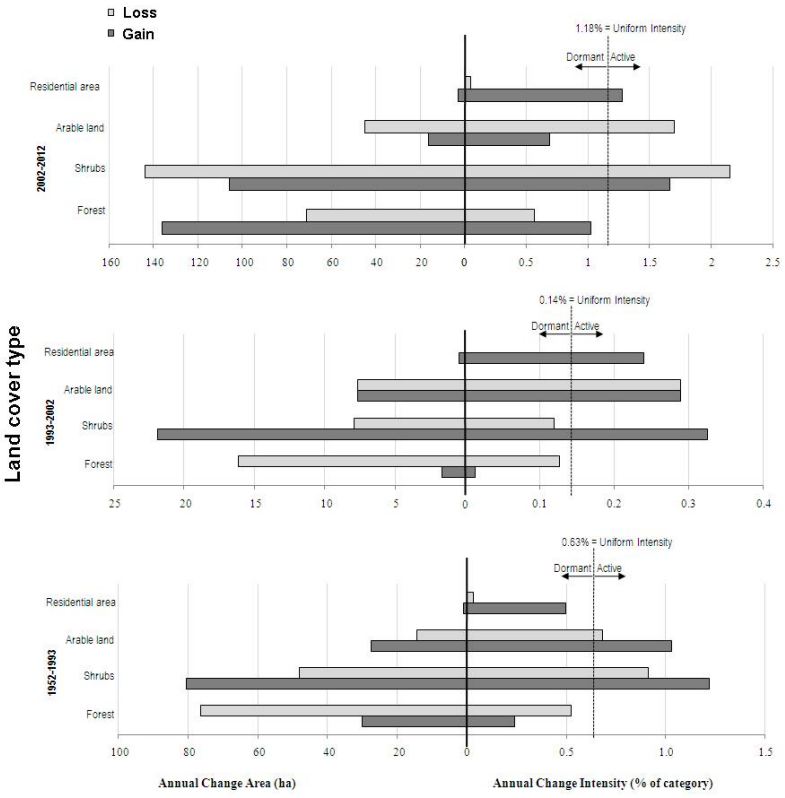


Figure 17. Category intensity analysis for three time intervals: 1952-1993, 1993-2002 and 2002-2012. Bars that extend to the left of zero show gross annual area of gains and losses for selected communes, while bars that extend to the right of zero show intensity of annual gains and losses within each category.

At the transition level, we investigate the transition between forest and shrubs. Figure 18 presents the annual rate and the transition intensity for the categories from which forest gains.

The left side of Figure 18 shows that forest gains mostly from shurbs in terms of the size of the annual transition. Moreover, the right side of Figure 18 also supports this statement as forest gains much more intensity from shurbs than other land cover types. Both size and rate of conversion from shrubs to forest were fastest in the third interval. The bar for shurbs is to the right of the uniform line while the bar for arable land is to the left side of the uniform line for all three time intervals, which means that the gain of forest targeted shrubs but avoided arable land during all the time intervals. This implies that the gain of forest from shrubs is perfectly stationary over time.

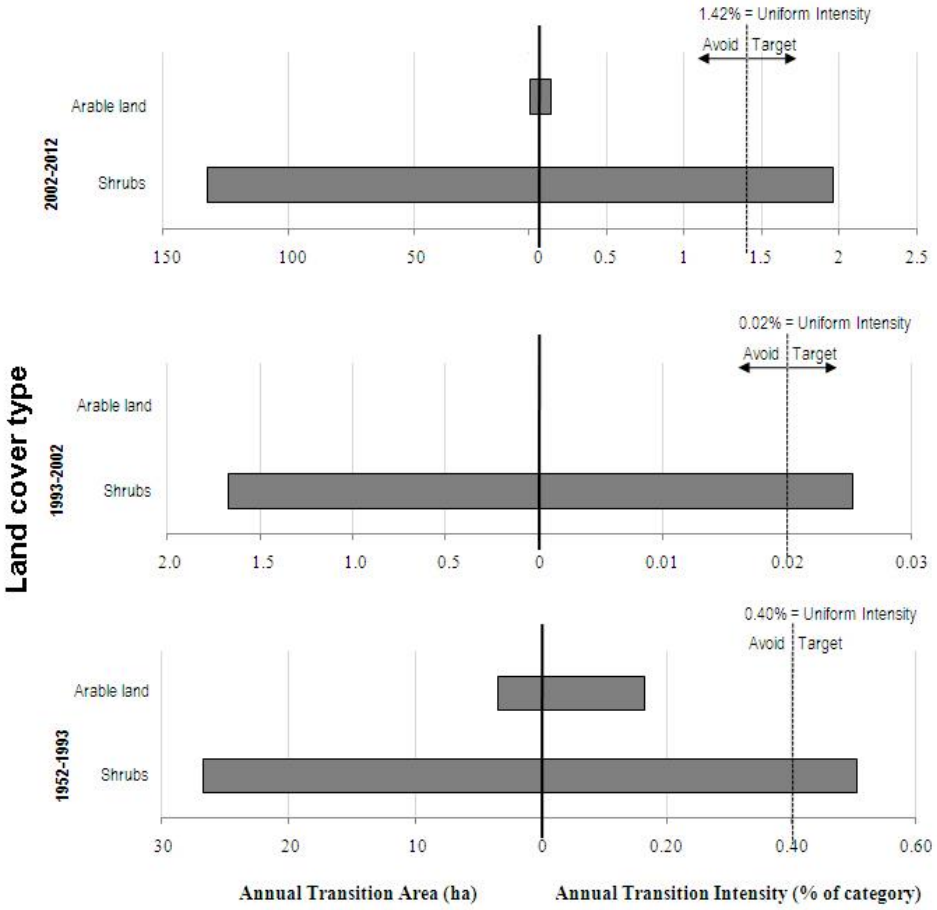


Figure 18. Transition intensity analysis to Forest for three time interval: 1952-1993, 1993-2002 and 2002-2012. Bars that extend to the left of zero show gross annual area of transitions to Forest, while bares that extend to the right of zero show intensity of annual transitions to Forest within each non-forest category.

Figure 19 shows the results for the transitions from shrubs. The left side of Figure 19 shows that when shrubs loses, the largest transition is to forest and arable land and there is small transition to residential area. This may be attributable to the fact that forest and arable land account for large percentages of the landscape and residential area accounts for a small percentage of the landscape. This is why it is helpful to examine the intensities on the right side of Figure 19.

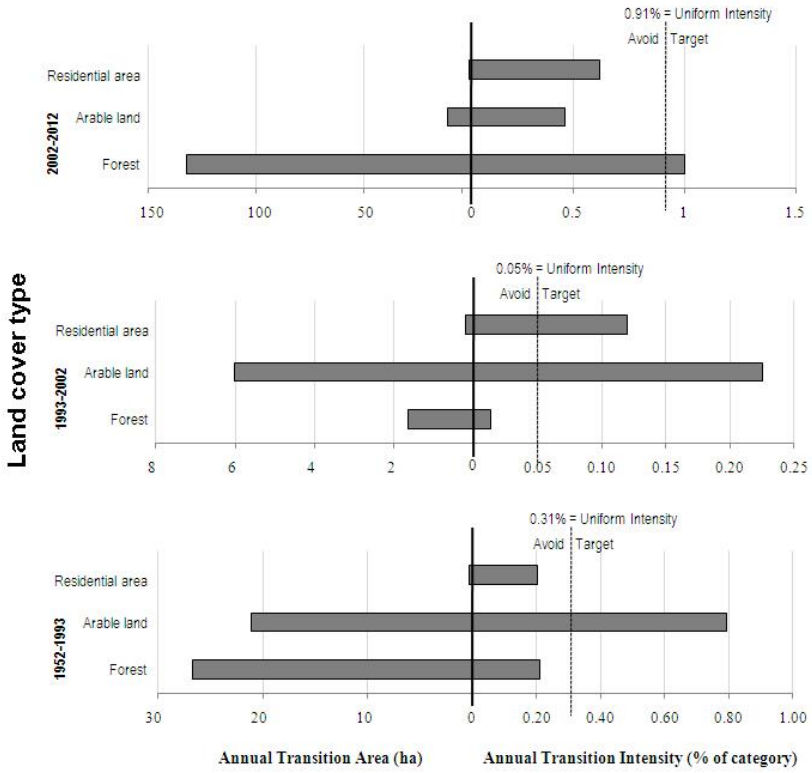


Figure 19. Transition intensity analysis from Shrubs for three time intervals: 1952-1993, 1993-2002 and 2002-2012. Bars that extend to the left of zero show gross annual area of transitions from Shrubs, while bars that extend to the right of zero show intensity of annual transitions from Shrubs within each non-shrub category.

At the first and second interval, the bars for forest extend to the left side of the uniform line while the bars for arable land extend to the right side of the uniform line. This indicates that when shrubs lose, it tends to lose intensively to arable land, more so than to forest. However, at the third time interval, the bar for forest extends to the right side of the uniform line while the bars for arable land and residential area extend to the left side of the uniform line. This indicates that at third interval when shrubs loses, it tends to lose intensively to forest more than arable land and residential area. This implies that the loss of shrubs is not perfectly stationary over time.

Table 12 shows the major land cover conversions in the selected communes for overall period 1952-2012. In this table, the grey cells are the unchanged areas, while the major changes are highlighted in bold. The major changes were the reduction of the forest area and the expansion of arable land. The conversion from shrub to forest and from arable land to shrubs is also remarkable. Over the last 60 years, 80% of the forest remained intact, while 18% has been transformed to shrubs and 2% to arable land. Similarly, only 59% of shrubs in 1952 remained: 25% was converted to forest and 15% to arable land (Figure 20).

Table 12. Absolute land cover changes between 1952 and 2012 for selected communes (ha)

2012 / 1952	Forest	Shrub	Arable land	Residential area
Forest	11719	**2563**	295	25
Shrub	**1347**	3100	**793**	24
Arable land	166	**665**	1278	18
Residential area	0	0	0	144

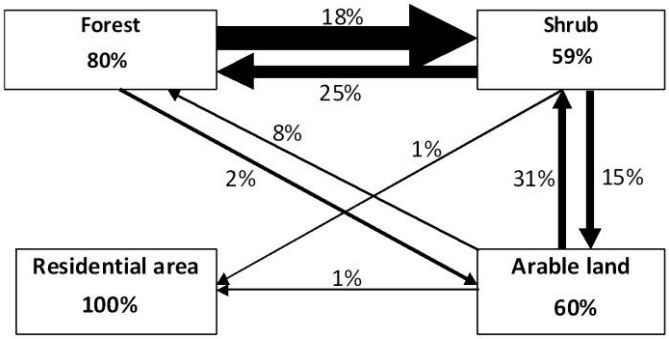


Figure 20. Synthesis of the major land cover changes between 1952 and 2012 (The width of arrows represents the area of each conversion)

4. Discussion

4.1. Land cover change over last 60 years (1952-2012)

Figure 21 presents the trends of land cover change over the past 60 years for 5 selected communes. The trends are based on the best available land cover data, i.e. the very high resolution aerial photographs and VHR SPOT images. For overall period (1952-2012), the major trends are the expansion of arable land and shrubs; and reduction of forest. The overall area covered by forest decreased by 9% while area covered by shrubs and arable land increased by 11% and 20%, respectively during last 60 years. However, these trajectories mask substantial inter-interval differences. The tendency of forest cover change seems to have reversed since 2002, some years after the implementation of forest policies and the introduction of tourism in Sa Pa district. The area covered by forest increased slightly after 2002 by 5% while shrubs and arable land decreased by 6% and 11%, respectively during the period 2002-2012 (Table 11). A forest transition could be observed in the study area as a shift from a net deforestation to a net reforestation occurring at the beginning of the 2000s.

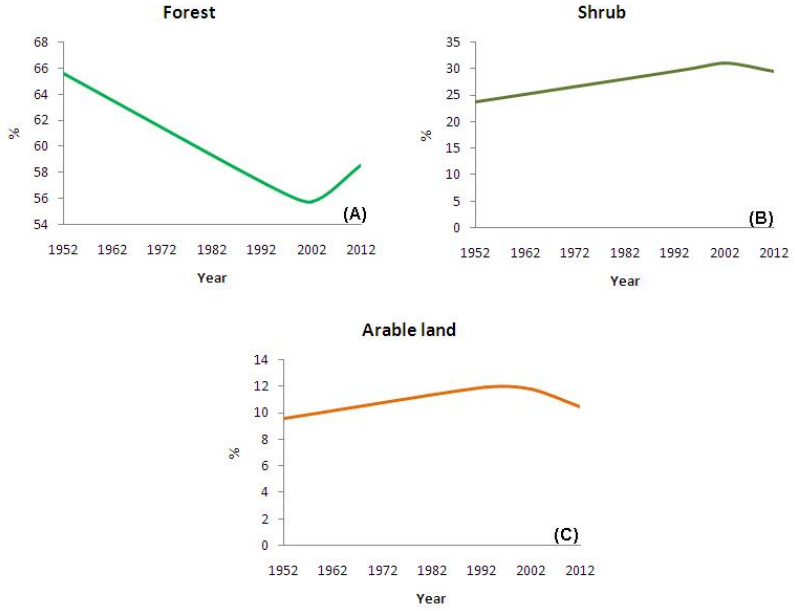


Figure 21. The trends of main land cover categories over the past 60 years in the case study: (A) Forest, (B) shrubs and (C) arable land

Table 13 presents the conversion rate calculated for the different time periods. The conversion from forest to shrubs peaked during 1952-1993 with the rate of 70ha/year while the conversion from shrub to forest peaked recently during 2002-2012 with the rate of 132ha/year. This reveals a trend of deforestation before 2000s and a recent phase of

reforestation. The conversion from shrub to arable land peaked during first period (1952-1993) while the conversion from arable land to shrub reached highest rate during 2002-2012. This result shows a trend of land expansion during the first period and recent trend of land abandonment. The first period (1952-1993) was remarkable with the highest rate of conversion from forest to shrub and shrub to arable land while the third period (2002-2012) was characterized with the highest rate of conversion from shrub to forest and from arable land to shrub. The mid-period (1993-2002) is characterized by lower land cover change rates.

Table 13. Overall land cover change rate at different periods (ha/yr)

Major land cover changes	1952-1993	1993-2002	2002-2012
Forest to shrub	70	14	65
Forest to arable land	6	2	5
Shrub to forest	27	2	132
Shrub to arable land	21	6	11
Arable land to forest	4	0	4
Arable land to shrub	11	8	41

4.2. Comparison with national-scale land cover dynamics

In Figure 22, the land cover dynamics in SaPa district are compared with those of other northern provinces and with national-scale land cover dynamics. The overall trends of forest cover change are similar at regional and national scale. All figures show a decrease of forest cover between 1952 and 1990s and a recent phase of forest cover increase. However, in Sa Pa district (Lao Cai province), the forest increase started in the early 2000s (Figure 22A), some years later than what has been observed at national scale and in other regions. This might be due to the fact that the impact of land use policies and socio-economic transformation is spatially variable [18].

The changes in arable land are different between the three regions (Figure 22A, B,C). In Lao Cai and Bac Kan province (northeast Vietnam), shrubs and arable land increased between 1950s and 1990s and decreased in recent years. While in Suoi Muoi catchment (Son La province, northwest Vietnam), arable land increased continuously from the 1950s to recent years. The recent decrease of arable land and shrubs in the northeastern provinces is probably associated with a reduction in shifting cultivation [6]. Most swidden rice fields with low yields have been left fallow to regenerate into shrubs and/or forest, and only a limited number of them were converted to permanent terraced fields [5]. In contrast, in Suoi Muoi catchment, shifting cultivation is still practiced by some ethnic minorities such as Thai, Khang, Hmong and Khomu farmers for the cultivation of cassava and maize [19]. In this region, the conversion of shrubs to arable land (and vice versa) occurred, something which is typical for shifting cultivation practices. In a shifting cultivation system, farmers create temporary upland fields by cutting and burning off the vegetative cover. After a few years of intensive cultivation, the soil is depleted and the upland fields are taken out of production in order to allow a natural recover of shrubs and forests[16].

In comparison with the study of Vu [16] for Son La province and Castella et al [6] for Bac Kan province, the land cover dynamics in SaPa district are small (Figure 22A, B, C). In SaPa district, the forest cover between 1952 and 2012 changed of only -9% in favor of shrubs and arable land that changed of +20% and +11% (percentage of category). These rates were much higher in Bac Kan province, where forest cover changed of -31% while shrubs and arable land changed of +220% and +57% resp.between 1952 and 2001. Similarly, in Suoi Muoi

catchment, where the forest and arable land changed of +6% and +57% resp. while shrubs changed of -29% between 1952 and 2008 (Figure 22B). Furthermore, the percentage of forest that remained intact between 1952 and 2012 in SaPa district is about 80-85%, in contrast to only 35% in Suoi Muoi catchment [16].

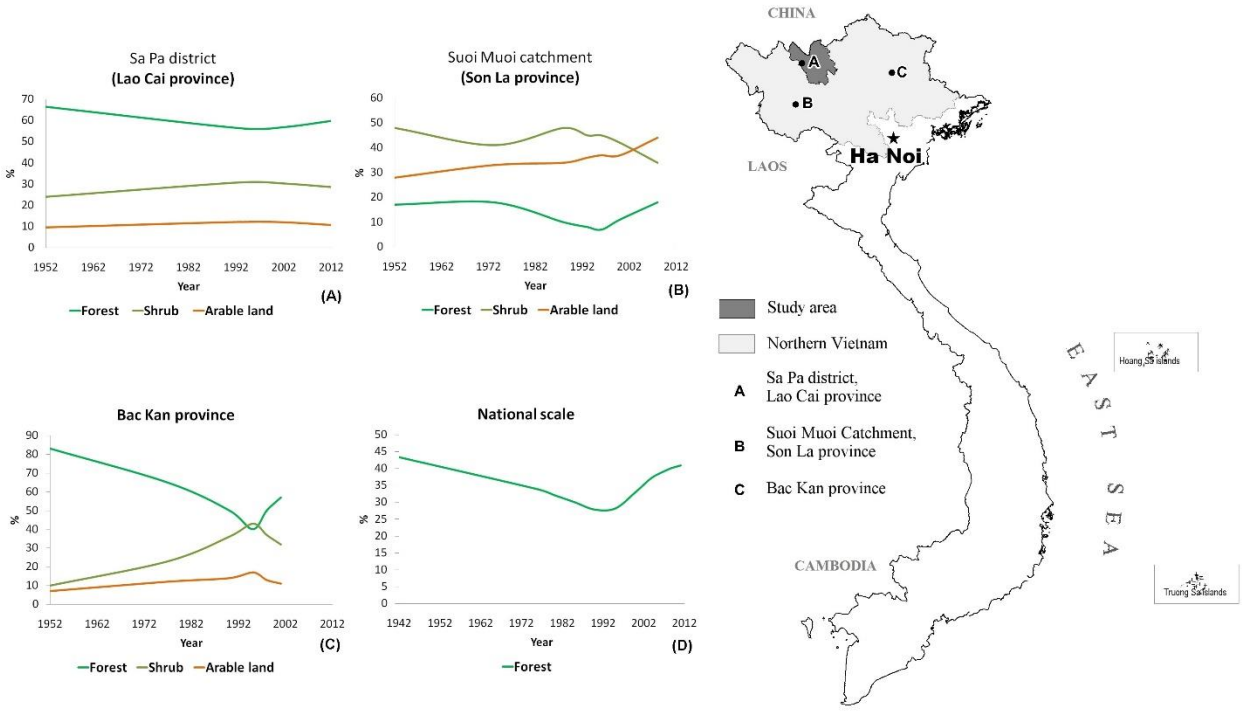


Figure 22. Comparison land cover change trajectories among national scale and different regions in Northern Vietnam: (A) Sa Pa district, Lao Cai province; (B) Suoi Muoi catchment, Son La province [16]; (C) Bac Kan province [6, 20], and (D) Trajectory of forest cover change at national scale [21, 22].

5. Conclusion

When considering the entire time period 1952 to 2012, the land cover data at very high resolution show that a net loss of forest area occurred in the five selected communes in SaPa district. Between 1952 and 2012, the overall forest cover decreased by 9% in favor of shrubs and arable land that increased by 20% and 11%. When considering only the last 15 years (2000-2014), the land cover data show an increase of forest cover by about 3% at village level. The forest cover dynamics in the five selected communes was much lower with rates of 65ha/year. The trends of land cover change that are observed in the study area are roughly similar to what is reported at the national scale and for other regions in Northern Vietnam. However, the land cover conversions are smaller in SaPa district, compared to the other regions in Northern Vietnam. At national-scale, it is documented that deforestation happened between 1952 and 1990, and that this was followed by a recent phase of forest increase. In the study area, forest cover increased was observed only from the early 2000s, some years later than that was reported for the national level and other regions in Northern Vietnam. The trends of arable land and shrubs in the study area were characterized by an increase of shrubs and arable land during the period 1952 to 2002, and a reversal of these trends since the 2000s. These trajectories are similar to what has been reported for Bac Kan province, where a reduction in shifting cultivation was reported. However, they are different to Suoi Muoi catchment, a place in the northwest region where shifting cultivation is still practiced.

References

1. Lang, C., Deforestation in Vietnam, Laos and Cambodia, in Deforestation, Environment, and Sustainable Development: A comparative analysis, V. DK, Editor. 2001: Praeger, Westport, CT, USA. p. 111-137.
2. Meyfroidt, P. and E.F. Lambin, The causes of the reforestation in Vietnam. Land Use Policy 2008. **25**(2): p. 182-197.
3. Clement, F. and J.M. Amezaga, Linking reforestation policies with land use change in northern Vietnam: Why local factors matter. Geoforum, 2008. **39**: p. 265-277.
4. Clement, F., et al., Drivers of afforestation in Northern Vietnam: Assessing local variations using geographically weighted regression. Applied Geography, 2009. **29**(4): p. 561-576.
5. Sowerwine, J., Territorialisation and the Politics of Highland landscapes in Vietnam: Negotiating property relations in policy, meaning and practice. Conservation and Society, 2004. **2**(1): p. 98-117.
6. Castella, J.C., et al., Analysis of village accessibility and its impact on land use dynamics in a mountainous province of northern Vietnam. Applied Geography 2005. **25**: p. 308-326.
7. Vanacker, V., Geomorphic Response to Human Induced Environmental Change in Tropical Mountain Areas. The Austro Ecuatoriano as a Case-study. 2002, Katholieke University Leuven.
8. MONRE, Aerial photos. 1952: Department of Survey and Mapping, Ministry of Natural Resources and Environment (MONRE).
9. MONRE, Aerial photos. 1993: Department of Survey and Mapping, Ministry of Natural Resources and Environment (MONRE).
10. MONRE, Aerial photos. 2002: Department of Survey and Mapping, Ministry of Natural Resources and Environment (MONRE).
11. Racurs, Photomod 4.4 Overview. User manual. 2009, Moscow.
12. MONRE, VHR-SPOT image 2006. 2006: Remote Sensing Center, Ministry of Natural Resources and Environment, Vietnam (MONRE).
13. MONRE, VHR-SPOT image 2012. 2012: Remote Sensing Center, Ministry of Natural Resources and Environment, Vietnam (MONRE).
14. Ruelland, D., et al., Comparison of methods for LUCC monitoring over 50 years from aerial photographs and satellite images in a Sahelian catchment. International Journal of Remote Sensing, 2011. **32**(6): p. 1747-1777.
15. Devereux, B.J., G.S. Amable, and C.C. Posada, An efficient image segmentation algorithm for landscape analysis. International Journal of Applied Earth Observation and Geoinformation, 2004. **6**: p. 47-61.
16. Vu, K.C., Land use change in the Suoi Muoi catchment. 2007, KULeuven: Leuven, Belgium.
17. Aldwaik, S.Z. and R.G. Pontius, Intensity analysis to unify measurements of size and stationarity of land changes by interval, category, and transition. Landscape and Urban Planning, 2012. **106**: p. 103-114.
18. Castella, J.C., N.R. Tronche, and V. Nguyen, Landscape changes in Cho Don District during the doi moi era (1990-2000) and their implications for sustainable natural resource management in Vietnam's mountainous provinces in Doi Moi in the mountains, J.C. Castella and D.Q. Dang, Editors. 2002, The Agricultural Publishing House: Hanoi, Vietnam. p. 149-173.
19. Vu, K.C., et al., Land Transitions in Northwest Vietnam: An Integrated Analysis of Biophysical and Socio-Cultural Factors. Human Ecology, 2013. **41**(1): p. 37– 50.
20. Fatoux, C., et al., From rice cultivator to agroforester within a decade: the impact of Doi Moi on agricultural diversification in a mountainous commune of Cho Moi District, Bac Kan Province, Vietnam, in Doi Moi in the Mountains. Land use changes

and farmers's livelihood stratergies in Bac Kan province Vietnam, J.C. Castella and D.D. Quang, Editors. 2002, The Agricultural Publishing House: Hanoi. p. 73–98.
21. De Jong, W., D.D. Sam, and T.V. Hung, Forest rehabilitation in Vietnam: histories, realities and future. 2006, Bogor Barat 16680, Indonesia: Center for International Forestry Research (CIFOR).
22. GSO, Vietnam statistical year book 2011. 2012, Statistical publishing house: Hanoi, Vietnam.

A Bayesian Belief Network For Sustainable Land-Use Management In Basalt Landscapes

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Abstract. The suitability of land use/cover policies in basalt landscapes has not been clearly understood in Vietnam. It has slowed down economic growth and generated various negative impacts on the environment (e.g. water and air pollution) in mountainous districts. Therefore, this study aims to develop scenarios assessing the sensitivity of biophysical characteristics in three basalt landscapes based on changes of land use policy towards sustainable development. Regarding scientific significance, authors simplified the inter-correlation between 16 biophysical characteristics and five land uses/covers of three basalt landscapes in one network based on the use of Bayesian approaches. Relations between input variables were validated based on correlation matrices and structural equation models. Results and scenarios pointed out different land-use management trends suitable for three basalt landscapes. Based on scenarios towards sustainable development, land-use managers should encourage (i) enlargement and maintenance of protected forests in Miocene basalt landscapes; (ii) agricultural development in Pliocene – Pleistocene basalt landscapes; and (iii) soil improvements in Pleistocene basalt landscapes. Additionally, the developed Bayesian Belief Network to assess the biophysical condition in basalt landscapes can be potentially used to assess new land-use policies; and to choose land use priority: economic development or conservation in future.

Key words: ecological modelling, urbanization, nature incentive, economic development, weathering process, scenario

1. Introduction

Basalt landscapes covering 23,000 km2 of area in Vietnam have provided various advantages for natural conservation and socio-economic development [1]. Due to the poor understanding about biophysical condition in different basalt landscapes, land-use policies in Vietnam cannot encourage local people developing suitable socio-economic fields [1]. It does not only slow down local economic growth, but has also led to negative impacts on environment in mountainous areas. For example, fertile soils in old basalt landscapes have been removed due to bauxite exploitation [2]. Primary forest areas have been converted to agricultural lands, leading to the increase of natural hazards. Therefore, it is necessary to clearly understand biophysical conditions in basalt landscapes to propose suitable land-use management trends and provide feedbacks for local land-use policy changes in time.

Remote sensing (RS) has become a potential tool to monitor physical processes and assess human activities affecting the earth from local to global scales. Remote sensing and GIS have been used widely in the fields of agriculture [3], environments [4], and ecological assessment [5]. Multi-temporal remote sensing analysis quickly identify conflicts between land-use distribution and local policies; then provide feedbacks to improve these policies. Additionally, these remote sensing indices have been used separately as indicators for a particular object in nature. For example, build-up index is used to indicate the expansion of urban, whereas chlorophyll content in the leaf calculated from Sentinel-2 data can be used to assess the plant health. In the last century, the application of remote sensing sensors and

indices for land-use policy assessments has become more diverse. It makes a high potential to use these indices to simplify social-ecological system in a particular landscape.

The use of BBN was chosen in this study to analyze complicated relations between geological, lithological and climatic characteristics and additional anthropogenic inputs between three basaltic landscapes. Land use/cover map, landscape map and 16 RS indices were harnessed to provide the main input data to develop a Bayesian Belief Network (BBN). Accordingly, the information related to biophysical parameters and weathering materials from basalt parent rocks were calculated from spectral bands in Landsat and Sentinel-2 data. The required basalt landscape and land use data to develop the BBN were collected and processed in Geographical Information System (GIS). Statistical methods and Structural Equation Models (SEM) were used to analyze the sensitivity and quantitative relations between parameters.

The overall aim of this research was to develop scenarios revealing the sensitivity of the weathering processes and biophysical parameters based on changes of land use policy in basalt landscapes towards conservation and urbanization ways. In detail, this study addresses the interactions between biophysical parameters and weathering materials embedded in three different basalt landscapes, allowing to check suitability of land-use policies.

2. Material and methods

2.1. Basalt landscapes in Vietnam

Basalt landscape covers homogeneously a total area of about 20,000 km2 in southern and central Vietnam with 100 km in diameter and several hundred meters thick [6]. Other basalt landscape in Vietnam distribute heterogeneously in mountainous areas of the northwest provinces (e.g. Dien Bien province) and some islands in the Central region. All above basalt landscapes that were formed during Neogene - Quaternary period can be divided into three groups based on their geological age including: i) Miocene (about 6.3 – 17.3 million years ago – so-called as Dai Nga formation) (ii) Pliocene – Pleistocene (about 0.12 – 5.0 million years ago – so-called as Tuc Trung and Xuan Loc formations); and iii) Pleistocene (after 0.12 million years ago – so-called as Phuoc Tan formation) basalt landscape.

The Miocene basalt landscape cover an area of about 3,250 km2. Petrographic composition of parent rocks changes from tholeiitic and plagioclase basalt to alkaline olivine basalt. The thickness of weathering crusts fluctuates from 10 to 25 m, containing a high amount of iron and aluminum. The Miocene basalt bedrock was strongly weathered in tropical countries, creating a thick laterite layer containing a large amount of bauxite ore mixed in soils. The terrain in the central part of the Miocene basalt landscape is a wide flat and stable surface. Whereas, bedrocks are revealed in the surrounding areas where have been strongly eroded by 4th and 5th level rivers. Nowadays, most area of the Miocene basalt landscapes has been used to enlarge primary forest area [1]. Some low and relatively flat terrain areas of this landscape have been heavily impacted by bauxite exploitation to extract aluminum such as in Nhan Co community, Dak Nong province and Tan Rai community, Lam Dong province [2].

The Pliocene - Pleistocene basalt landscape covers an area of about 15,800 km2. Erupted materials overflowed on the surface and created stable arches at different height levels from 800m upwards [7]. This basalt landscape formed during 3-5 successive eruptions. The bedrocks consist of 10-20% of olivine filled by carbonate materials and 50-90% plagioclase and pyroxene. The upper part of lithological layers was thoroughly weathered, generating a red soil layer. The thickness of weathering crust is about 15.0 m, whereas the thickness of basalt bedrocks varies from 18.3 to 312.4 m. Therefore, the Pliocene - Pleistocene basalt landscape has been used for agricultural development in Vietnam, such as planting coffee trees, rubber trees and flowers [8].

The Pleistocene basalt landscapes cover an area of about 480 km2. Erupted material overflowed in a large area, filled eroded grooves and generated fairly flat surfaces [7]. The composition of bedrocks consists of alkaline olivine, andesite and olivine crystal. The thickness of bedrocks changes from a few dozens to hundreds meters. Erosion process in these basalt landscapes is weak in 1st and 2nd level rivers. The weathering crust on the Pleistocene basalt landscapes is from 3 to 5m depth, with a thin laterite layer, compared to two older basalt landscapes [9]. Due to the unfertile soils in the Pleistocene basalt landscapes, land covers mainly is bare soils and pastures.

In this study, landscapes in Dong Nai province, Vietnam are selected to assess and compare the trend of land use management between three basalt landscape types. The distribution of three types of the basalt landscapes in the research area is shown. Regarding water resources, former hydrological studies proved that the flow seeping from bedrocks can reaches 26.2 liters per second. The main water source for aquifers is rainwater with good quality for living and agricultural development. The Tri An hydroelectric reservoir was built among these basalt landscapes as a testament to the abundant water resources [7].

2.2. Remote sensing indices for biophysical assessments in basalt landscapes

The Landsat and Sentinel-2 images have been widely used in natural resource management, particularly in inventory of natural resources, as well as monitoring their reduction [10]. Whereas, the MODIS data have been used to monitor climate characteristics such as solar radiation, precipitation and temperature [11]. Impacts of human activities and climate on land-use changes that can be observed by remote sensing analysis are important information for policy development. This section explains in detail 16 remote sensing indices used in this study to quantify weathered basaltic materials, biophysical parameters and land uses/covers based on above three satellite data.

Table 1. *Remote sensing indices were used to quantify biophysical parameters. The number of variables is used for all analysis in this study.*

No.	Remote sensing index	Abbreviation	Function	Satellite
1	Ferric iron, Fe2+	Fe2+	$\frac{SWIR_2}{Near_Infrared} + \frac{Green}{Red}$	Landsat 8
2	Ferric iron, Fe3+	Fe3+	$Red/Green$	
3	Ferric Oxides	Fe2O3	$SWIR_1/Near_Infrared$	
4	Laterite	Laterite	$SWIR_1/SWIR_2$	
5	Carbonate	Carbonate	$TIRS_1/TIRS_2$	
6	Silicates	Silicate	$SWIR_2/SWIR_1$	
7	Topsoil Grain Size Index	GSI	(Red - Blue) * (Red + Blue + Green)	
8	Biological crust index	CI	$1 - \frac{Red - Blue}{Red + Blue}$	
9	Normalized Difference Water Index	NDWI	$\frac{NIR - SWIR_1}{NIR + SWIR_1}$	
10	Normalized Difference Vegetation Index	NDVI	$\frac{NIR - RED}{NIR + RED}$	
11	Built-up index	BU	$\frac{SWIR_1 - NIR}{SWIR_1 + NIR} - \frac{NIR - RED}{NIR + RED}$	
12	Temperature	Temp		MODIS

13	Precipitation	Prep	Downloaded from WorldClim[1] website - Free global climate data (period of 1960–1990)	
14	Fraction of photo-synthetically active radiation	FAPAR	Calculated based on SENTINEL-2 Toolbox level-2 biophysical variables algorithm by ESA [2]	Sentinel-2
15	Leaf area index	LAI		
16	Cover fraction	FVC		

2.3. BBN development for urbanization assessments on basalt formations

The development of Bayesian Belief Networks (BBN) based on Bayes's theorem [12] represents posterior probabilities of parent nodes in evidences of related child nodes. A BBN network generally includes nodes (or boxes) and links (or arrows) [13]. According to the Bayes' rule, three main components integrated in the network include the prior probability and conditional probability tables (CPTs) of parent and child nodes. The training and testing data to develop a BBN can be obtained from field measurements, expert judgments or any former qualitative and quantitative data. Different advantages and disadvantages of the BBN application were explained in studies of Cain (2001) and Dang et al. (2018).

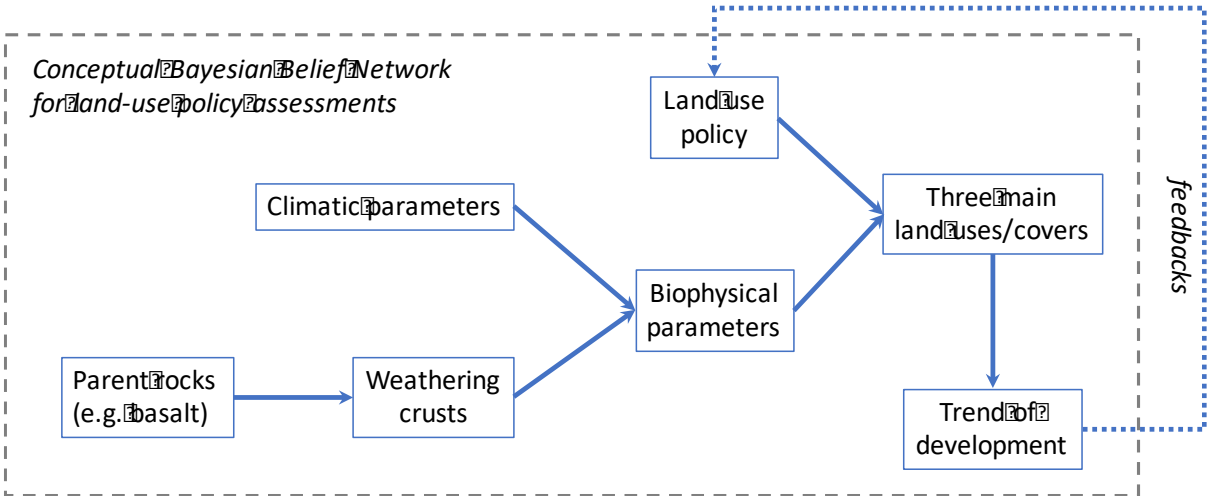

Figure 3. Conceptual framework of Bayesian Belief Network for urban land-use policy assessments.

The development of Bayesian Belief Networks requires a repetitive process to improve and update new data from former networks in order to complete an effective network. Adapted from Dang et al. (2018) and Kragt (2009), a BBN to assess the biophysical condition in basaltic landscapes was developed in the following six steps:

Step 1 "Identification of model objectives": The main objective and scope of the BBN is to support managers, decision makers and specialists in land-use management in three basaltic landscapes. In **step 2 "Conceptual model development",** as an important selection criterion, all input indicators used to represent the key contents have to be measurable, observable and predictable for the initial conceptual network. **Step 3 "Model input data selection"** started with the selection of input data for the conceptual model. First, all 16 remote sensing indices listed in Section 2.2 were calculated by the use of remote sensing analysis.

[1] http://www.worldclim.org
[2] https://earth.esa.int/web/guest/home

The biophysical condition obtained from the remote sensing indices was added to the attribute table of the collected samples before coming to data analysis in the next step.

Step 4 "Parameterizing the model": The remote sensing indices in the step 3 were used as key input data to calculate the probabilities between variables in the BBN. The third and fourth steps have to be repeated until receiving (i) positive feedback from experts and local managers; (ii) highly statistical meanings in all connections of the final SEM model; and (iii) a high performance from the final BBN network (based on the calculation of mutual information and entropy reduction values integrated in the Netica software). They are the main task **of step 5 "Model evaluation and testing".** When the BBN was finalized, this network was used to calculate the posterior probabilities of the biophysical nodes; identify environmental management trends; and develop different scenarios or hypotheses that are done in the **sixth step** (section 3.4). Due to the training and testing steps in the BBN development are an iterative process, a large network to simplify the complex interactions between nature and social activities in this study was developed during a long-term period.

3. Results

3.1. Statistical analysis of interdependences as basis to parameterize the BBN

Figure 4 showed the distribution of 16 natural parameters in three basaltic landscapes. In general, it is easy to observe the differences of biophysical characteristics between the Miocene basaltic landscape with two others. The values of Fe(II), laterite, CI, NDVI, LAI and Prep indices in the Miocene basaltic landscape were significantly higher than those indices in two others. Whereas, the values of Fe (III), Carbonate, NDBI and Temp indices in the Miocene basaltic landscape were clearly lower than those in two others. The biophysical characteristics in the Pliocene – Pleistocene and Pleistocene basaltic landscapes are more difficult to separate, compared to in the Miocene basaltic landscape, especially in the cases of Fe (II), GSI, FAPAR, FVC and LAI indices. Clear differences between these two landscapes in the Pleistocene period only can found in the Temp and Prep indices.

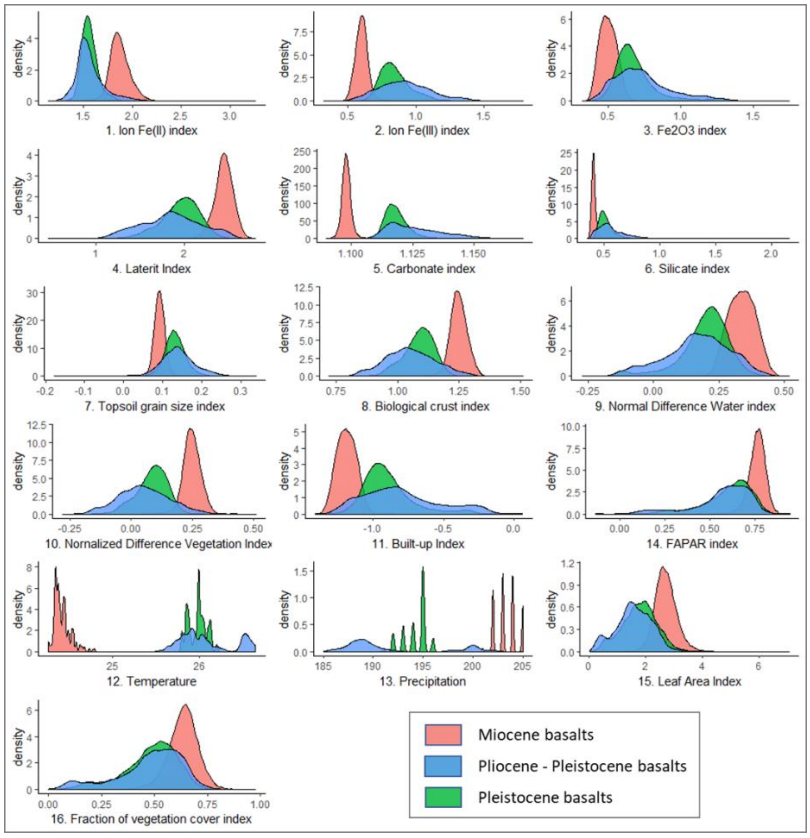

Figure 4. Histograms of 16 natural parameters separated in three basaltic landscapes.

Figure 5 illustrated the correlation between remote sensing indices representing biophysical characteristics in basaltic landscapes. 16 natural parameters can be divided into two groups based on the negative correlations between variables within these two groups. Group 1 include five biophysical variables (GSI, Carbonate, Fe2O3, Fe3+ and Silicate) and the build-up index (BU). Accordingly, positive correlations were found between five biophysical variables and the BU index. Group 2 include six biophysical variables (FVC, FAPAR, LAI, Fe2+, Laterite and CI) and two land-use variables (NDWI and NDVI). The strongly positive correlations were also found between variables in group 2.

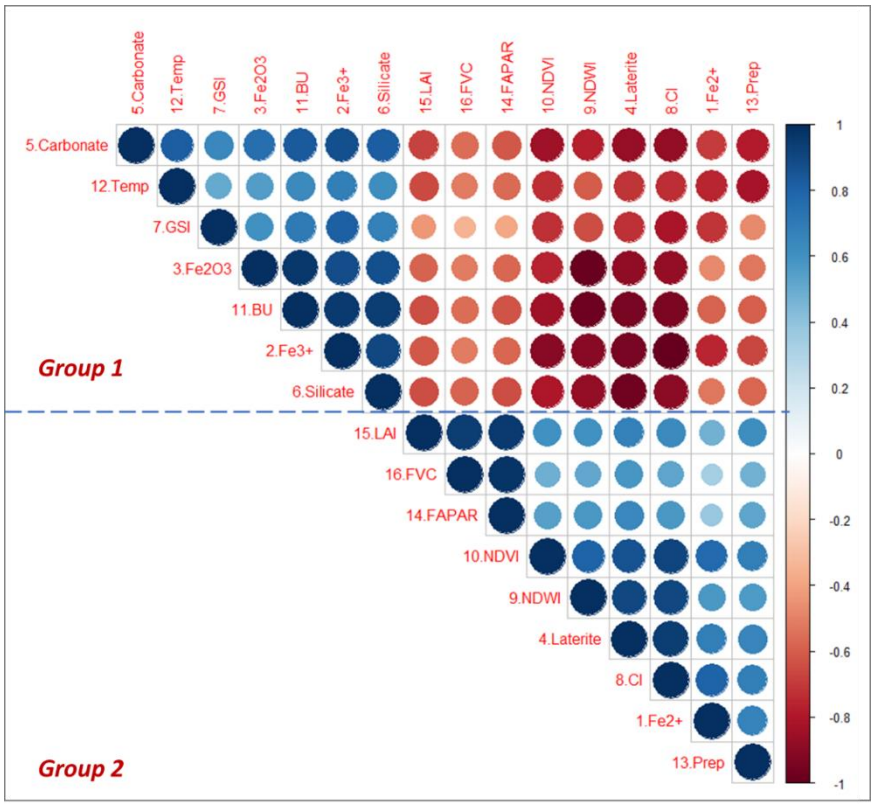

Figure 5. Correlation matrices analyzing relations between remote sensing indices.

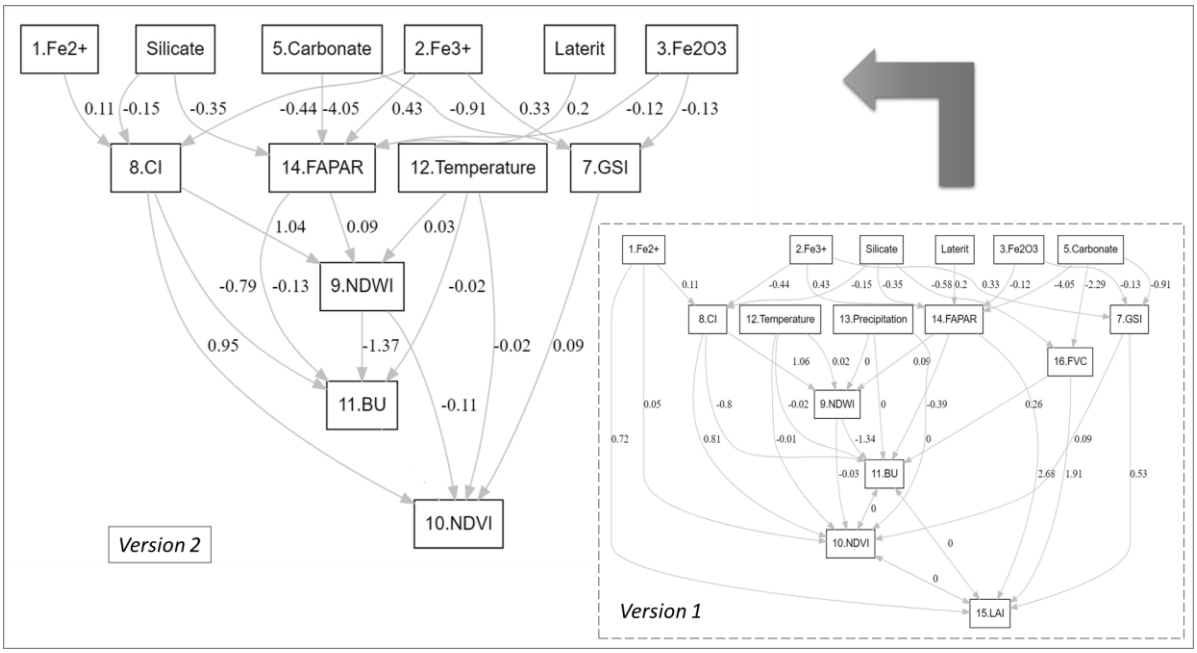

Figure 6. Two versions of structural equation model for biophysical assessments in basalt landscapes.

Figure 6 showed two SEM versions to connect biophysical parameters with land uses/cover variables in basaltic landscapes. According to the first version, the connections were analyzed between 16 biophysical variables. Three variables including "Precipitation" (No.13), "FVC" (No.16) and "LAI" (No.15) were eliminated due to their poor correlations with other variables. In the second version, the correlations between 13 variables were re-calculated. Three layers were reclassified including layer 1 with lithological variables (e.g. Fe2+, Fe3+, Fe2O3, Laterite, Silicate and Carbonate), layer 2 with biophysical variables (e.g. CI, FAPAR and GSI) and layer 3 with land-use variables (e.g. NDVI, NDWI and BU). The second SEM version was used as the intermediate network translating the conceptual network to an applicable BBN that will be presented in next section.

3.2. BBN to assess land-use management trends in basalt landscapes

After integrate Bayes' theorem to the second version of SEM model, the BBN was developed to assess land-use management trends in the basaltic landscapes (Figure 7). Compared to the SEM model, three nodes were added including "basalts" (No.17), "land uses/covers" (No.18) and "land-use management trends" (No.19). Firstly, six lithological variables (from No.01 to No.06) directly depend on weathering process in different basaltic landscapes. Therefore, the node "basalts" (No.17) was added and directly links to six lithological variables. Secondly, five main land uses/covers were added to the No.18 representing the efficiency of land-use policies through three main remote sensing indices that are the NDVI, NDWI and BU indices. The probabilities of five land uses/covers were calculated based on their areal allocation in the research area.

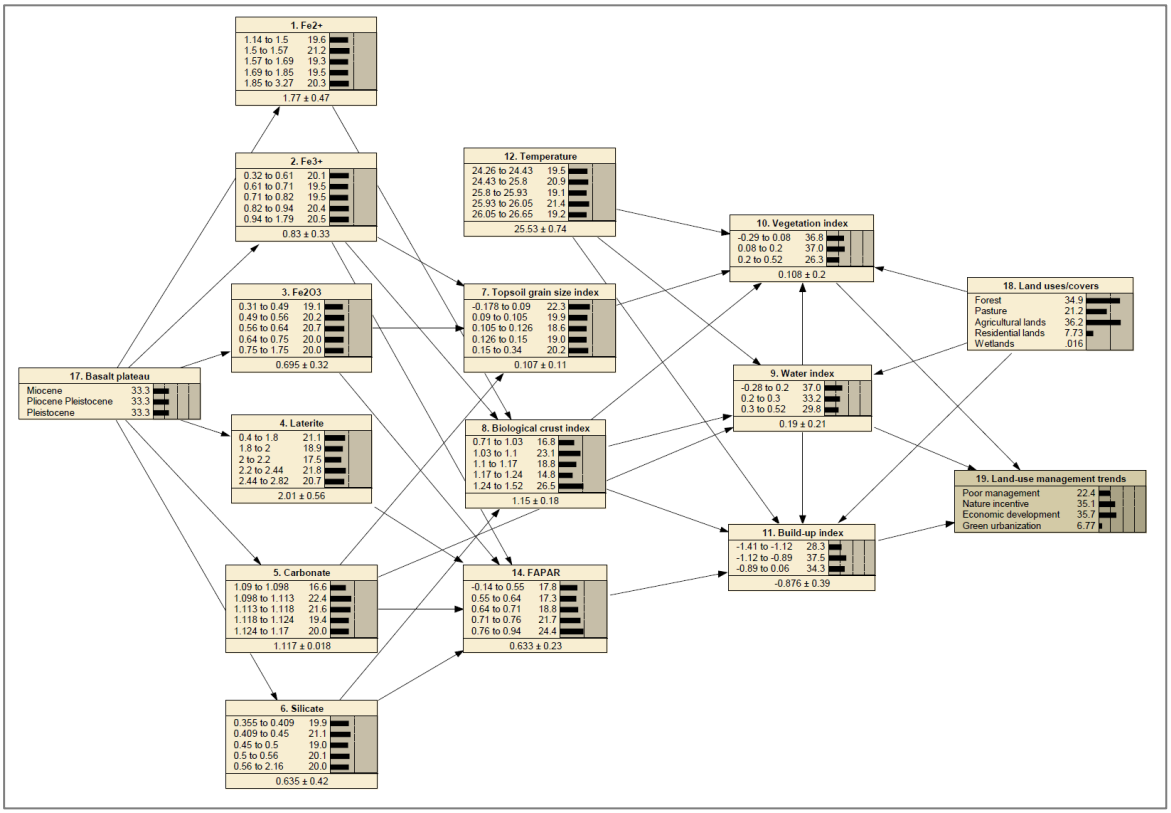

Figure 7. Bayesian Belief Networks for land-use management trend assessments in basalt landscapes.

Lastly, four states of the land-use management trends were added to the node 19. Its conditional probability table is presented in Table 3. The land-use management can be assessed based on changes in three land-use indices including NDWI (No.09), NDVI (No.10) and BU (No.11). According to alternative changes in three land use indices (as parent nodes), the posterior probabilities in four states of the node "land-use management trends" (as a child

node) was estimated accordingly. In general, the areas with higher NDVI and NDWI indices were assessed as "nature incentive" or "green urbanization" ones. In contrast, the areas with low NDVI and NDWI indices were assessed as "poor management" ones. Whereas, the areas with higher BU index and low NDVI and NDWI indices were assessed as "economic development" ones.

4. Conclusions

The study analyzed biophysical characteristics in three basalt landscapes based on satellite imageries in combination with the landscape and land use/cover maps in a highland area of Vietnam. All geological, lithological, climatic, environmental and land use/cover variables were simplified in the developed BBN. All connections between variables in the network were verified through correlation analysis and SEM model before assigning to the developed BBN network. The results represented actual situation in three basalt landscapes in the study case.

Three basalt landscapes should be managed in different land-use policies. Regarding the Miocene basalt landscape, nature incentive should be encouraged to enlarge and maintain the protected forest areas. Regarding the Pliocene – Pleistocene basalt landscape, local managers can take full advantage of their specific biophysical condition for agricultural development. Regarding the Pleistocene basalt landscape, policies related to soil improvements should be implemented to improve the soil fertility in future. The developed BBN can provide prediction about land-use management trends in three basalt landscapes on the present situation. It could furthermore predict the effects of policy changes on the land-use management during a long-term stage.

References

1. A. N. Dang and A. Kawasaki, "Integrating biophysical and socio-economic factors for land-use and land-cover change projection in agricultural economic regions," Ecol. Modell., vol. 344, pp. 29–37, 2017, doi: 10.1016/j.ecolmodel.2016.11.004.
2. L. T. Phuc, L. T. Tuat, T. Q. Hai, and N. T. M. Ngoc, "Caves in Basalts in Krông Nô Area , Đắ k Nông Province , Vietnam," VNU J. Sci., vol. 31, no. 2, pp. 36–46, 2015.
3. J. Xue, D. Gui, J. Lei, H. Sun, F. Zeng, and X. Feng, "A hybrid Bayesian network approach for trade-offs between environmental flows and agricultural water using dynamic discretization," Adv. Water Resour., vol. 110, pp. 445–458, 2017, doi: 10.1016/j.advwatres.2016.10.022.
4. V. Metelka, L. Baratoux, M. W. Jessell, A. Barth, and J. Je, "Remote Sensing of Environment Automated regolith landform mapping using airborne geophysics and remote sensing data , Burkina Faso , West Africa," no. July, 2017, doi: 10.1016/j.rse.2017.08.004.
5. R. Fensholt, I. Sandholt, and M. S. Rasmussen, "Evaluation of MODIS LAI, fAPAR and the relation between fAPAR and NDVI in a semi-arid environment using in situ measurements," Remote Sens. Environ., vol. 91, no. 3–4, pp. 490–507, 2004, doi: 10.1016/j.rse.2004.04.009.
6. N. Hoang and F. Martin, "Petrogenesis of Cenozoic Basalts from Vietnam: Implication for Origins of a `Diffuse Igneous Province'," J. Petrol., vol. 39, no. 3, pp. 369–395, 1998, doi: 10.1093/petrology/39.3.369.
7. N. Dao, N. Yem, N. Tuyet, and L. Tam, "Geomorphological features of the basalt areas in the South Vietnam," J. Geol., vol. 172, no. 1, pp. 17–20, 1986.
8. N. T. Thuy and L. T. Anh, "Assessment of Basalt Soil Quality under Different Land Use Types in Bao Loc - Di Linh Area, Lam Dong Province," VNU J. Sci. Earth Environ. Sci., vol. 33, no. 3, 2017, doi: 10.25073/2588-1094/vnuees.4117.

9. L. Schirrmeister and M. Störr, "The weathering of basaltic rocks in Burundi and Vietnam," Catena, vol. 21, no. 2–3, pp. 243–256, 1994, doi: 10.1016/0341-8162(94)90015-9.
10. E. Mandanici and G. Bitelli, "Preliminary Comparison of Sentinel-2 and Landsat 8 Imagery for a Combined Use," Remote Sens., vol. 8, no. 12, p. 1014, 2016, doi: 10.3390/rs8121014.
11. J. Park, J. Baik, and M. Choi, "Satellite-based crop coefficient and evapotranspiration using surface soil moisture and vegetation indices in Northeast Asia," Catena, vol. 156, no. April, pp. 305–314, 2017, doi: 10.1016/j.catena.2017.04.013.
12. T. Bayes, "An Essay towards Solving a Problem in the Doctrine of Chances," Philos. Trans. R. Soc. London, vol. 53, no. 0, pp. 370–418, 1763, doi: 10.1098/rstl.1763.0053.
13. R. K. McCann, B. G. Marcot, and R. Ellis, "Bayesian belief networks: Applications in ecology and natural resource management," Can. J. For. Res., vol. 36, no. 12, pp. 3053–3062, 2006, doi: 10.1139/x06-238.
14. P. Poppenborg and T. Koellner, "A Bayesian network approach to model farmers' crop choice using socio-psychological measurements of expected benefits of ecosystem services," Environ. Model. Softw., vol. 57, pp. 227–234, 2014, doi: 10.1016/j.envsoft.2014.03.006.
15. J. Cain, "Planning improvements in natural resources management water sector and beyond," vol. 44, no. 0, 2001.
16. K. B. Dang, W. Windhorst, B. Burkhard, and F. Müller, "A Bayesian Belief Network - based approach to link ecosystem functions with rice provisioning ecosystem services," Ecol. Indic., vol. 100, pp. 30–44, Apr. 2019, doi: 10.1016/j.ecolind.2018.04.055.
17. R. Farmani, H. J. Henriksen, and D. Savic, "An evolutionary Bayesian belief network methodology for optimum management of groundwater contamination," Environ. Model. Softw., vol. 24, no. 3, pp. 303–310, 2009, doi: 10.1016/j.envsoft.2008.08.005.
18. M. E. Kragt, "A beginners guide to Bayesian network modelling for integrated catchment," Landsc. Log., no. 9, p. 22, 2009.

Causes and solutions to repair the river bank erosion phenomenon in the Tra Khuc river basin, Quang Ngai province

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Abstract. In order to provide a scientific basis for solutions to limit and overcome damage caused by riverbank erosion in the Tra Khuc river basin, Quang Ngai province, The authors have conducted a survey, collected, analyzed, and synthesized data, combined with GIS application to determine the location and scale of riverbank erosion points, and analyzed the leading causes this phenomenon. Research results show that: the Tra Khuc river basin has a total area of 3240km^2, and the total length of the mainstream is 148 km, in which there are a total of 55 erosion points with a total length of 54,194m, of which the mainstream has 36 points with a length of 36,518m; tributaries and distributaries have 19 points with a total length of 17,676m; The left of the river has a total of 41 points with a total length of 30,964m; The right of the riverside has 14 points with a total length of 23,230m. The leading causes are geological, topographical, soil, and hydrological characteristics, including human causes, making illegal sand and gravel mining increasingly severe.

Keywords: Riverbank erosion, Tra Khuc river basin, Quang Ngai province

1. Introduction

Erosion is a relatively common natural hazard along river basins and coastlines. The destabilization and displacement of slopes and side slopes destabilize structures, destroy farming areas and habitats, and lead to significant disasters for people and society.

Tra Khuc River has a total length of the main river from upstream to the sea of 148 km; about two-thirds of the river's length flows through mountains and dense forests at an altitude of 200 - 1,000m; the rest flows through the plains (Dao, 2019). The basin area is about 3,240 km^2 (accounting for 55.4% of the basin area in the province) (figure 1). Tra Khuc River has an abundant water source, the leading irrigation and domestic water source in Quang Ngai province (Loan, 2012).

However, the impact of climate change, rain, flood, and several other causes such as river flow characteristics, topographic and soil geological characteristics, sand mining problems on rivers, and inadequate construction coastal infrastructure planning... has led to severe riverbank erosion in recent years and increasing frequency. This leads to the loss of agricultural land, property damage, and a severe impact on people's lives. In the past, at the Tra Khuc river basin, many river sections were seriously eroded, causing significant damage to agricultural land and residential areas of the population. Typically, in the last months of

2013, occurred coastal erosion and severe sedimentation of the Phu Tho river estuaries; major floods after storms No. 6, 9, 10, and 13 in 2020 in An Tho and Dong villages (Tinh Son commune, Son Tinh district) the landslide area is the north bank of Tra Khuc river with a total length of about 700m; landslides affected about 70 households living along the river and 10 hectares of agricultural land; The landslide in Ha Tay village (Tinh Ha commune, Son Tinh district) with a total length of about 400 m affected about 60 households living along rivers, country roads and about 1.5 ha of agricultural land; In 2021, the section through Tinh Minh commune suffered a landslide with a total length of more than 3,000m, washed away 7 ha of people's productive land. The section through Minh Long village has an erosion length of about 500m; many sections are up to 30 m deep, creating a vast "cleft palate," washing away farmers' crops. There are about 15 riverside households directly affected, and 30 others are at risk of being threatened.

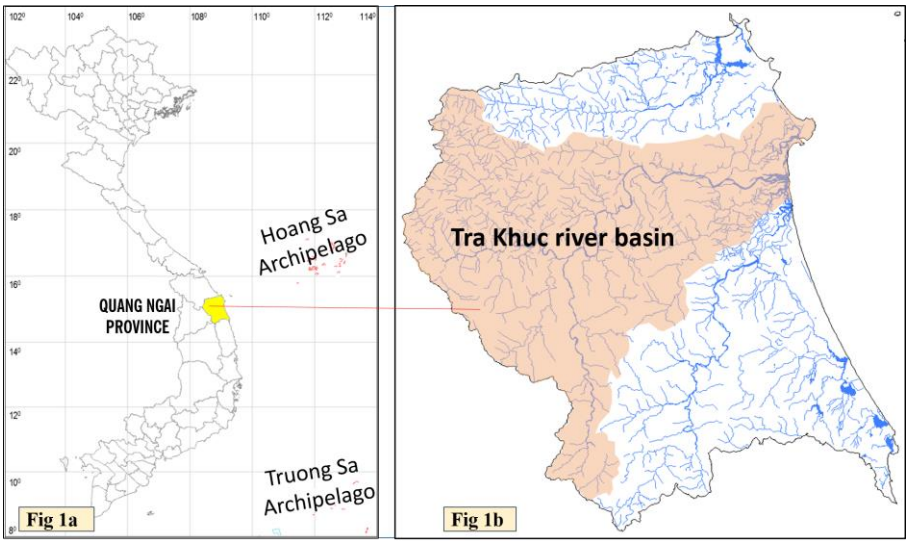

Figure 1. Location of Tra Khuc river basin, Quang Ngai province, Vietnam

The study of the current situation and the correct identification of the causes of erosion have essential implications in providing solutions to overcome limitations, thereby contributing to stabilizing social life and promoting local economic development

2. Data and research methods

2.1. Data

Through 3 field surveys, the research team has collected primary data, including location, the scale of landslides; pictures of the current state and factors causing erosion; feedback from experts, officials, and people related to the cause, and the current status of erosion. In addition, the research team inherits secondary data such as hydrological, geological, topographical, and soil maps...; reports on natural and socio-economic conditions of the study area, and Selected relevant topics and scientific articles to serve the research process.

2.2. Research methods

Currently, the study of river bank erosion has used many research methods. However, the author has used some typical methods as follows:

2.2.1. Methods of data collection and field survey

The investigation and collection of information are conducted through searching and looking up data sources related to the research content, that is, data on the current state of erosion; thematic maps; data on meteorological, hydrological, natural, and socio-economic characteristics of the Tra Khuc river basin, Quang Ngai province (Son et al., 2013a).

The research team conducted three field trips in December 2021 in Tu Nghia, Nghia Hanh, Ba To districts, and Quang Ngai city; February 2022 in Son Tinh and Tra Bong districts

and May 2022 in Son Ha and Son Tay districts. Field investigation and survey, on the one hand, verify the accuracy of the information on the current state of erosion from existing articles and studies. On the other hand, it helps to provide accurate location and scale data, as well as an initial assessment of erosion risk. Through survey questions for officials and local people, it is possible to identify the causes of erosion partly and, at the same time, offer some solutions to limit and overcome the consequences (Dao, 2019).

2.2.2. Methods of analysis and synthesis

Based on the collected data, focus on analyzing topographical geological, geomorphological, soil and hydro-meteorological factors as well as socio-economic factors from a geographical point of view synthesis to clarify the cause of erosion (Son et al., 2022). The research team has conducted the construction of topographic slices to analyze the flow slope, built thematic maps to visualize the location and scale of landslide points, etc. Based on the analysis results, the project paper proposes solutions to cope with and minimize damage caused by erosion.

2.2.3. Map method

The research team used an Etrex10 handheld locator combined with a Google map satellite map to accurately determine the geographic coordinates of the beginning and the end of the erosion sections, thereby accurately determining the length of the erosion sections (Son et al., 2013b). Then the research team combined the collected data, classified, analyzed, and evaluated the factors, using Arcgic 10.5 software to create a topographic slice along the Tra Khuc river flow and build a thematic map to visualize the location and scale of riverbank erosion sections of the Tra Khuc river basin.

3. Results and discussion

3.1. Current status of riverbank erosion in Tra Khuc river basin, Quang Ngai province

Synthesized results from 03 field surveys in December 2021; In, February 2022, and May 2022 in the districts with the Tra Khuc river basin flowing through, combined with the reports of the Department of Agriculture of Quang Ngai province, the study determined in full detail the location and scale of the erosion points. The aggregated data is shown in table 1 and Figure 2.

Table 1. The current status of riverbank erosion belongs to the Tra Khuc river basin

Total number of erosion points	55
The total length of erosion (meters)	54.194
Total number of erosion points on the left side of the river	41
Total number of erosion points on the right side of the river	14
The total length of erosion on the left side of the river	30.964
The total length of erosion on the right side of the river	23.230
Total number of erosion points in the mainstream	36
Total number of erosion points in tributaries and distributaries	19
The total length of erosion in the mainstream (meters)	36.518
Total landslide length of tributaries and distributaries (meters)	17.676

Table 1 and Figure 2 show that the level of riverbank erosion in the Tra Khuc river basin is taking place very seriously. There are 55 sites in the entire basin where erosion occurs or are at high risk of erosion. The total length of the main section of the river is 148 km, while the total length of erosion in the mainstream is up to 36.5 km, accounting for 24.7% of the total length of the main river.

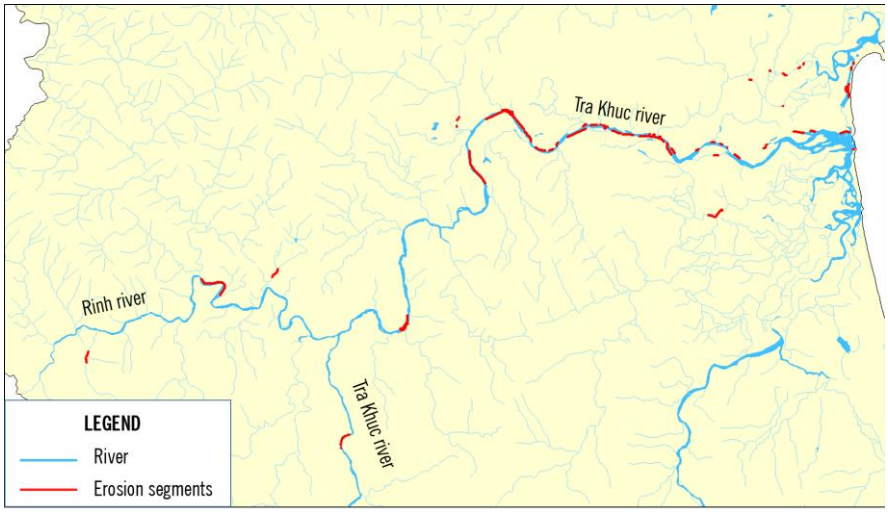

Figure 2. Location map of erosion points and sections of riverbank in Tra Khuc river basin

Although the total length of the tributaries and distributaries is much longer than that of the mainstream, the number of erosion sites surveyed is 19, accounting for about one-third of the total number of landslides. This shows that the discharge and flow characteristics significantly influence the erosion phenomenon. In terms of scale, most large-scale landslides (longer than 500m) are mainly concentrated in the mainstream and distributed in the downstream area.

It is discovered that while comparing the erosion on the river's two sides, the left side tends to erode more severely than the right side. The total number of erosion points on the left side of the river is 41, while on the right side is 14. The total length of the erosion sections on the left side is 30,964m, and on the right side is 23,230m. The cause of the more vigorous erosion on the left side is mainly due to the less durable geological and fragmented soil structure; moreover, farming and sand mining activities on the left bank also happen more often.

Areas subject to intense and large-scale erosion include Tinh Minh, Tinh Son, and Tinh Ha communes of Son Tinh district; Tinh Thien, Tinh Long, Tinh Hoa, Tinh Son, Nghia Phu, Nghia Thuan, Tinh Khe, Nghia Lo wards of Quang Ngai city; Nghia Thang commune, Nghia Lam commune, Di Lang town of Tu Nghia district; Son Thuy and Son Giang communes of Son Tra district; Son Dung commune of Son Tay district…

3.2. Causes of riverbank erosion in the Tra Khuc river basin

There are many causes of riverbank erosion (Tung, 2019), (Institute of Geography, 2010). However, through analysis and assessment of the actual situation, Some of the main reasons can be concluded as follows:

- Geological features

The geological features in the basin are pretty complicated; the northern part of the Kon Tum block colony mainly consists of ancient metamorphic formations and an intrusive magma complex aged from Arke rozoi to Kainozoi. The geology of the river bottom is a mainly coarse sand with little gravel, about 2 m thick, lying on a compacted layer of small pebbles, with some lying on the bedrock layer. There are many places at the bottom of the river bed with bedrock exposed to the surface. Further downstream, the geology of the riverbed is mainly yellow sand, minor sand, and alluvium. The geology of the riverbank is composed of clay and sandy clay, medium-grained sand, and quartz gravel. This form of alluvium is quite

sporadic, so under the influence of currents, especially the flows in the flood season, the phenomenon of riverbank erosion occurs strongly.

In the curved sections, annual erosion can be from 3 to 8 m deep on average, even a few tens of meters. Also, because the riverbed is composed of loose sediments, the deformation is substantial; only after a significant flood the main riverbed and the banks on the river can be displaced to form a new form river.

- *Soil characteristics*

Soils in mountainous areas are often distributed on steep terrain, with many thick soil layers due to the accumulation of leaves over many years. Valleys' soil is formed during erosion from high mountain areas, where the water is often muddy and acidic. The soil in the hilly areas is eroded and degraded, and the arable land layer is thin, concentrated mainly in Son Ha and Son Tay districts.

In the delta and coastal areas, the soil is mainly alluvial, mixed sandy soil and sandy soil with discrete structure, which is widely distributed downstream of the river within Son Tinh, Tu Nghia, and Quang Ngai cities. These soils are easily eroded under the impact of external forces, especially in the flood season with great intensity or in areas affected by sand and gravel mining.

- *Topographic characteristics*

The upstream part of the Tra Khuc river consists of mountain ranges over 1,000m high (figure 3); the terrain is sloping, so the river in this section has a significant flow coefficient and fast water concentration time. Floods on the Tra Khuc River often occur very quickly, with an amplitude of 3 - 5 m; flood usually occurs in a day, the shortest is 12 hours, and the longest is 71 hours; The water intensity is usually 30 - 40 cm/hour, the highest is 78 cm/hour. In the dry season (January to August), the average discharge is less than 100 m^3/s (Tung, 2019).

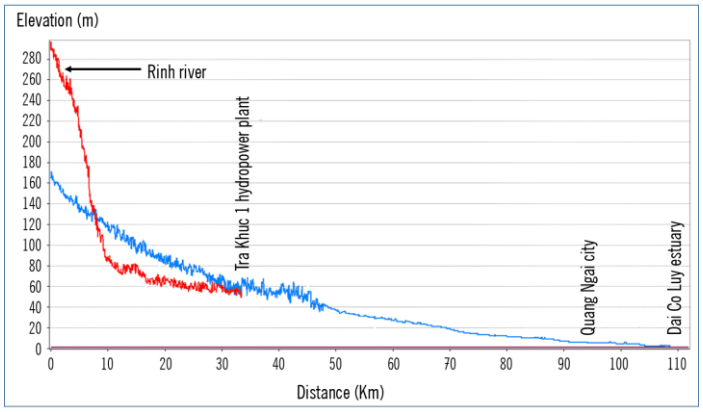

Figure 3. Terrain slice of Tra Khuc river

- *Hydrological and hydraulic characteristics*

One of the leading causes of riverbank erosion is increasingly complicated weather, heavy rains causing floods, and high tides. The flood regime has a significant impact on causing erosion and landslides on the riverbank. The annual flood season in the Tra Khuc river basin lasts from October to December. However, the flood season here is also unstable. Many years of floods occurred from September, and also many years lasted until January of the following year.

In recent decades, floods have become more frequent and unusual, with large floods and severe consequences such as floods in 1986, 1996, 1998, 1999, 2003, 2010, and 2020. Sixty-five to seventy-five percent of the yearly flow occurs during the three months of the flood season, and the volume of water in the flood season varies significantly from year to year. The amount of water during a flood season in a year with plenty of water might be ten times greater than the amount during a flood season in a year with little water (in 1996, the water flow during the flood season was 3,401 m^3/s, compared to 355 m^3/s in the flood season of 1982). The month with the most significant flow is November, with an average monthly

flow of over 30% of the annual flows; the largest is November 1998 in Son Giang (Tra Khuc river), accounting for 49.2% of the annual flows.

The flow of the Tra Khuc river system is influenced by three flows upstream of the Xa Lo river, Rin river, Rhe river, and the influence of tides in the East Sea, so the hydraulic regime of the Tra Khuc river system can be divided into three regions.

The flow in the Tra Khuc river system is influenced by three upstream flows, namely the Xa Lo river, Rin river, and Rhe river, and influenced by tides of the East Sea, so the hydraulic regime of the Tra Khuc river system can be divided into making three areas. The upstream and flood-affected areas include Son Tay district and part of Son Ha district. The midstream area affected by upstream floods includes part of Son Ha district, Son Tinh district, Tu Nghia district, and The downstream area under the tidal influence of the East Sea includes Quang Ngai City and part of Son Tinh, Tu Nghia, and Nghia Hanh districts.

- *The problem of mining sand and gravel on the river*

This is also one of the significant socio-economic factors that contribute to erosion. The province of Quang Ngai currently has about 96 sand and gravel mines with a total area of more than 1,274 hectares. In the Tra Khuc river basin districts, all sand mines are in the process of exploitation or are about to be put into operation. Typically, on the Tra Khuc River, the section flowing through Quang Ngai city, nearly a dozen sand mines are forced to stop working, but illegal mining activities still occur. Large-scale sand mining and gathering activities occur openly in Son Tinh, Tu Nghia, Nghia Hanh, and Tra Bong districts. Massive mining activities make the riverbed deeper, leading to severe riverbank erosion and loss of agricultural land for people on both sides, causing many complicated security cases in these areas.

Figure 4. Illegal sand mining in the section through Quang Ngai city (Photo taken on October 5, 2021)

Negative impacts of illegal sand mining activities in the form of suction pumps often create local deep pits (figure 4), eddy currents, turbulent flows, and change currents. Excessive sand and gravel mining activities in rivers will reduce the amount of silt and sand downstream, especially for sanding mining near the shore, plus the complicated situation of rain and flood, which can easily cause landslides and destruction dykes and embankments along river banks; directly affect people's production life.

3.3. Some solutions to prevent riverbank erosion in the Tra Khuc river basin

3.3.1. Non-structural solutions

- Review, supplement, and complete legal regulations under the authority of the Provincial People's Council and Provincial People's Committee to strengthen the management of activities in riparian and coastal areas and handle riverbank and coastal erosion to prevent proactively, respond to and overcome landslides, ensure life safety and limit damage to property of the people and the State.

- For areas with severe erosion, such as Tinh Minh commune and Tinh Son commune, it is necessary to apply policies to support population relocation from landslide areas and areas at risk of landslides associated with livelihoods stabilize people's lives.

- The dike project in Quang Ngai City has a length of 3,188m; so far, many sections have shown signs of deterioration and severe damage caused by the construction of tents, bamboo, and steel frames embedded in concrete to operate Quang Ngai night market, at the same time, there are 30 toilets in the night market area, and about 30 drilling wells are in operation. Therefore, in order to return to the original dyke condition, the Provincial People's Committee is requested to consider and direct the People's Committee of Quang Ngai City to organize the dismantling of all shops and temporary works on the dyke and in the dyke protection corridor, and at the same time repair damaged flower beds, replant the affected trees.

- To organize the selection of competent and experienced agencies and units in the field of riverbank and coastal erosion prevention and control to carry out tasks such as essential investigation of landslides, population, and works riverside; Investigate and evaluate the changes of sediment and sand, the current situation of sand exploitation on the river, thereby giving the overall plans to correct and prevent riverbank erosion in the basin.

- Currently, more than 30 illegal sand mining sites are regularly operating on the Tra Khuc river, seriously affecting the riverbank erosion. Therefore, it is necessary to have a policy of sanctions and severe penalties to deter and prevent these activities.

- Propagating and disseminating the law, raising awareness of people, agencies, and organizations on riverbank erosion prevention; implementing projects to protect, restore and develop watershed protection forests.

3.3.2. Construction solutions

- Protecting forests and planting new forests in the upstream districts of Son Ha and Son Tay is an effective measure to reduce the risk of flash floods and many other hazards, especially soil erosion.

- Promoting green tree planting along both sides of the river is essential in ensuring vegetative cover, limiting river bank erosion, especially in the rainy and flood season, and creating a beautiful, clean landscape.

- Some sections of river embankment have been damaged and need to be repaired, such as Embankment to prevent erosion of Tra Khuc river bank, section through Ha Tay village, Tinh Ha commune, Son Tinh district; Anti-erosion embankment of Ve river, section passing Xom A, Duc Loi commune, Mo Duc district. Anti-erosion embankment of Son Chau river, Long Son commune, Minh Long district; Nghia Chanh embankment, Quang Ngai city…

- It is necessary to focus on the early construction and completion of dikes and embankments (figure 5) in critical areas of erosion such as Tinh Minh, Tinh Son, Tinh Ha communes of Son Tinh district; Tinh Thien, Tinh Long, Tinh Hoa, Tinh Son, Nghia Phu, Nghia Thuan, Tinh Khe communes, Nghia Lo ward, Quang Ngai city; Nghia Thang commune, Nghia Lam commune, Di Lang township of Tu Nghia district; Son Thuy and Son Giang

communes of Son Tra district; Son Dung commune in Son Tay district… to ensure the safety of the riverside infrastructure, to protect the production land and the safety of the people.

- Applying the project to reduce the speed along the shore is an effective solution for cases where the velocity along the river mouth is high, and the estuary's roof is steep. This solution is often combined with roof embankment to create a continuous work system that effectively prevents erosion and protects coastal arable land.

Figure 5. Roof embankment in Ky Xuyen village, Tinh Ky commune, Quang Ngai city

4. Conclusions

Through the methods of collecting and synthesizing documents, cartographic methods, field surveys, and expert consultation, research, and survey on riverbank erosion in the Tra Khuc river basin, Quang Ngai province can be done some general conclusions are drawn as follows:

- The level of riverbank erosion in the Tra Khuc river basin is taking place very seriously. The basin currently has 55 points with a total length of up to 54,194 m.

- The phenomenon of erosion occurring in the mainstream is more potent than in the tributaries and distributaries; The erosion on the left side of the river is more and more robust than on the right side of the river; The delta and coastal areas erode more strongly than the midland and mountainous areas.

- The causes are geological, topographical, soil, and hydrological characteristics and the problem of illegal sand and gravel mining. Hydrological, soil, and sand mining problems are the leading causes of erosion.

- It is recommended that the locality implement concurrent and synchronous structural and non-structural solutions to limit and overcome the consequences. At the same time, it is necessary to identify and assess areas at risk of erosion; propose a strategy to gradually regulate the Tra Khuc river flow until 2030 to implement it effectively.

References

1. Dao, C. D. (2019). Study to evaluate hydrolithic dynamic factors affecting the accretion and erosion processes in the estuary and coastal areas from Quang Nam to Phu Yen in the condition of climate change and sea level rise. In *National project*.
2. Institute of Geography, 2010. (2010). Research planning for flood prevention, control and drainage of Tra Khuc river and Ve river in Quang Ngai province. In *Vietnam Academy of Science and Technology*.
3. Loan, N. T. P. (2012). Research on scientific basis and solutions for sustainable development of water resources and environment in Tra Khuc river basin. In *Technical Thesis, Hanoi*.
4. Son, H. N., Mai, T. T. T., & Lang, C. P. Le. (2013a). Raising Awareness Education and Response Capability with Climate Change for the Residential community in Mid-central Coastal Provinces of Vietnam. *The International Journal of Education Administration and Development, 4 (2)*, 812-818.
5. Son, H. N., Mai, T. T. T., & Lang, C. P. Le. (2013b). Raising Awareness Education and Response Capability with Climate Change for the Residential community in

Mid-central Coastal Provinces of Vietnam. *The International Journal of Education Administration and Development 4(2): 812-818. Mahasarakham University, Thailand.*

6. Son, H. N., Tin, V. Le, Chan, V. M., Thinh, H. P., Tu, X. D., & Dan, N. N. (2022). Assessing the status of landslides along key transport routes in Thua Thien Hue province during the stormy season in 2020. *International Symposium Hanoi geoengineering 2022 innovative geosciences, circular economy and sustainability*.
7. Tung, T. T. (2019). Analysis of morphological changes of Tra Khuc estuary, Quang Ngai province. *Hydrometeorological Journal*.

Sustainable production model adapted to climate change in hilly and mountainous areas of Thua Thien Hue province

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Abstract. This study examines the combined impact of climate changes on the livelihood activities of people living in the hilly areas of Thua Thien Hue province. On that basis, identify livelihood models that can be replicated and applied to mitigate the impacts of natural disasters such as storms, floods, landslides, droughts, and cold. The results show that the proposed livelihood models replicated and applied include: (1) Forest - Garden - Pond - Barn, (2) Orchard, (3) Garden - Ponds - Stables, (4) Forest gardens, (5) Upland forests or grazing grounds. In addition, we also propose more technical solutions to increase the sustainability of elements of the livelihood model, such as (1) planting drought-tolerant rice varieties; (2) switching from rice cultivation to drought-tolerant crops (corn, sugarcane, pineapple, bananas, peppers) for greater economic efficiency; (3) early harvesting and the use of short-term crops to avoid storms and flooding rains; (4) combination of acacia, rubber, and firewood harvesting; (5) changing the types of livestock and diversifying home garden crops. These results will help local leaders come up with solutions for sustainable socio-economic development in the future.

Keywords: Climate change, Livelihood, Thua Thien Hue, Environmental science, Ecological

1. INTRODUCTION

Climate change has become a reality (Vermeulen et al., 2010). Vietnam is among the ten countries most affected by climate change in the world (National Strategy on Climate Change -Decision 2139/QĐ-TTG on December 05, 2011, 2011), (CARE Vietnam, 2013). Climate change significantly impacts production, the environment, and livelihoods (Mugi-Ngenga et al., 2021). Ethnic minorities in Viet Nam are particularly vulnerable to climate change as they are highly dependent on natural resources and climate-sensitive (McElwee et al., 2010), (Apraku et al., 2021). The impact of climate change increases natural disasters, affecting crop yields, reducing arable land, and food shortages in ethnic minority groups living in hilly areas in central Vietnam (Delisle & Turner, 2016), (Son et al., 2013), (Son et al., 2014), (Son et al., 2017). Therefore, climate change adaptation strategies need to be studied and applicable to households living in mountainous areas. Many studies lead to the common point of diversifying livelihoods and awareness of climate change as key factors that sustainably promote people's livelihoods.

Thua Thien Hue province's hilly and mountainous areas are the most vulnerable to climate change, forest area is degraded, and erosion and landslides take place seriously during

the typhoon season (Son & Quan, 2021), (Son et al., 2022). The area is mainly inhabited by ethnic minority communities such as Co Tu, Pa Co, and Ta Oi (Thua Thien Hue Statistics Office, 2021). The characteristics of agriculture-based livelihoods are mainly production model solutions, farming practices adapting to climate changes, and natural disasters playing an essential role (Hang et al., 2021).

However, the application of production models to adapt to climate change remains limited. Therefore, this article focuses on sustainable agricultural production models in Thua Thien Hue province's hilly and mountainous areas. We hope to provide valuable information on possible livelihood models and measures to increase the sustainability of household livelihood models. Thereby helping managers and leaders integrate methods into local socio-economic development plans in line with sustainable development goals.

2. RESEARCH METHODS

2.1. Field survey methods

The research team conducted 04 surveys and field trips: on November 12, 2020, March 3, 5, 2022. We met with district authorities, research agencies, and communes during the field sessions to get a socio-economic overview of the study area. Secondary data collected, including statistical and annual reports, climate data, natural disasters (temperature, precipitation, landslides, drought, etc.) from 1961 to 2019, and the locality's socio-economic development from 2015 to 2020, was also recorded through these trips. The survey trips' data and information have helped us better shape the research content.

2.2. In-depth interview method

- Meetings and interviews at district and commune levels: Two meetings were held with 04 key delegates of Nam Dong and A Luoi districts (Figure 1, Figure 2). Includes the following members: one is in charge of running the district office, and one is in charge of the district's agriculture. In addition, we conducted six meetings with leaders and officials in charge of the agriculture of communes in those two districts. Questions used meeting sting and gs, interviews mainly related to the production situation, natural advantages and disadvantages in agricultural production; vulnerable areas due to climate risks, natural disasters, farmers' capacity to cope with climate changed age, extreme weather phenomena; production models are being adopted by the people; sustainability of production models. Through the meeting, the team came to the following conclusions: (1) the livelihoods of the people here are primarily based on agriculture and the exploitation of forest resources; (2) households are susceptible to different types of natural disasters such as hurricanes, cold, thunderstorms, cyclones, lightning, droughts, flash floods, and landslides; and (3) the livelihood models of households are primarily on a small scale, single production, and poor economic efficiency (Son et al., 2013).

Figure 1. Meeting in Nam Dong district

Figure 2. Meeting in A Luoi district

- Interviews with reputable people of the community: Participants are reputable people in the community (Figure 3, Figure 4) (Thua Thien Hue Statistics Office, 2021) had knowledge and experience in agricultural production and disaster prevention, such as village heads,

village elders, patriarchs. As a result, they are willing to offer their expertise and respond to the team's inquiries. To confirm the consistency and accuracy of such information sources, we also compared the outcomes of the interviews with secondary documents. This procedure has aided the research team's understanding of the locals' economic circumstances. Per case, the interview procedure takes an hour.

Figure 3. Interviews with reputable people

Figure 4. Interview with The Village Elder

- Household interview: After collecting and classifying information and data from interviews with reputable people of the community, a questionnaire was designed by us for household interviews (Figure 5, Figure 6). In addition, some open-ended questions are used to allow households to explain their answers in more detail, especially questions related to production models, farming practices in agricultural production, and the impact of climate change on people. Each interview lasts about an hour. Sixty households were selected for interviews in Nam Dong district, A Luoi district. The interviews were conducted on November 12, 2020, March, and May 2022. Criteria for selecting households for the survey include people with agricultural land in the area, directly involved, and having 5-10 years of experience in agriculture. With discussion and suggestions from village leaders and officials in charge of agriculture in chosen communes, a list and criteria for choosing homes were developed (Van Mai et al., 2022), (Son et al., 2014), (Son et al., 2022).

Figure 5. Interviewing households with farming models

Figure 6. Interviewing households with livestock production models

2.3. SWOT analysis methods

SWOT analysis helps analyze the research area's livelihood models' strengths, weaknesses, opportunities, and threats. According to a SWOT analysis, the potential assessment and proposal of sustainable lifestyle models are affected positively or negatively by the aims and circumstances inside and outside the research domain. Assessment of livelihood models in study domains is intended to assist researchers in having a comprehensive picture of the state of livelihood models while also capturing the causes of sustainability, SWOT analysis plays an essential role in the process of proposing sustainable livelihood models adapted to climate change in hilly and mountainous areas of Thua Thien Hue province (Lang et al., 2022).

2.4. Sustainability assessment methodology

Methods for assessing the sustainability of livelihood models, thereby helping the research team propose sustainable livelihood models in the hilly and mountainous areas of Thua Thien Hue province. This method is formulated with 12 criteria (Nguyen et al., 2022), (Phan et al., 2022). In particular, each criterion gives 1 point with different weights.

+ Criteria of coefficient 5 (criteria): Output interest rate; the number of households applying this model in the village; the model's ability to protect and use the land effectively and sustainably; forest protection, climate adaptation, and water protection.

+ Criteria of coefficient 2: Income of the model; the level of satisfaction of farmers, contribution to household economic income; ability to resist environmental pollution (air, soil, water ...).

+ Criteria of coefficient 1: Cost; the possibility of spreading; conditions for spreading.

- The maximum total number of points calculated is: (5 x 3) + (3 x 2) + (3 x 1) = 24 points.

- How to calculate points for each criterion:

+ Each criterion is evaluated according to the level of comparison between the models and the number of models scored. For example, for income criteria: the evaluation by score is conducted for six different models; if compared hierarchically, each step is separated by 0.16 points.

+ Thus, the scale to evaluate for the income criteria of each of the 6 evaluation models is: 0.16; 0,32; 0,48; 0,64; 0,8; 1,0.

- Determine the point interval for the model's sustainability levels: There are three levels of sustainability that separate points at even intervals:

+ Level 1: From 14.6 - 24 points.

+ Level 2: From 7.3 - below 14.6 points.

+ Level 3: From 1 - below 7.3 points.

2.5. Methods of data collection and analysis

This study's quantitative data included data on rainfall and temperature from 1961-2019 in Thua Thien Hue province. These data are used to confirm local climate change. This data was recorded at Nam Dong and A Luoi district meteorological station và provided by Thua Thien Hue Hydrometeorological Observatory. Then analyzed using Excel software (2019). In addition, thematic analysis analyzes and processes qualitative data manually by the research team (Le Phuc et al., 2022).

In addition to the research mentioned above methodology, we collect additional information supplemented by the insights and experiences of scientists, leaders, local managers, published documents, and other sources of information.

All of the above methods fully ensure the regulations on research ethics. All interview processing stages are supervised by the Delegation of the Institute of Open Training and Information Technology, Hue University, and officials in communes and villages participating in the delegation. All participants agreed with the content of the interview and allowed the use of their opinions in the article.

3. RESULTS OF RESEARCH AND DISCUSSION

3.1. Areas of research

Thua Thien Hue Province is located on the central coast of Vietnam, from $16^0$13’18’’ N đến $16^0$44’30’’ N, (Figure 7). In Thua Thien Hue, there is no apparent difference between the rainy and dry seasons, but only the rainy and less rainy seasons (Vu & Son, 2004). The rainy season runs from September to December and accounts for 70% of the total annual rainfall. The average temperature for the whole year is 25°C. The number of sunny hours for the whole year is 2000 (Dung & Son, 2017), (Thua Thien Hue Statistics Office, 2021). The hilly and mountainous area is mainly concentrated in Nam Dong district and A Luoi district (Dung & Son, 2020). Previous reports indicated that the livelihood of the mountainous people of Thua Thien Hue province mainly depends on natural conditions. As a result, they are vulnerable to natural disasters and climate change, such as hurricanes, floods, landslides, droughts, and colds (Vu & Son, 2004), (Phan et al., 2022). Therefore, the construction of sustainable livelihood models in this region is necessary.

3.2. Impacts of climate change on Thua Thien Hue hilly and mountainous areas

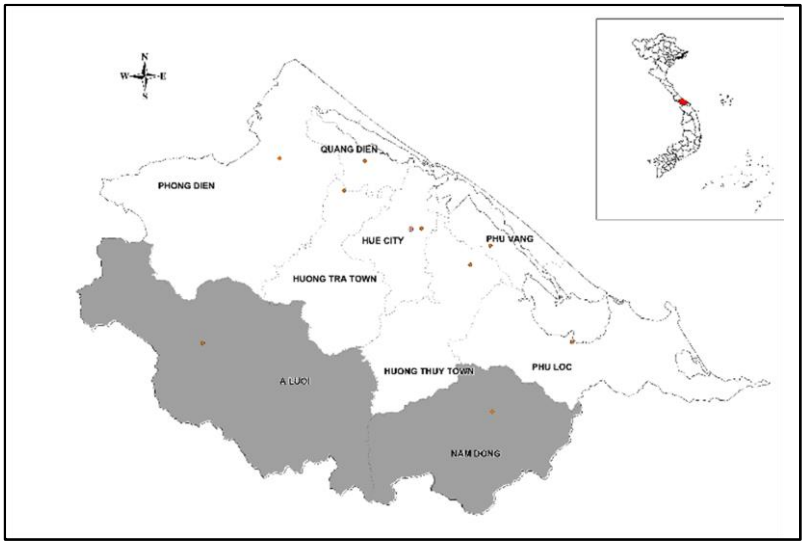


Figure 7. Map of the study area

"In recent years, the local climate has gotten increasingly unpredictable, and different kinds of natural disasters have increased in frequency. Storms, torrential rains, soil erosion, and landslides, in particular, seem to occur less frequently than in the past, but their severity and effects are increasing and becoming more unpredictable”. 71.5% of individual households in our surveys agreed.

Meteorological data prove farmers' perception that there has been an increase in temperature and precipitation. According to available data, Nam Dong district, A Mesh district, has endured higher average temperatures and a significant upward trend for forty years from 1975 to 2019 at an increased rate of about 0,2^{o}C//10 years (Thua Thien Hue Statistics Office, 2021), (Figure 8, Figure 9). Days of intense heat (Tx≥ 37^{o}C) tend to increase in the period 1975 -2019 (Figure 10, 11).

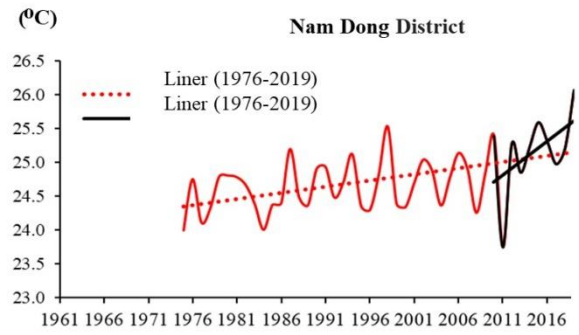


Figure 8. Average temperature and linear trend in Nam Dong district during the period 1975 -2019

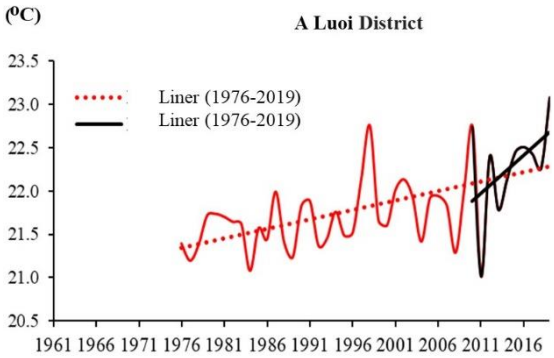


Figure 9. Average temperature and linear trend in A Luoi district during the period 1975 -2019

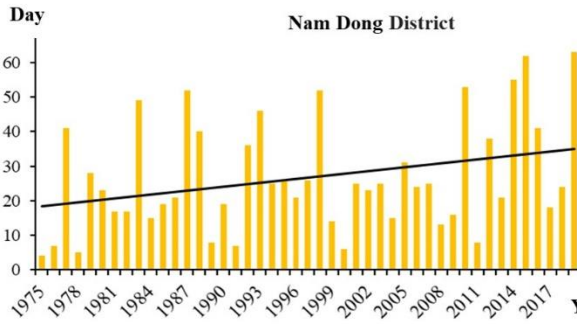


Figure 10. Number of days of intense heat (Tx≥ 370C) and linear trend in Nam Dong district during the period 1975 -2019

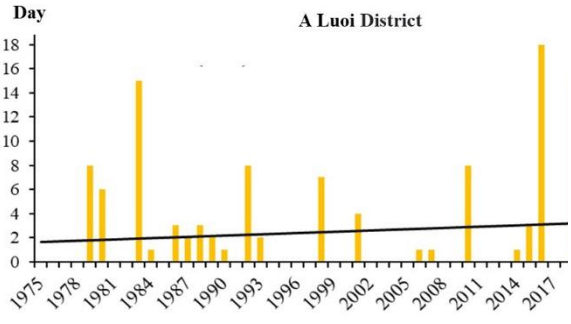


Figure 11. Number of days of intense heat (Tx≥ 370C) and linear trend in A Luoi district during the period 1975 -2019

Source: Thua Thien Hue Provincial Government, 2020

Analysis of annual rainfall trends for 1975-2019 also indicates that local perceptions are relatively consistent with meteorological data. Accordingly, the average multi-year rainfall in Nam Dong district, A Luoi district increased and stabilized from 1981 to 2010 and has decreased slightly in the past ten years; average rainfall ranges between 3400-4000 mm, with years above 5000 mm as in 1973, 1996 and 1999 (Table 1). However, the number of days of heavy rain tends to increase a lot (Figure 12, Figure 13).

Table 1. Average rainfall in Nam Dong District, A Luoi District from 1975 - 2019

Period	Nam Dong district	A Luoi district
1975-1990	3428,8	3228,3
1991-2000	4041,6	4079,3
2001-2010	4012,2	3745.4
2011-2019	3360,2	3360,2

Source: Thua Thien Hue Provincial Government, 2020

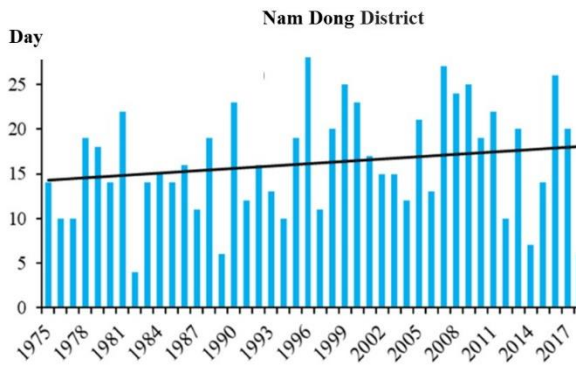


Figure 12. Change in the number of heavy rain days and linear trends in Nam Dong district in the period 1975 -2019

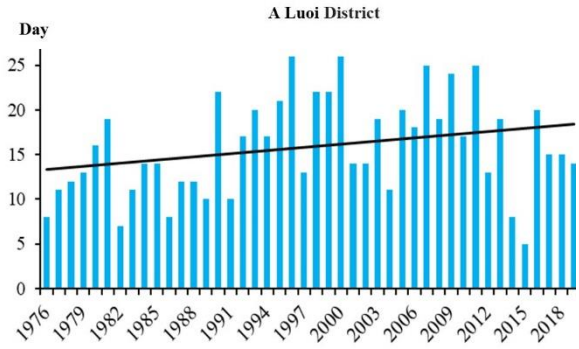


Figure 13. Change in the number of heavy rain days and linear trends in A Luoi district in the period 1975 -2019

Source: Thua Thien Hue Provincial Government, 2020

In addition, geological, topographic, and hydrological data prove that people's perception of the increase in natural accidents is correct. When there are storms, thunderstorms, or cyclones, most communes in the district are affected, but depending on the population distribution, the status of safe houses, land use, and different levels of impact. The hilly and mountainous area of Thua Thien hue province has many valleys surrounded by mountains; there are many streams with a significant slope, a vast water concentration basin, and heavy rainfall in the rainy season, especially the rain on the day is substantial. Hence, the amount of water concentrates quickly, and the intensity of the flow is vigorous. Therefore, this place is often affected by flash floods and landslides for areas on both sides of rivers and streams.

Similarly, the households surveyed often mentioned an increase in the intensity, frequency, and duration of cold snaps in winter and drought in summer 65% of those surveyed agreed that the frequency of cold spells and droughts tends to be less. However, the duration is longer, and the impact intensity is more significant 15% of those surveyed said that cold spells and droughts are more severe but not too intense, and 20% choose normal. Those changes are more frequent and severe, causing more damage to people, property, and agricultural production.

These natural accidents have adversely impacted their livelihoods and daily activities (Table 2).

Table 2. Impact of natural disasters on people's livelihoods and activities

No	Type	Influence
1	Agricultural, forestry, and fishery production	- Food crops such as rice, cassava, or vegetables of all kinds, sugarcane, and bananas are caused by high winds or waterlogging. - Storms for rubber trees and plantations (acacia) that break and fall. - Aquaculture, livestock, and poultry were also washed away or died but not in large quantities. - Loss of arable land, residential land due to stream bank landslides, hill and mountain landslides, or flash floods
2	People	Bear the risk of natural disasters such as storms, flash floods, landslides, thunderstorms, cyclones, and lightning.
3	House	Collapsed or damaged when various types of natural disasters occur.

4	Infrastructure, irrigation transport	- When there is a natural disaster, many irrigation works are buried and damaged, and landslides. The self-flowing water supply systems were all buried by sand, and damaged some pipes due to falling trees. - Inter-village, commune and district roads are at risk of damage. - Electricity, communication, and telecommunication systems: there is a risk of breakage; some lines are broken and damaged.

Source: Results of the team's investigation

People claim that this has a significant impact on their livelihoods. The three most common natural disasters are hurricanes, droughts, and cold snaps. The damage caused by hurricanes has increased recently. In interviews, they mentioned the harm done by typhoons Nari in 2013, Noul in 2014, and Rai in 2020 to demonstrate the severe effects of natural disasters.

3.3. Proposing livelihood models to be replicated and applied in hilly and mountainous areas of Thua Thien Hue province

3.3.1. Livelihood models

3.3.1.1. Forest Garden

The model of forest gardens using gardens to grow forest trees applies measures to intensive farming in the style of horticulture to produce traditional products with high commodity value. This model is built by people in low mountain or hilly areas, in areas with high rainfall, sloping and degraded land that is less likely to develop agriculture Table 3, Figure 14).

Table 3: Evaluation of SWOT factors for the Forest Garden model

S: Strengths	W: Weaknesses
- After 5 - 10 years of planting forest, wood can be obtained for making paper materials, intercropping products, branches, and thinning trees for sale and cooking. - The garden provides daily food; you can also sell agricultural products to buy necessary things. - Although the forest garden has a simple structure, it uses indigenous tree species highly adaptable to local ecological and soil conditions. - Maintain and develop the low tree layer that has the effect of supplementing the main tree layer, so it still creates a stable ecological environment for the sustainable development of crops. - Forest gardens are suitable for farming customs of ethnic minorities, helping to take advantage of all time and labor resources in the house, investing in forest care and nurturing to gain great results; help them get their investment back to cultivate crops and	- The land is dry when the model is newly developed; it takes time to work the land. - The land has a high slope, prone to soil erosion in the first years of afforestation. - Due to the inability to self-produce seedlings, people cannot develop a reasonable afforestation plan. - Forest trees often take a long time to produce, limiting farmers' acceptance, especially for poor households. - The ability to meet immediate needs is still low, the business cycle is long, the initial cost is relatively large, but the payback period is slow. - Focusing mainly on pure-species forests, the number of tree species in the model is small. - There are no products from livestock in the model. - Products from the garden are not significant.

exchange other necessary goods. This model also helps people protect and develop forest capital, harmonizing immediate and long-term benefits both in terms of economy and environment.

O: Opportunities	T: Threats
- Get the attention of local authorities with seed support policies and technical training. - The current market demand is relatively large, and the price is high. - There is still a lot of forest land for forest development.	- Inability to water in the dry season and when new plants are planted. - Lack of investment capital. - Information on market price changes is limited, forced by buyers.

***Figure 14**. Forest garden model in A Luoi district*

3.3.1.2. Home garden with fruit trees

The model is developed in the low valley area with alluvial soil that drains or is dug for drainage in the rainy season and water supply in the dry season. In addition, the ancient alluvial gray soil area has a relatively flat or wavy surface Table 4).

Table 4: Evaluation of SWOT factors for the home garden model with fruit trees

S: Strengths	W: Weaknesses
- Bananas and fruit trees are crops with high economic value, bringing high income to people (Figure 15, 16). - Varied and abundant plant species, a large volume of products, and income, are currently traded commodities on the market. In addition, also for products to serve the needs of the family. - Simple model, easy to care for and manage. - Create jobs for local workers. - Take advantage of the land fund between the rows of fruit trees to grow bananas. - When the model is developed, the fruit tree system will act like a forest, so	- Model was built mainly based on personal experience. - The investment level is relatively high, and the care technology is relatively tricky, so poor households cannot afford to invest in this model. - The growth cycle of bananas is shorter than fruit trees, so bananas have to be replanted after a few years of exploitation when fruit trees easily shade replanted seedlings. - Competitive effects on light, nutrients, and water and creating shelter for pests and diseases are things to consider. - Requires significant investment, including

environmental protection and climate regulation will promote well.	labor. - Cultivation techniques are pretty complicated, requiring experience. It is restricted to areas with steep slopes.
O: Opportunities	**T: Threats**
- Received the attention and financial and technical support of the district agricultural extension center... - Increasing market demand for agricultural products.	- Prices of fruits and bananas often fluctuate, depending on the supply-demand relationship of the market, often forced by traders. - Quality requirements of consumers are increasing day by day.

Figure 15. Guava and banana garden

Figure 16. Orange orchard

3.3.1.3. Model of forest + upland or grazing land + field

This model should be located in hilly and low mountainous areas (Table 5, Figure 17, Figure 18). The reason is that the terrain has a relatively steep slope in this area, and the forest has been destroyed. Most of the forest is recovering after shifting cultivation, usually, only small patches or patches remain in high sloping places, along the river basins and drought tolerant shrubs. The valley below has a small area of water fields that people have cultivated for a long time.

Table 5: Assessment of SWOT factors for the model of forest + upland or grazing land + field

S: Strengths	**W: Weaknesses**
- Large scale, making full use of the local fallow land. - Diversification contributes to a significant increase in income for people. - It has the effect of developing forest capital and preventing soil erosion. - Between components have a supporting effect, reducing input costs. - The model is sustainable; forest composition plays an essential role in regulating upstream water to lead to wet rice fields and forest trees to protect the land from landslides. In addition, the forest is also a place to provide necessary products	- The components in the model are not highly connected. - Forest land has a steep slope and lousy soil. - The model has a relatively large area, so it is difficult to manage. - Product quality is low, uneven, and easy to be pressured by traders. - Very laborious in building and maintaining the system. - The most significant difficulty of this model is that it can only be applied in areas with natural water sources; Water management is essential. Due to the location in the mountainous area, if in remote areas,

for farmers, such as construction wood, firewood, and bamboo, ... - Upland rice and paddy fields provide most food, such as maize, cassava, upland rice, and wet rice, for the household's needs, and a little for livestock and sale. - There are several other revenues based on livestock and agricultural products obtained from the home garden, which partly meets the family's daily needs, although it is not significant. - To gradually turn sloping land into a place of sustainable production and forest protection.	trading is relatively tricky.
O: Opportunities	**T: Threats**
- The market's demand for products in general and livestock products is excellent, especially local specialties. - There are many large models in other localities for reference through mass media and training courses.	- Many products people do not understand the market price, often forced by traders. - The level of application of science and technology is still low. - The epidemic took place firmly, making livestock development more precarious.

Figure 17. Upland forest model

Figure 18. Grazing yard model

3.3.1.4. Garden - Pond - Barn

The garden - pond - barn model was formed relatively early; the primary purpose of the household model is to serve the family's needs. In this model, the crops are arranged in a mixed manner, with no specific planning, low productivity, and low product quality. Each household raises mainly pigs and poultry and grows crops such as bananas, persimmons, longans, guava, and other cash crops (potatoes, cassava...). Additionally, there is a fishpond with primary tilapia and carp in the garden or at the foot of the hill. (Table 6, Figure 19).

Table 6: Evaluation of SWOT factors for the Garden - Pond - Barn model

S: Strengths	**W: Weaknesses**
- Flat terrain, good soil, moist suitable for many crops.	- People have not been trained in planting and caring for fruit trees, mainly using local

- Because it is in the valley, this model can water in the dry season to ensure good growth and development of crops. - The model's product is diverse, and the support between the components is tremendous. - High efficiency in both economic and environmental terms. - Reduce input costs. - Take advantage of the limited land fund to develop many types of uses.	knowledge in production. - The species composition is many, and understanding the complex ecological relationships between them is still limited, so most of the model area has not been precisely planned. It- Easy to spread disease in the model. - Ecological competition between large species. - Need to invest a lot of capital and technology, so it is limited to poor people
O: Opportunities	**T: Threats**
- Good land, relatively flat terrain. - Has a convenient location in terms of traffic and irrigation. - Consumption of products is convenient because it is close to the center and has a source of purchasing revenue.	- In poor storage conditions; Fruits and vegetables that are harvested and not yet consumed are often damaged, so prices are forced - Prices of agricultural products often fluctuate. The risk of getting sick is excellent. - There has not been the attention of the agricultural and forestry extension agencies.

a **b** **c**

Figure 19*. Model Garden (a) - Pond (b) - Barn (c)*

3.3.1.5. Forest - Garden - Pond - Barn

This model is built in low hill areas, natural forests, or hilltop plantations and is also managed by the forestry enterprise or the local community. This model is an improved Garden-Pond-Stable model, combining forests, orchards, aquariums, and livestock (Figure 20). Forests are planted or protected at the top of the hill, the hillside area develops industrial crops such as rubber, coffee, or fruit trees such as bananas. Maize and cassava are intercropped or planted separately in the following area. The foothill area is planned to be a garden and barn to grow green vegetables, wet rice, beans, beans of all kinds, and dig ponds to release fish (Table 7).

Table 7: Evaluation of SWOT factors for the Forest - Garden - Pond - Stable model

S: Strengths	**W: Weaknesses**
- Having a large scale, making full use of the local fallow land.	- The components in the model do not have high cohesion; Typically, it is difficult to

- Diversification contributes to a significant increase in income for people. - The effect of developing forest capital is to protect the environment and prevent soil erosion. - Between components that have a supporting effect, reducing input costs.	care for and water the forest when lakes and ponds are located far away. - Forest land has a high slope and lousy soil. - The model has a relatively large area, so it is difficult to manage. - Product quality is low and uneven, making it easy to be pressured by traders.
O: Opportunities	**T: Threats**
- The market's demand for products in general and livestock products is excellent, especially local specialties. - Agricultural and forestry extension work is being promoted in the locality. - There are many large models in other localities for reference through mass media and local training courses.	- Many products people do not understand the market price, often forced by traders. - The level of application of science and technology is still low. - The epidemic took place firmly, making livestock development more precarious. - Often lacks water in the dry season.

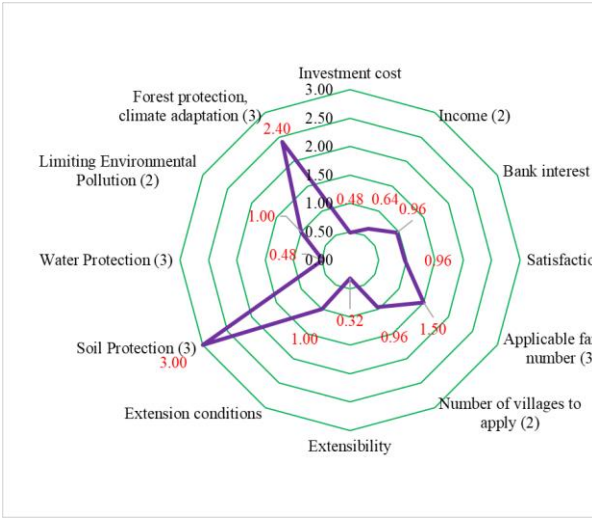
Figure 20. Model of Forest - Garden - Pond - Barn

3.3.2. Evaluation of the sustainability of livelihood models in hilly and mountainous areas of Thua Thien Hue province

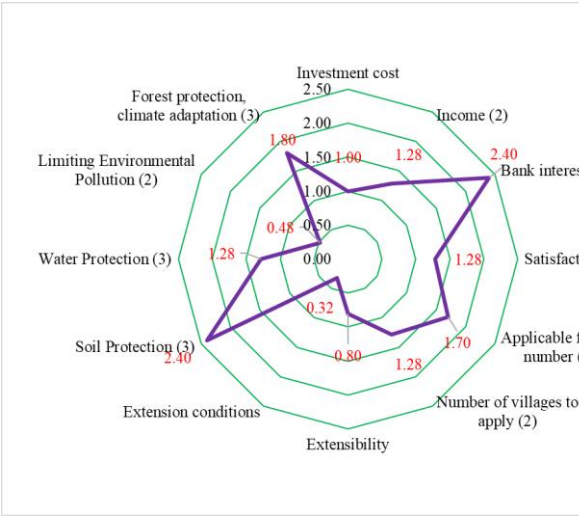
Sustainable development needs to be reflected in all three aspects: economic (benefits must be greater than or equal to costs, increased income); social (contributing to hunger eradication, poverty alleviation, creating social justice, improving the quality of life of the community, enhancing social and environmental assurance factors, and having a high degree of acceptance by the people); environment, climate (use, protect the environment, enhance adaptation to climate change). The evaluation must pay attention to all the above aspects in an aggregated manner, with weights assigned according to the contribution value of each criterion

in each evaluation target corresponding to each factor. In addition, a sustainable livelihood model that adapts to climate change is the rational use of land to create economic, social and environmental, and climate effects. Therefore, there are different production models in places with different soils and ecological conditions, so the assessment is fixed on each model in each territory.

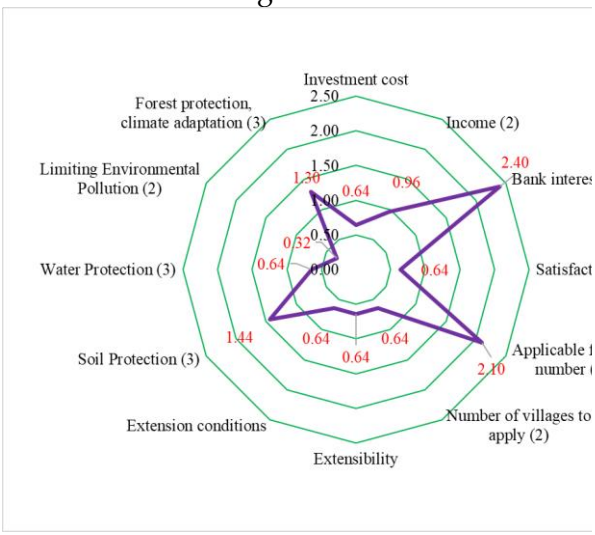
Using the weighted sustainability assessment method, the models have the following results (Figure 21):



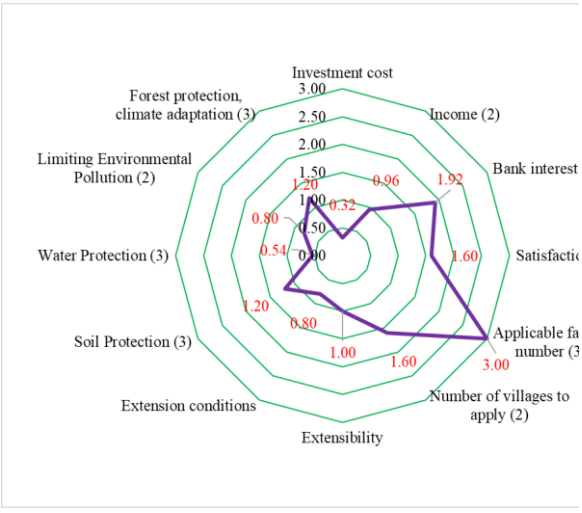
a. Forest garden model



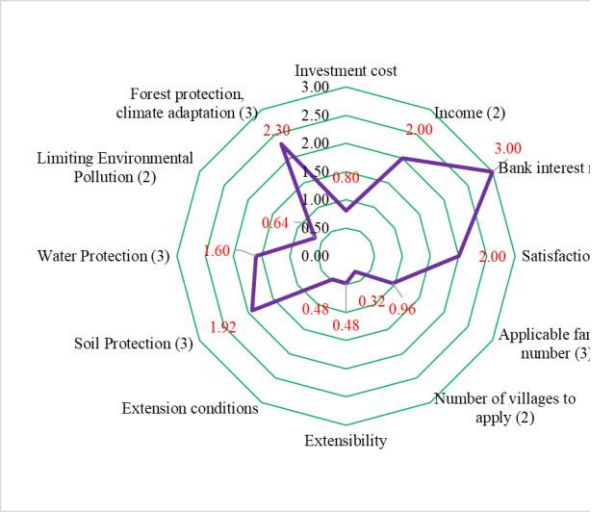
b. Fruit garden model



c. Arable forests or grazing grounds model



d. Garden - aquarium - Barn model



e. Forest - Garden - aquarium - Barn model

Figure 21. Value comparison chart of models

It can be seen that most of the climate change adaptation livelihood models in mountainous areas are sustainable and are ranked in order from high to low: Forest - Garden - Pond - Stable, Orchard, Garden - Pond - Stable, Forest garden, Upland forest or grazing grounds (Figure 22). The models applied by the people aim to directly exploit the advantages of land and topography to solve the daily needs of food and food households. However, farming techniques are still backward, mainly based on experience, and heavily dependent on nature; productivity is very low, product quality is not high, and traders are often forced on prices, leading to low economic efficiency. On the other hand, in the condition that the terrain is mainly hills and mountains with very steep slopes, the models have not been effective in protecting the environment of land, water, and forest resources and reducing disaster risks. In addition, with the same variation, the Garden - Pond - Stable model has a higher number of households applied than the Forest - Pond - Garden - Barn model. The reason is that the production forest area is limited, and not every household has a home garden next to the production forest.

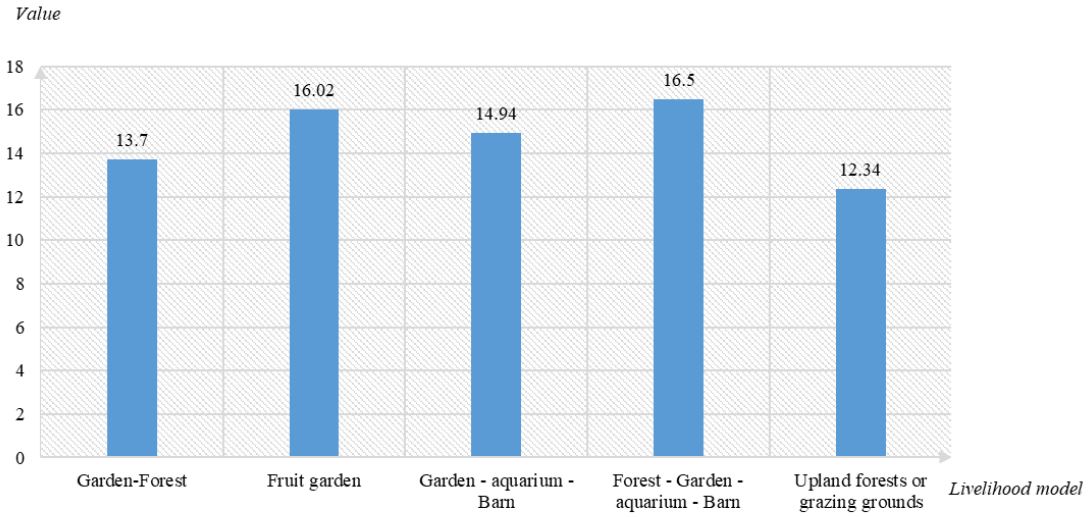


Figure 22. Graph of sustainability of livelihood models

3.4. Orientation of solutions to increase the sustainability of livelihood models in hilly and mountainous areas of Thua Thien Hue province

To apply and expand sustainable livelihood models in hilly and mountainous areas of Thua Thien Hue province, we propose the following solutions:

- Strengthening the role of the community in resource management: Implement management policies towards empowering communities (household groups, interest groups, village communities); strengthen the legal status of the rural residential community. Once they have legal status, the village community will promote its role as inherent customs and traditions... in the protection of natural resources. It promotes the role of customary law in the exploitation of land and forest resources... eliciting the values of traditional customs and using customary law in managing land and forest resources today.

- Develop forms of community management suitable to local realities: Forming groups of households to have common land and forests for production and management, to be able to cooperate and exchange work as traditional farming practices, and show the bond of community members in the everyday use of resources, avoiding the transfer and trade.

- Maximize the role of the Farmers' Association: Mobilize members and farmers to participate in building new countryside. Spreading and encouraging others to model good production and business practices, motivating farmers to alter their behavior and way of thinking, actively restructuring crops and livestock, and incorporating new scientific and technological advancements into production. These activities also help to develop household economies, farm economies, and farms, as well as small- and medium-sized concentrated specialized production areas connected to the consumer market.

- Consulting on model application. Each model will have its own economic and technical solutions. Clearly and accurately define the structure of crops: Depending on the crop type, cultivation techniques are different; seasonal scheduling.

- Disseminate technical instructions, and apply scientific experiments to clean agricultural production according to Viet - GAP standards for each model. Detailed instructions on how to perform production techniques.

- Improve understanding and develop people's attitude towards issues related to exploitation and use of land, forest, and water resources: Deforestation; hunting of wild animals; shifting cultivation; livelihood activities are inefficient and cause degradation of land and forest resources; impacts of degradation of land and forest resources on the lives of ethnic minority communities; activities of daily life and production capacity of protecting land and forest resources by the community's practices and achieving high economic efficiency; buying, selling and exchanging goods...

- Support borrowing production capital for near-poor households, predominantly ethnic minority households, because these subjects find it difficult to access capital from commercial banks to develop production. Near-poor households can become poor very quickly when the economy fluctuates badly. In particular, for near-poor households who are ethnic minorities in remote and mountainous areas, the line between poverty and near-priority becomes even more fragile when natural disasters, storms, and floods occur...

- Expand the market for agricultural products. Need local government support: Help with information on the product's consumption market; create conditions for producers to participate in trade fairs and exhibitions, introduce products; plan and build industrial processing zones right in concentrated cultivation areas...

- Planting drought-resistant rice varieties.

- Switching from rice to drought tolerant crops (maize, sugarcane, pineapple, banana, chili) for higher economic efficiency.

- Harvest early and use short-term crops to avoid storms and floods.

- Combination of growing acacia, rubber, and harvesting firewood.

- Change the livestock types and diversify the home garden plants.

4. CONCLUSIONS

The study explores the impact of climate change on the livelihoods of people living in hills and mountains in two districts of Nam Dong district, A Luoi district of Thua Thien Hue province. The study results show that The hilly and mountainous areas of Thua Thien Hue province are the most sensitive and vulnerable due to climate change. In recent years, the region's natural and environmental resources have been severely compromised and threatened by people's livelihoods. Risks from natural disasters such as storms, floods, flash floods, mountain landslides, riverbank erosion, and drought... has made life difficult for people in the hilly and mountainous areas of Thua Thien Hue province. On the other hand, most of the population depends mainly on the exploitation of various forms of natural resources, especially land and forest resources, which have put tremendous pressure on the upstream ecosystems of rivers. To minimize adverse impacts on nature and improve material and spiritual life for ethnic minority communities, The problem for this territory is the need for an overall development strategy with mining solutions, rational use of resources, and environmental protection to promote the advantages and potentials of localities. In particular, the selection of sustainable livelihood models suitable to natural conditions, natural resources, climate change, lifestyle, and farming practices of ethnic minority communities in an appropriate way will increase sustainability on all three fronts: economy, ecological adaptation, climate, and environmental protection, society. In the study, we used field methods, in-depth interviews, and SWOT analysis to assess the status, strengths, weaknesses, opportunities, and challenges of developing household livelihood models. On that basis, the study compared the sustainability of each livelihood model by the value scale method. The results show that the proposed livelihood models replicated and applied include: (1) Forest - Garden - Pond - Barn, (2) Orchard, (3) Garden – Ponds – Stables, (4) Forest gardens, (5) Upland forests or grazing grounds. One of these models has been applied in agricultural production and has been effective. We believe that the need to expand these models has increased sustainability in production. In addition, the study also suggests additional solutions to increase the sustainability of elements of the livelihood model, such as applying science and technology to production, increasing capital, raising people's awareness, and needing support policies for hill and mountain areas. These results will be the scientific basis to help local leaders make land use planning and socio-economic master development planning, used to review and adjust agricultural and forestry development policies and tourism in a sustainable way in the future.

References

1. Apraku, A., Morton, J. F., & Apraku Gyampoh, B. (2021). Climate change and small-scale agriculture in Africa: Does indigenous knowledge matter? Insights from Kenya and South Africa. Scientific African, 12, e00821. https://doi.org/10.1016/j.sciaf.2021.e00821
2. CARE Vietnam. (2013). Climate Vulnerability and Capacity of Ethnic Minorities in The Northern Mountainous Region of Viet Nam. 28. http://www.care.org/sites/default/files/documents/CC-2013-VNM-CARE_ClimChg_Vietnam.pdf
3. Delisle, S., & Turner, S. (2016). 'The weather is like the game we play': Coping and adaptation strategies for extreme weather events among ethnic minority groups in upland northern Vietnam. Asia Pacific Viewpoint, 57(3), 351-364. https://doi.org/10.1111/APV.12131

4. Dung, T. D., & Son, H. N. (2017). Current satus and solutión to developing tourism in highland districts of Thua Thien Hue province. Hue University Journal of Science, 126, 5-14.
5. Dung, T. D., & Son, H. N. (2020). Orientation of links to develop tourism products in the mountain districts of Tri - Thien area. Review of Regional Sustainable Development. Vietnam Academy of Social Science, 2.
6. Hang, A. P., Thang, V. Le, Tuan, A. T., & Son, H. N. (2021). An Environmental Zoning for Sustainable Development in Thua Thien Hue Province, Vietnam. Global Changes and Sustainable Development in Asian Emerging Market Economies. https://doi.org/https://doi.org/10.1007/978-3-030-81443-4
7. Lang, C. P. Le, Son, H. N., Cham, D. D., Bay, N. T., Bao, Q. P., & Cuong, X. N. (2022). Cooling island effect of urban lakes in hot waves under foehn and climate change. Theoretical and Applied Climatology. https://doi.org/https://doi.org/10.1007/s00704-022-04085-6
8. Le Phuc, C. L., Nguyen, H. S., Dao Dinh, C., Tran, N. B., Pham, Q. B., & Nguyen, X. C. (2022). Cooling island effect of urban lakes in hot waves under foehn and climate change. Theoretical and Applied Climatology, 149(1-2), 817-830. https://doi.org/10.1007/s00704-022-04085-6
9. McElwee, P., Tuyen, P. N., Hue, V. T. Le, Huong, D. T. V., Be, V. N., Tri, Q. Le, Trung, H. N., Tuan, A. Le, Dung, C. Le, Duat, Q. Le, Phuong, T. D., Dung, T. N., & Adutt, G. (2010). The social dimensions of adaptation of climate change in Vietnam : The social dimensions of adaptation of climate change in Vietnam. The World Bank.
10. Mugi-Ngenga, E. W., Kiboi, M. N., Mucheru-Muna, M. W., Mugwe, J. N., Mairura, F. S., Mugendi, D. N., & Ngetich, F. K. (2021). Indigenous and conventional climate-knowledge for enhanced farmers' adaptation to climate variability in the semi-arid agro-ecologies of Kenya. Environmental Challenges, 5(August), 100355. https://doi.org/10.1016/j.envc.2021.100355
11. Nguyen, S. H., Dao, C. D., Phan, H. A., Nguyen, Q. T., & Le, T. A. (2022). Climate Change Vulnerability of Agriculture in Coastal Communes of Quang Tri Province, Vietnam. Global Changes and Sustainable Development in Asian Emerging Market Economies Vol. 2, 2, 579-597. https://doi.org/10.1007/978-3-030-81443-4_37
12. Phan, H. A., Van Le, T., Tran, T. A., & Nguyen, S. H. (2022). An Environmental Zoning for Sustainable Development in Thua Thien Hue Province, Vietnam. Global Changes and Sustainable Development in Asian Emerging Market Economies Vol. 2, 2, 817-841. https://doi.org/10.1007/978-3-030-81443-4_52
13. Son, H. N., Cham, D. D., Mai, T. T. T., Tin, V. Le, Hang, A. P., Lang, C. P. Le, & Quan, T. N. (2017). GIS application in assessment on environmental management and natural resources of communes in Thua Thien - Hue province. Proceeding of the International Conference on Earth Observation & Natural Hazards 2017 (Iceo 2017). ISBN: 978-604-913-650-4.
14. Son, H. N., Mai, T. T. T., & Lang, C. P. Le. (2013). Raising Awareness Education and Response Capability with Climate Change for the Residential community in Mid-central Coastal Provinces of Vietnam. The International Journal of Education Administration and Development 4(2): 812-818. Mahasarakham University, Thailand.
15. Son, H. N., Mai, T. T. T., Lang, C. P. Le, & Tin, V. Le. (2014). Raising Awareness of Environment and Resource Management Among People in The Coastal Area of Thua Thien Hue Province. The 7th International Conference on Educational Reform (ICER 2014).

16. Son, H. N., & Quan, T. N. (2021). Assessing the level of vulerability due to climate change in extremely poor coastal communes in Quang Binh, Quang Tri, and Thua Thien Hue provinces, VietNam. Prace i Studia Geograficzne, 133-150. https://doi.org/10.48128/pisg/2021-66.2-08
17. Son, H. N., Tin, V. Le, Chan, V. M., Thinh, H. P., Tu, X. D., & Dan, N. N. (2022). Assessing the status of landslides along key transport routes in Thua Thien Hue province during the stormy season in 2020. International Symposium HANOI GEOENGINEERING 2022 INNOVATIVE GEOSCIENCES, CIRCULAR ECONOMY AND SUSTAINABILITY.
18. Thua Thien Hue Statistics Office, 2021. (2021). Thua Thien Hue Statistical Yearbook 2020. Statistical Pubblishing House.
19. Van Mai, C., Nguyen, S. H., Dao, C. D., Le, T. Van, & Phan, H. A. (2022). A GIS Application in Optimizing the Collection and Transportation Route of Domestic Solid Waste in Hue City, Vietnam. Global Changes and Sustainable Development in Asian Emerging Market Economies Vol. 2, 2, 599-609. https://doi.org/10.1007/978-3-030-81443-4_38
20. Vermeulen, S. J., Aggarwal, P. K., Ainslie, A., Angelone, C., Campbell, B. M., Challinor, A. J., Hansen, J., Ingram, J. S. I., Jarvis, A., Kristjanson, P. M., Lau, C., Thornton, P. K., & Wollenberg, E. K. (2010). Agriculture, food security and climate change: Outlook for knowledge, tools and action. CCAFS Report, 3. https://cgspace.cgiar.org/handle/10568/3090
21. National strategy on climate change -Decision 2139/QĐ-TTG on December 05, 2011, Central Government Office (2011).
22. Vu, D. N., & Son, H. N. (2004). The effects of climate on ecotourism in Thua Thien - Hue province. Journal of Sciences of the Earth, 26(2), 181-187.

Remote Sensing and GIS in Dengue Vulnerability in Urban Jaipur Area, India

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Abstract. Vector-borne diseases (VBD) like Malaria, Dengue, Japanese encephalitis (JE), Kala-azar, Lymphatic Filariasis, and Chikungunya are common in India. There are many different kinds of vectors, such as mosquitoes, aquatic snails, blackflies, fleas, lice, sandflies, ticks, etc. most of these vectors are common in India. India is a tropical country, which makes it a good place for pathogens and parasites to grow and spread and for vectors to live. One of the characteristics that aid in vertical disease transmission is population distribution and makeup. Individuals and governments alike pay a high price for vector-borne illnesses. Individuals and their families may incur costs such as the purchase of treatments and preventive measures, missed work days, and funeral costs in the event of death. The supply and staffing of health facilities, public health initiatives, and missed possibilities for economic growth and tourism are all costs to governments. The city of Jaipur is a major tourist destination, with a constant growth rate of 3% and a population density of 6,500 people per square kilometre, as per latest surveys (Indian Census web site). Henceforth, this study was to assess the vulnerability of the urban Jaipur population to dengue virus infection. The proximity and exposure, to vector habitat and climatic parameters such as temperature and precipitation were evaluated and assimilation of aspects of vulnerability the (total population, ward wise population density, Literacy rate, social and cultural practises, waste management) as significant factors ambulating weightage for vulnerability indicators. The total population of the urban Jaipur depicts span of people that might fall prey to dengue infection, the density of population portrays the rate of vertical transmission of the virus among the populace, literacy rate displays that the high education relates to the awareness for precaution and technique to control vector breading and transmission, working class population depicts the exposure to viral transmission. Along with these paradigm vector prevalence and habitat directly relates to the Dengue Virus Transmission consequently exposing large share of vulnerable urban population.

Based on assimilation of all the determining factors the outcome of the study depicts that the dense populace areas. The male population contributes to 67% of the total dengue cases where as only 33 % of female population, of which the 15 to 24 age group manifest the dengue virus infection in both male and female population. This dengue cases reports are cyclic in nature with the precipitation and temperature ranging between 25 to 30degree. The entire north and north-western area of the urban Jaipur is Vulnerable to dengue during monsoon and post monsoon season.

Key words: GIS, Vector Born Disease, Dengue, Remote Sensing, Jaipur.

1. Introduction:

The dynamics of the earth's phenomena and interactions between diverse components, like land, agricultural land cover and land use, are all important to human well-being (Adrizain et.al. 2018). Vector-borne illnesses are one such phenomenon which directly negatively affects

humans. These are diseases that affect humans or other animals are spread by blood-feeding living organisms such as mosquitoes, ticks, and fleas (Boroushaki et.al. 2010; Focks et.al., 2000). Vector borne diseases were mostly fatal till about a century ago, because neither were the diseases identified due to lack of medical knowledge, nor were there any remedies known for the same (Sarfraz et.al., 2012; Husnina et.al., 2019; Stanaway et.al., 2016).

Despite the advancements of medical sciences were and are enjoyed by the developed countries, most of the developing Third World countries are still coping with the problem of vector borne diseases. There are number of Vector Borne Diseases Malaria, Dengue, Kala-azar/ Leishmaniasis, Filariasis, Japanese Encephalities (JE), Chikungunya. About 390 million dengue virus infections occur each (Dash et.al., 2013; Thomas et.al., 2013). Asia bears 70% of the burden of dengue infection and it has grown by more than 8-fold in past two decades, Unfortunately, newer region like the European countries, where earlier there were no cases are now facing explosive outbreaks. In 2019, the world had the highest number of dengue cases ever recorded. Such a widespread of the disease across continents in the past few decades might be due to globalisation, and the movement of people across countries and continents in much bigger numbers than before, thus resulting in a greater spread of the disease and posing many people at risk.

2. Study Area:

Rajasthan is one of India's dengue-endemic states. Due to the lack of water, residents in arid locations overstore household water, allowing dengue vectors to thrive inside the home. Water storage behaviours throughout the summer season have been identified as a risk factor for vector abundance in dry and semi-arid urban locations. Many dengue outbreaks have been documented in Rajasthan (Fig.1).

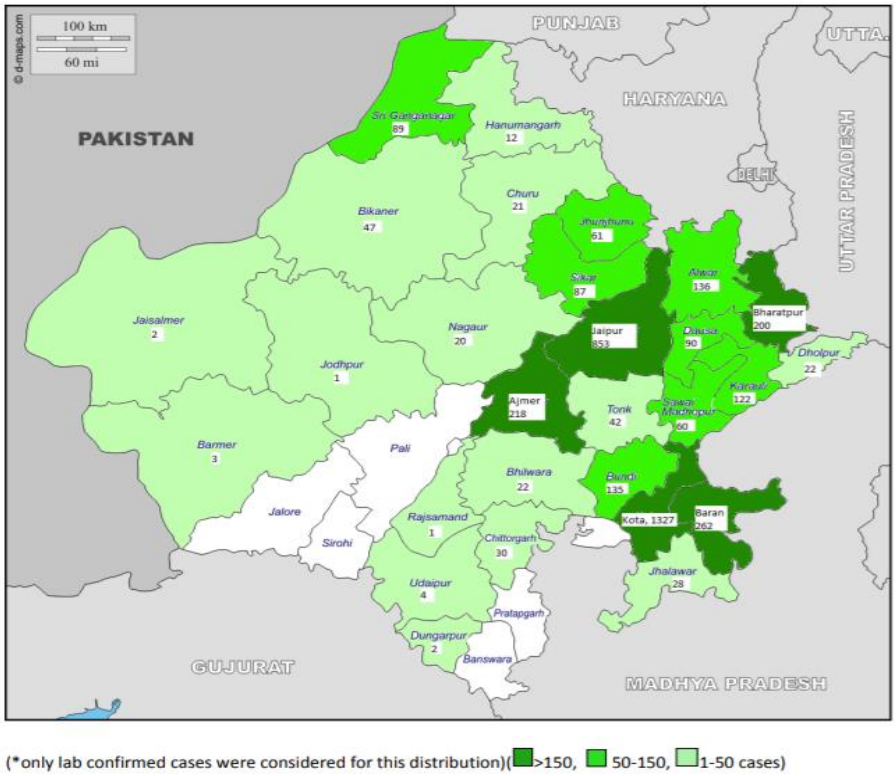

Fig.:1. Dengue Confirmed Cases in Rajasthan Districts, 2015.

The study area, Jaipur was founded in 1727 by Maharaja Sawai Jai Singh and it was a walled city, surrounded by hills. Jaipur has a hot, semi-arid climate with more than 63 cm of annual rainfall. The summer months records high Temperature, with heavy rain,

thunderstorms, and hail during the monsoon season and a fairly cold winters. Jaipur's population grew more than tripled since 1991 to 2011 (Fig.2).

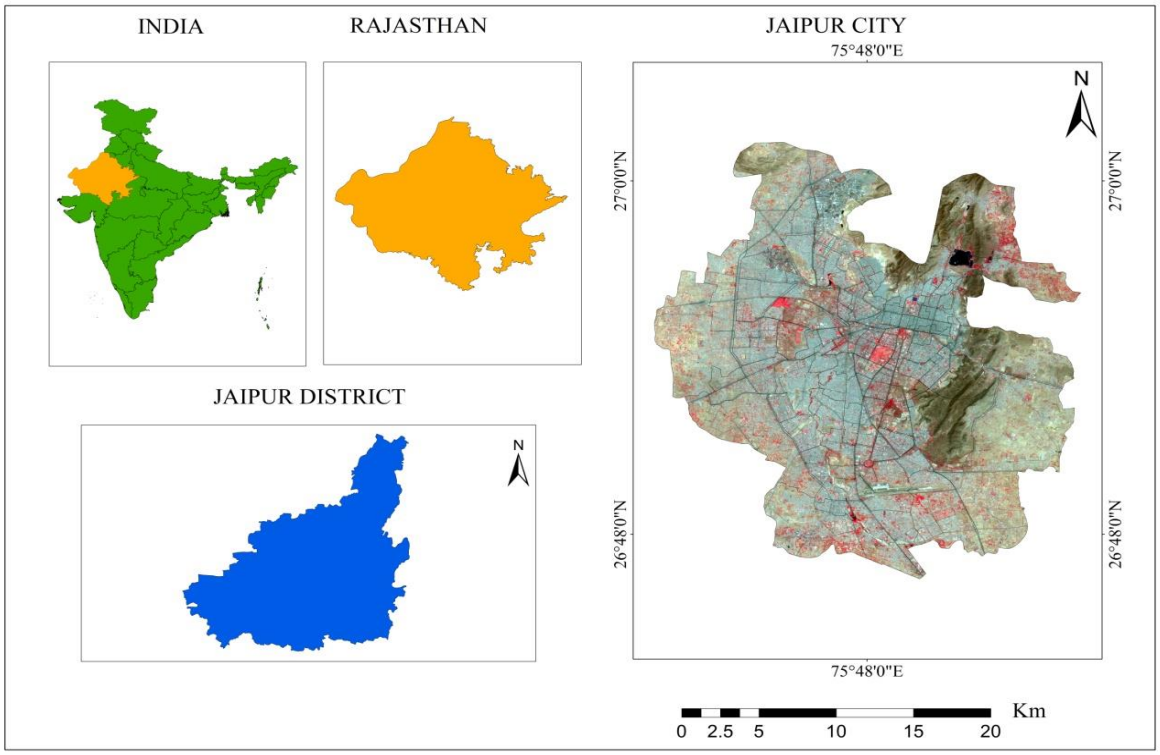

Fig :2. Study Area

Municipal Corporation and Jaipur Development Authority are in charge of the city of Jaipur (JMC & JDA). For administrative convenience, it has been divided into ten administrative zones and further in to wards. The administration of the city's municipal infrastructure and the management of administrative activities are the responsibility of the Jaipur Municipal Corporation. An elected official represents each of the city's wards. The planning and development of Jaipur, which is divided into two parliamentary constituencies: Jaipur and Jaipur Rural is done by the Jaipur Development Authority or the JDA.

3. Objectives:

All the geographical factors play a cardinal role in calculating the risk areas of dengue transmission. It also helps identify the critical areas for the out breaker of the vectors and the disease hotspot.

The main aim of this study is:

To determine the vulnerability of the city, equal weightage is given to each of the vulnerable factors.

4. Data Used and Methodology:

During the study, Census 2011 data for Jaipur city were used for demarcating socioeconomic aspects associated to dengue vulnerability, like population density. Furthermore, for demarcation of various hazard parameters like vegetation density cover, agriculture area and land use land cover. The method for Risk analysis of vector born disease with specific focus on Dengue. Dengue Risk Analysis (DnRA), layers using Geospatial techniques, the data like vectors breading and survival, socio-economic data and administrative ward data. Then hazard and vulnerability factors were integrated to generate risk assessment.

Dengue has come up as urban source of plight, dengue involves several factors transmission. The entomological factors, habitat, temperature and precipitation for the vector breeding and survival, in other words in simple understanding there is physical aspect, climatic aspect. Here, fourth calculation of risk was done by ambulating hazard and vulnerability to the disease in the city.

DnR=hazard*Vulnerability

Thus, if any of the factors like hazard or vulnerability increase will increase dengue risk (DnR).

5. Result and Discussion

Risk assessment

The identification could be developed through assigning weightage to each the elements of hazard are land use-land cover, climatic variation, ground water condition, Potential breeding habitat which are derived from Container Index and Breteau Index conducted for the study area.

Elements of vulnerability are total population, ward wise population density, literacy rate, main working class, socio-cultural habits like water storage, city waste management and waste disposal, application of mosquito protection measures. The ambulation of weightage of all the elements of vulnerability results in vulnerability indices. The Hazard indices (Hi) and Vulnerability (Vi) is then verified with the lab confirm cases of dengue over the decade.

Hazard

The relation of land use land cover change is directly associated with vector breeding and change in vector habitat. Dengue vector has evolved into the urban environment. The other factor which attracts the vector to the human dowelling is the carbon dioxide (CO2), hence is assumed that the closer the dowelling or housing are there higher the chances of the Aedes mosquitos' density will be found. Therefore, the change in the LU/LC pattern in the city has affected the dynamics of the dengue occurrence in the city (Fig. 3).

Agricultural: On damp soil or in containers, the female Aedes mosquito lays its eggs.

Forest cover: The forest cover/vegetation cover plays a vital role in species survival.

Land Use Land Cover (LU/LC): Changes in land usage land cover are intimately linked to changes in vector breeding and habitat. To survive in the urban environment, **Aedes needs temperatures between 25°C to 28°C**, which is also the perfect temperature for human doweling. The carbon dioxide (CO_2) also draws the vector to human dwellings.

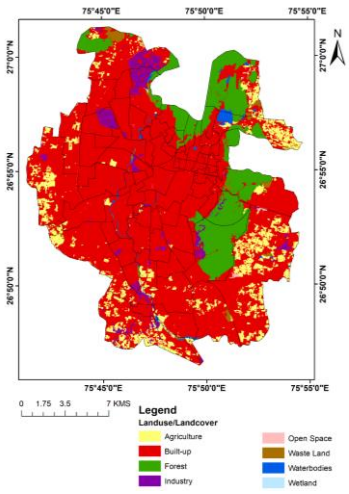

Fig. 3: Vegetation Cover, Agriculture and LU/LC.

Temperature: In the life cycle of Ades mosquitos, temperature is the most crucial factor to consider. They are particularly vulnerable to heat stress since their bodies are unable to regulate their own temperature. As a result, this species has developed to be adaptable to a variety of environmental conditions (Fig. 4 & 5).

Temperature has an impact on mosquito development, host seeking and feeding behaviour, and infection growth, all of which are important in supporting horizontal viral transmission from the environment to the vector or the vector to the environment.

Precipitation: Because of the moisture brought by the monsoon, the temperature can be maintained at an ideal level while also providing the bare minimum of moisture necessary for the hatching of an egg into a pupa, which needs water to live. The pupa hung upside down at an angle and breathes via a syphon that absorbs oxygen from the surrounding environment; following this stage, it grows into adult mosquitoes and reproduces.

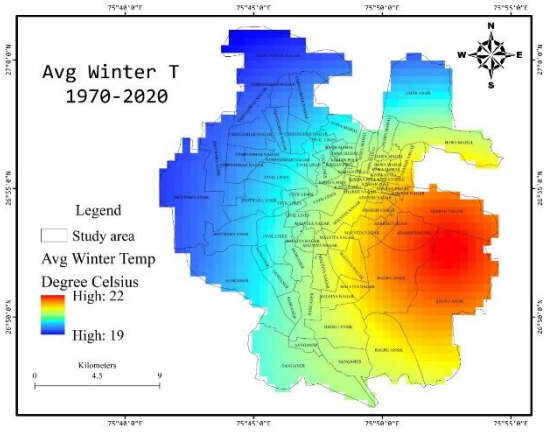

Fig.: 4. Average winter Temperature of past five decade

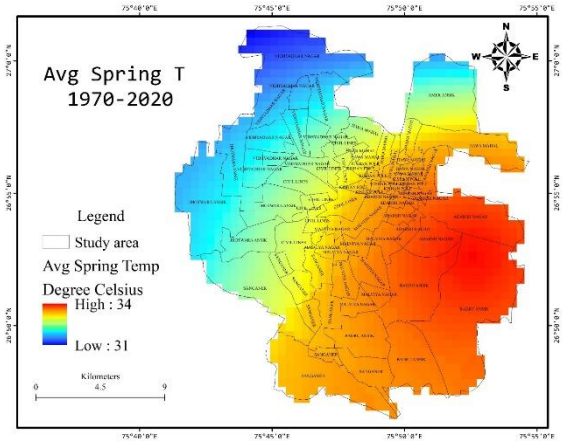

Fig.5: Average Spring Temperature of past five decade

For identifying Aedes prevalence in the residential areas in city, data have been collected from houses in the city where many households have tested positive with aedes mosquito larva, specifically found in all kind of water holding like flower pots, drain, overhead water tanks etc. among which the table Breteau Index. Through this surveillance it was seen that the most part of city falls in the range of moderate to high percentage of vector density (Fig.6).

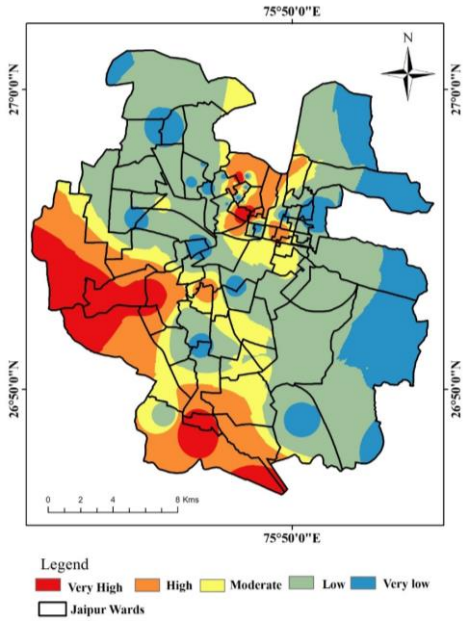

Fig.: 6. Breteau Index (BI) Map

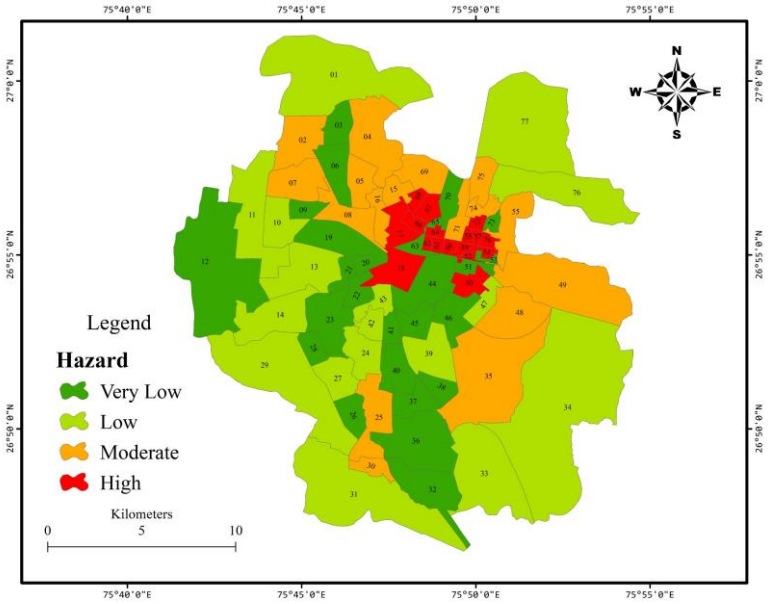

Fig.7. Risk Assessment Map of Dengue Infection

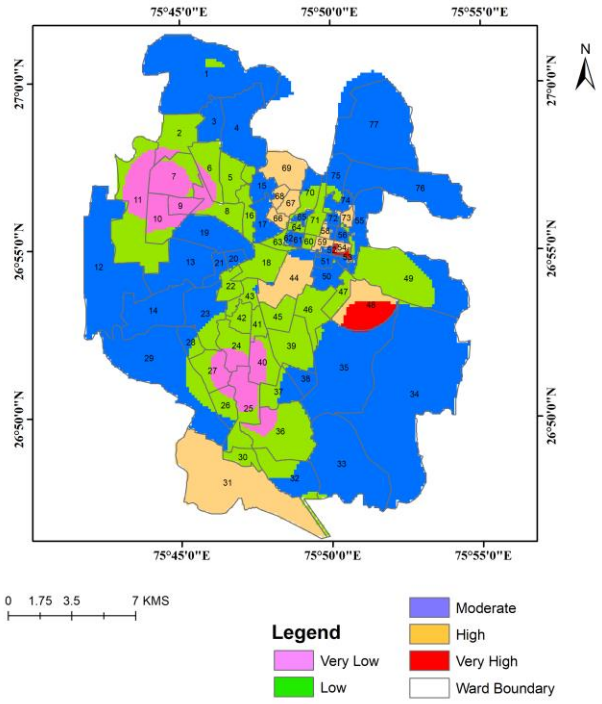

Fig .8. : Vulnerability Assessment Map of Dengue Infection

For vulnerability indices, parameters like total city population, population density, and literacy rate, and based on field survey study conducted for sociocultural determents for dengue cases are analyzed with the lab-confirmed dengue cases in the city (Fig.8). By overlaying all the determents, which increase the vulnerability of the population in the city. Thus, each factor was given weightage as to how it affects the dynamics of dengue cases in the city

6. Conclusion:

The vulnerability component for the analysis of dengue occurrence has a very close relation to the city's total population.

The vertical transmission is more where there is a high population density; thus, parameters make the high populace region more vulnerable to dengue prevalence.

Education plays a significant role in the dengue incidence; it has been observed through survey conducted that the high educated households are more aware of the precaution needed to control vector breading and measures taken to prevent mosquito bites. Therefore, the percentage of literacy in the region is considered in the vulnerability component.

The working class also has a significant contribution to the spread of Dengue from human-to-human vis vector transmission.

References:

1. Adrizain R, Setiabudi D, Chairulfatah A. Hospital-based Surveillance: Accuracy, Adequacy, and Timeliness of Dengue Case Report in Bandung, West Java, Indonesia of 2015. J Glob Infect Dis. 2018; 10:201–5. https://doi.org/10.4103/jgid.jgid_108.
2. Boroushaki S, Malczewski J. Using the fuzzy majority approach for GIS-based multicriteria group decision-making. Computers & Geosciences. 2010; 36:302–12.
3. Dash AP, Bhatia R, Sunyoto T, Mourya DT. Emerging and re-emerging arboviral diseases in Southeast Asia. J Vector Borne Dis. 2013; 50:77–84.
4. Focks DA, Brenner RJ, Hayes J, Daniels E. Transmission thresholds for dengue in terms of Aedes aegypti pupae per person with discussion of their utility in source reduction efforts. The American journal of tropical medicine and hygiene. 2000; 62:11–8.
5. Husnina Z, Clements ACA, Wangdi K. Forest cover and climate as potential drivers for dengue fever in Sumatra and Kalimantan 2006–2016: a spatiotemporal analysis. Trop Med Int Health. 2019; 24:888– 98. https://doi.org/10.1111/tmi.13248.
6. Stanaway JD, Shepard DS, Undurraga EA, Halasa YA, Coffeng LE, Brady OJ, et al. The global burden of dengue: an analysis from the Global Burden of Disease Study 2013. Lancet Infect Dis. 2016; 16:712– 23. https://doi.org/10.1016/S1473-3099(16)00026-8.
7. Sarfraz MS, Tripathi NK, Tipdecho T, Thongbu T, Kerdthong P, Souris M. Analyzing the spatio-temporal relationship between dengue vector larval density and land-use using factor analysis and spatial ring mapping. BMC Public Health. 2012; 12:853. https://doi.org/10.1186/1471-2458-12-853.
8. Thomas SJ, Endy TP. Vaccines for the prevention of dengue: development update. Human vaccines. 2011; 7:674–84. https://doi.org/10.4161/hv.7.6.14985 5. Bhatt S, Gething PW, Brady OJ, Messina JP, Farlow AW, Moyes CL, et al. The global distribution and burden of dengue. Nature. 2013; 496:504. https://doi.org/10.1038/nature12060.

Research on solutions to enhance flood drainage capacity to minimize damage in coastal areas of Vu Gia - Thu Bon River basin, Quang Nam province

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Abstract. Through the study and analysis of the impacts of the Da Nang - Quang Ngai expressway on the flood flow regime and inundation in the Vu Gia - Thu Bon River basin (part of Quang Nam province), the flooded area has been greatly reduced. increased to nearly 9 km^2, total flooding time increased by 84 hours for 5% flood frequency (2007) [3]. Therefore, in order to enhance the flood drainage capacity for Vu Gia - Thu Bon basin, the article proposes a solution to expand the sewers at locations on the highway [2], in which, using the MIKE model. FLOOD to assess flood drainage capacity in coastal areas of Quang Nam province. The model results show that the solution to expand the sewers increases the drainage capacity at the expanded locations, the flood direction is concentrated in the expanded locations, however, to make the flood drainage more effective. It is necessary to combine further studies on the construction of the Flood Corridor.

Keywords: MIKE FLOOD; FLOOD; Vu Gia – Thu Bon

1. Introduction

Quang Nam province has a large area (10,406 km^2) located in the Central Central region of Vietnam in the central key economic region. In recent years, the province's economic development has made strong leaps and bounds. In 2018, the province's total product reached 68,100 billion VND, an increase of 8.11% compared to 2017. In the future, Quang Nam will double the size of the economy in the next 5 years and become a good province. income by 2025, turning Quang Nam - Da Nang - Quang Ngai into a new growth pole with pervasive power in the central region.

The annual flood season in the Thu Bon - Vu Gia River system is from October to December but accounts for 60-65% of the total annual flow. In each flood season, there are usually 3-5 large floods exceeding alarm 1. Therefore, floods in the Thu Bon - Vu Gia River system rise rapidly, descend rapidly with large flood amplitude and intensity in the upper and middle areas. The flood rises relatively quickly but recedes slowly downstream.

In the flood season, the flow in the upstream has a high speed, the flood is concentrated quickly and pours into the delta, the plain has a small slope, the river bed is shallow, the riverbank is straight, the estuaries are often filled and narrowed leading to the flood drainage capacity is poor, most of the flood flows when approaching Ai Nghia and Giao Thuy station overflowed their banks and flooded the entire lower river. Floods are often consecutive and occur in a short time, so floods rise and fall quickly with great intensity in the upper and middle areas, but rise quickly and recede slowly in the downstream, causing prolonged flooding on a large scale, causing many damages. heavy loss of life and property to people in the delta. According to monitoring data over the past 40 years, there have been some particularly large floods such as floods of 1998, 1999, 2007, 2009, 2013, 2017, 2018, 2020. Due to the

characteristics of the basin, the flood season, the flow in the upstream has a high speed, the floods are concentrated quickly, and the river delta has a small slope, the bed is shallow, the riverbank is straight, the estuaries are often alluvial and narrow, leading to the possibility of flood drainage. The majority of flood flows near Ai Nghia and Giao Thuy station overflowed their banks and flooded the entire lower river. In terms of flood shape here, it is mainly a double flood with 2-3 individual peaks to 5 consecutive peaks (1998). Being affected by storms, tropical depression or cold air, it often rains over large and large basins. Total rainfall per day is the highest in some places, such as: Tam Ky 433mm (December 10, 2018) compared to 405mm (December 3, 1999), Cau Lau 608mm (December 10, 2018) compared to 542mm (November 3, 1999), so although the flood on the river is not large, the flood situation in the downstream area is very large. Areas in Thang Binh district were flooded for nearly one meters, National Highway 1A, the section through Thang Binh and Que Son districts, was deeply flooded, in some places up to 1 meter deep, making traffic here paralyzed. Heavy rains in Quang Nam killed 4 people, washed away thousands of livestock and poultry, and damaged many traffic and irrigation works.

In the north-south direction, there are four main and important national highways in Quang Nam province (from west to east, the length of Ho Chi Minh Road is 175 km, the length of Da Nang - Quang Ngai highway is 90 km, the length of national Highway 1A is 85 km and the length of coastal road is 48 km). In the East - West direction, there are length of national highways 14B is 42 km, length of national highway 14D is 74.4 km, length of national highway 14E is 89.4 km. In addition, there are 20 inter-provincial roads with a total length of about 465 km and rural and urban roads with over 7,905 km. The system of roads running parallel to the coastline crosses the basin with an elevation of about 1 - 5 m higher than the topographic elevation and together with the connecting road system has become a system of dikes that divides the natural space. helping to store and drain floods, etc. Although there are many locations of drainage pipes along the route, the aperture is still not meeting the requirements. Besides, the commune and inter-commune roads are actively built by people to travel in the flood season and almost no flood drainage works are arranged, making the level of inundation more serious [3].

In our country, the national transport system places too much emphasis on roads and leads to the shaping of an urban system that is mainly associated with the road transport system and the central coastal region, the urban system is mainly formed on deltas, or in estuaries, with low terrain that is both influenced by high tides and has a high risk of flooding because the rivers are very short, and the water will accumulate very quickly. With the common form given for low ground areas is the regulation of the foundation beyond the level of inundation. But raising the local foundation of each project, without a comprehensive urban strategic plan will lead to distortion of natural topographic conditions. The problem of flooding is not solved, but moves from one place to another and no longer follows the topographic logic, so it is difficult to determine at the overall level. On the other hand, the sharp increase in concreting also causes the amount of surface water to be concentrated in the culvert in a short period of time, increasing the risk of flooding.

This paper uses MIKE FLOOD model to study solutions to enhance flood drainage capacity to minimize damage in coastal areas of Vu Gia - Thu Bon River basin, Quang Nam province. Research results help planners have an overview of flooding in coastal areas of Quang Nam province, serving warning, forecasting and disaster prevention.

2. Methodology

Flood inundation simulation: Currently, there are many models that have been used to simulate the hydraulic regime of river systems. Each model has strengths, either in hydraulic theory and mathematics, or in practical application, or in the utility of analysis of results. Based

on the collected data, the paper uses the MIKE model set with the modules Mike Nam, Mike 11, Mike 21 and Mike Flood to determine flood and inundation in the lower Vu Gia - Thu Bon and thereby giving specific impacts of roads on the flood situation in the river basin.

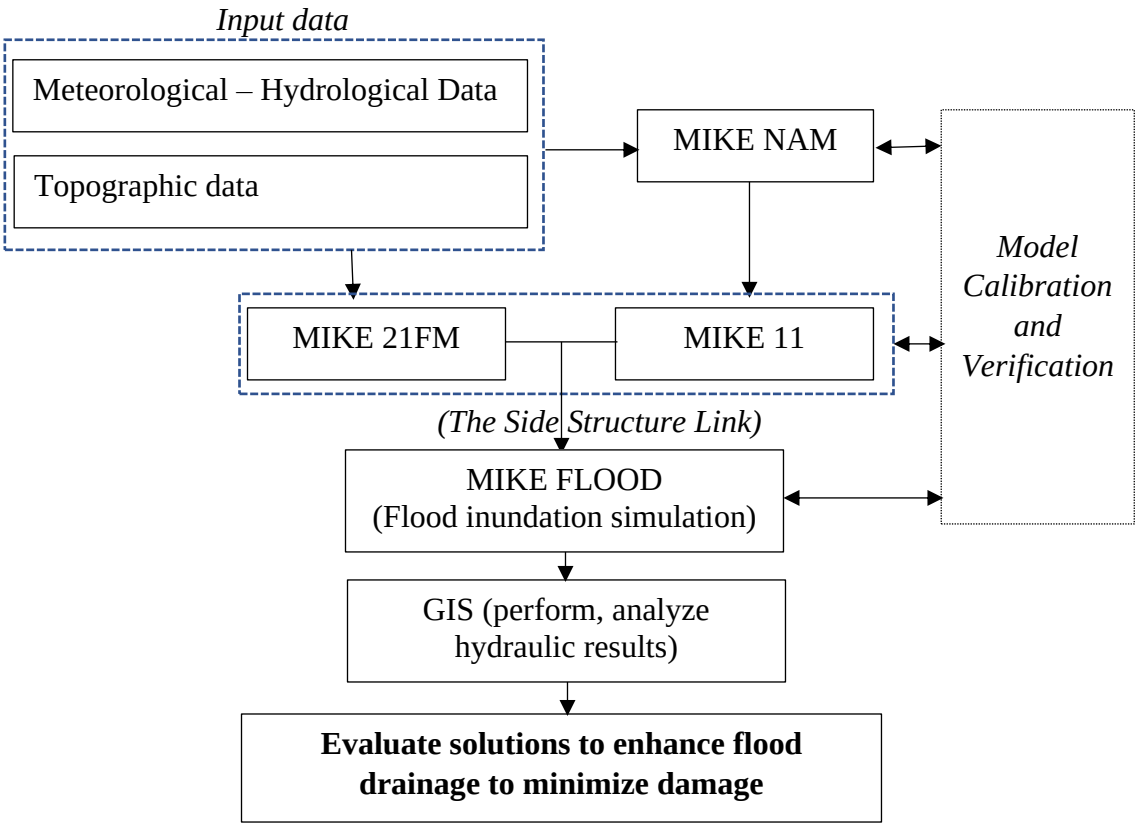


Fig 1. Diagram of Evaluate solutions to enhance flood drainage to minimize damage

3. Study area and Data used

3.1. Study area

Vu Gia – Thu Bon river system is originated in the Truong Son mountain range at the elevation of 1,600m [7]. The system is formed by two main rivers, namely Vu Gia and Thu Bon, flowing through major part of Quang Nam province and discharging into the sea at three inlets named Han, Dai va Lo.

3.2. Data used and setup model

* *Meteorological - hydrological data:* The series of rain measurement data at stations from 2000 to 2020, hydrological documents of 5 measuring stations of hydroelectric power plants and other measuring points: Ai Nghia station, Nam My station (Cu De river), Hoa Phu (Tuy Loan river), A Vuong Hydropower (A Vuong river), Song Con 2 Hydropower (Con river).

* *Topographic data:* The digital elevation model (DEM) was built based on the topographic map of 1/10,000 issued by the Ministry of Natural Resources and Environment [2,5], corrected by remote sensing data in 2020 and additional topographic survey data in 2020;

River cross-sectional data were collected through topographic surveys on 19 rivers conducted by staff of the Institute of Geography in the years 2010, 2015, 2020 according to the VN2000 national coordinate system; Since then, a digital elevation model (DEM) has been built that combines the topography of the river bed with the topography of the delta, the Mike 11GIS Module is used to determine 785 river cross-sections throughout the system.

* *Setup MIKE 11 model:* Based on the collected data and the map of river and stream network in the river basin digitized from satellite images, the hydraulic network of Vu Gia-Thu Bon river basin is established on the Mike 11 model as follows:

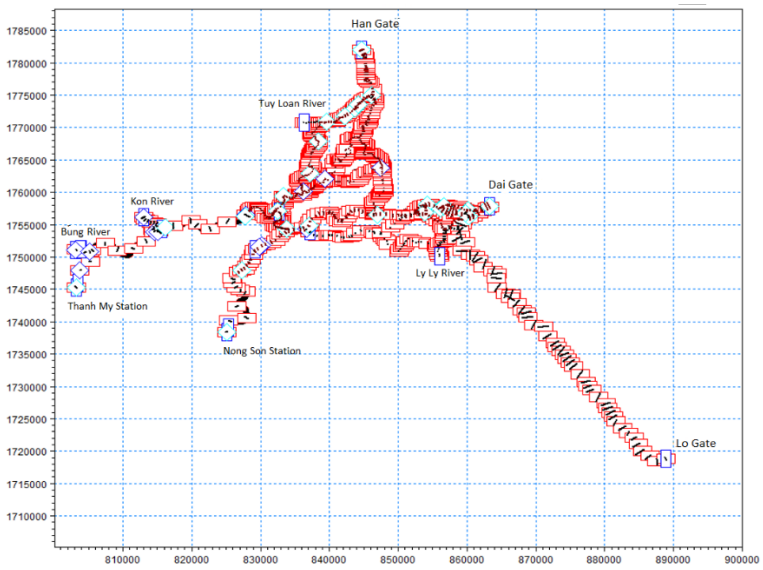


Fig 2. Setting the cross-section on the hydraulic diagram MIKE 11 [2]

The boundary condition used in the model is that the upper boundary is the flow process data at Nong Son and Thanh My control stations; discharge data of hydropower reservoirs, the lower boundary is the process of water level at Han and Cua Dai mouths.

Checking stations: is the process of water level measured at the Ai Nghia, Cam Le stations on Vu Gia River. Giao Thuy and Cau Lau stations on Thu Bon River.

* *Setup MIKE 21FM model [5]:* On the basis of the research domain has been determined and built a triangular grid to proceed to set up the MIKE 21FM model for the research domain. Mike 21FM model is established on the basis of topographic file, coefficient of roughness and rain joining the middle zone. Terrain data are mined from topographic maps at scale 1/10,000.

* *Define the links in MIKE FLOOD [5]:* Use the Side Structure Link method to connect the side between the MIKE 21FM model and the MIKE 11 model. The tributaries in the Mike 11 model are connected to the right and left banks with the topographic map in MIKE 21FM. The bridges in MIKE 11 are connected with the standard structure upstream and downstream of the building with the topographic map in MIKE 21FM.

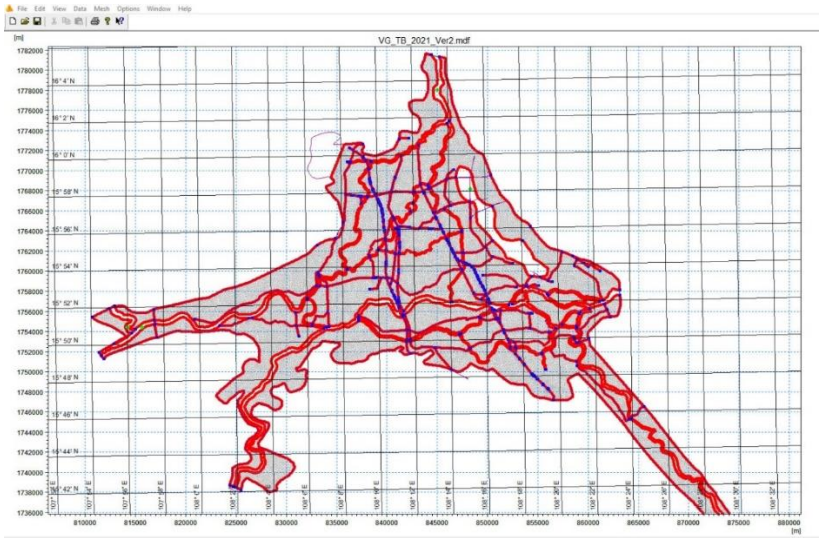


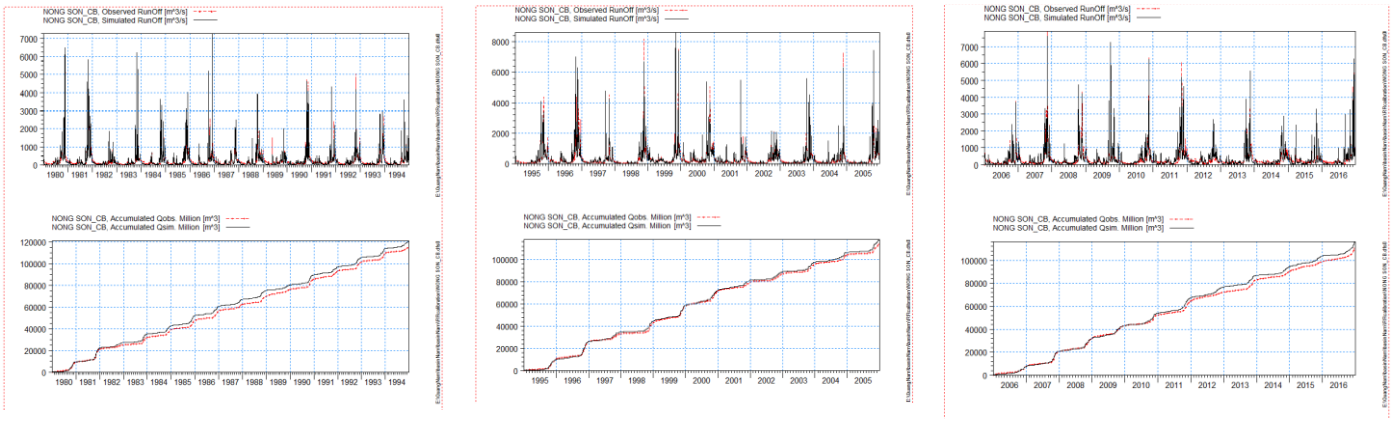
Fig 3. Define the links in MIKE FLOOD.

** Model Calibration and Verification*

- MIKE NAM model: Results of calibration of MIKE NAM model parameters according to real data measured at Thanh My, Nong Son hydrological stations in the period from 1980-1994 and verification in the period from 1995-2005 give the results evaluated through the Nash coefficient and the correlation coefficient R2 as follows

Table 1. Reliability assessment index of MIKE NAM model in Vu Gia-Thu Bon basin

Station	Calibration (1980-1994)		Verification (1995-2005)	
	Nash	R2	Nash	R2
Nong Son	0.81	0.81	0.88	0.88
Thanh My	0.73	0.73	0.76	0.76



a) 1980-1994 *b) 1995- 2005* *c) 2006-2016*

Fig 4. Comparison of simulated and measured lines at Nong Son station

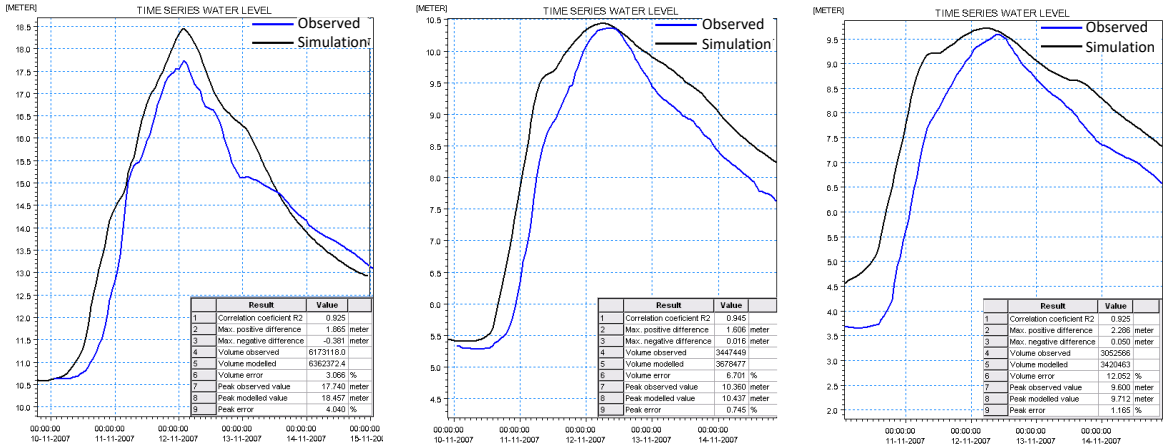
- MIKE 11 model: In this study, we choose the data of 2015 as the basis to calibrate the set of model parameters, the data of 1999 and 2007 to verification the set of model parameters because those years observed data is relatively full as well as the closest simulation time with topographic data, river cross-section.

Table 2. Result of verification in 1999 and 2007

Station / year	**Nash-Sutcliffe** (%)		
	Hoi Khach	Ai Nghia	Giao Thuy
1999	86.9	95.8	90.6
2007	9.2.5	94.5	92.5

Table 3. Comparing flood peak values at Cau Lau station

Year	Hobserved (m)	Hsimulation (m)	ΔH (m)
1998	5.09	5.03	0.06
1999	5.23	5.33	0.1
2007	5.39	5.53	0.14



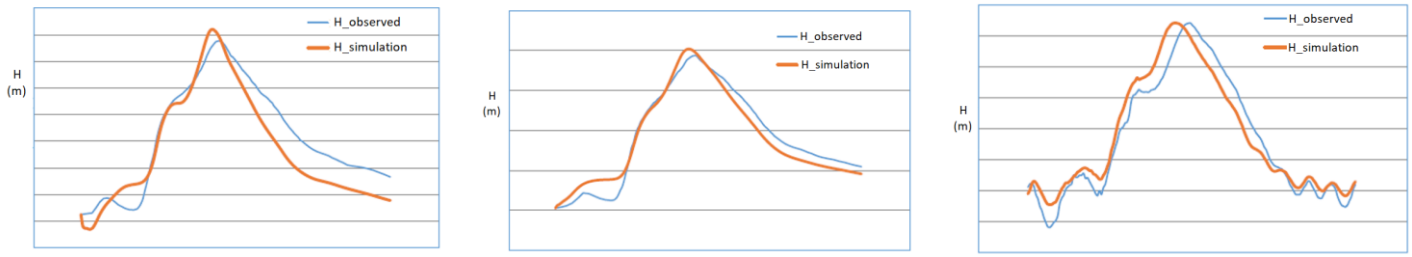
a) Hoi Khach *b) Ai Nghia* *c) Giao Thuy*

Fig 5. Result of verification with 2007 data

- MIKE 21FM model: Calibrating the model parameters by the flood from October 31 to November 11, 1999 and verification the model parameters with two other floods, the December 1999 flood and the flood from September 27 to October 03, 2009. The results of verification by the two floods above show that the actual water level process lines observed and simulation at the test stations are quite similar. The error value of the flood peak is relatively small (absolute values are all < 0.2m), the Nash coefficients are all larger than 0.8. This result shows that the parameter set of the hydraulic model that has been calibrated above is reliable enough to apply the simulation to the river basin within the research scope identified above.

Table 4. Flood simulation results from September 27 to October 3, 2009

No.	Hydrology stations	River	Nash-Sutcliffe
1	Ai Nghia	Vu Gia	0,83
2	Giao Thuy	Thu Bon	0,95
3	Cau Lau	Thu Bon	0,88
4	Hoi An	Hoi An	0,93



a) Ai Nghia *b) Giao Thuy* *c) Hoi An*

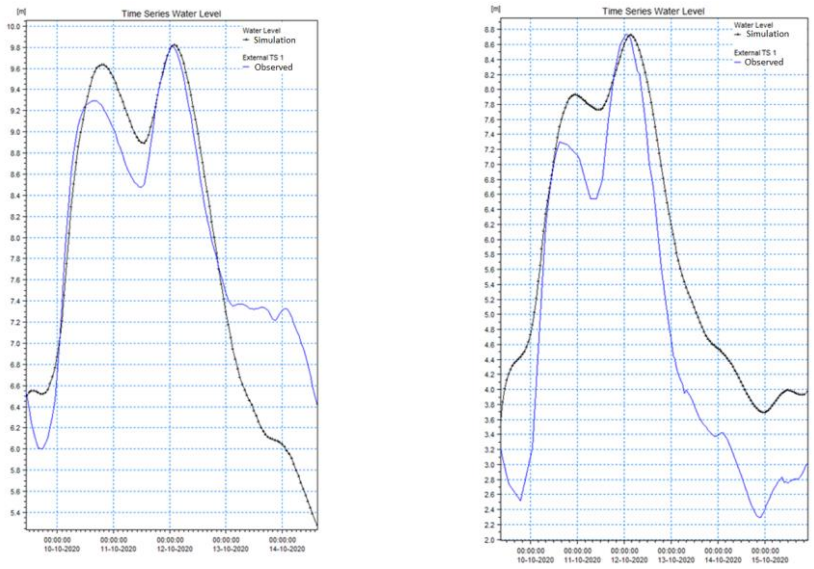
Fig 6. The simulation and observed water level of the 2009 flood

- MIKE FLOOD model: Calibration and verification with floods in 2007, 2009, 2017 and 2020 with good grade. The simulation results of the water level and the time of occurrence of the flood peak compared with the actual data measured at Ai Nghia, Giao Thuy and Hoi An stations show a small error.

Table 5. Comparison of time of occurrence and peak value of flood in 2009

Station	Simulation	Observed	ΔH

	Time of appearance	Hmax (m)	Time of appearance Thời gian xuất hiện	Hmax (m)	
Ai Nghia	29/09/2009 23:00	10.901	30/09/2009 01:00	10.74	0.161
Giao Thuy	30/09/2009 01:00	9.601	30/09/2009 01:00	9.6	0.001
Cam Le	30/09/2009 08:00	3.149	30/09/2009 07:00	3.13	0.019



a) Ai Nghia *b) Giao Thuy*

Fig 7. The simulation and observed water level of the flood in 2020

4. Result and Discussion

From the results of the study assessing the impact of the highway on flooding [3] it is shown that the Da Nang – Quang Ngai expressway has the clearest impact on the problem of increasing flooding because the road has a north-south direction, has an altitude of over 5m above the actual terrain surface and is located in the flooded area of the Vu Gia – Thu Bon river basin; Followed by the embellishment of National Highway 1A, the Unified Railway is also one of the impacts that increase flooding in terms of areas as well as the distribution of flooding, increasing the duration of flooding. Therefore, the paper proposes a solution to expand 3 times the culverts on Da Nang – Quang Ngai highway, National Highway 1A and railway to consider the possibility of flood drainage for the coastal area of Vu Gia – Thu Bon river basin in Quang Nam province.

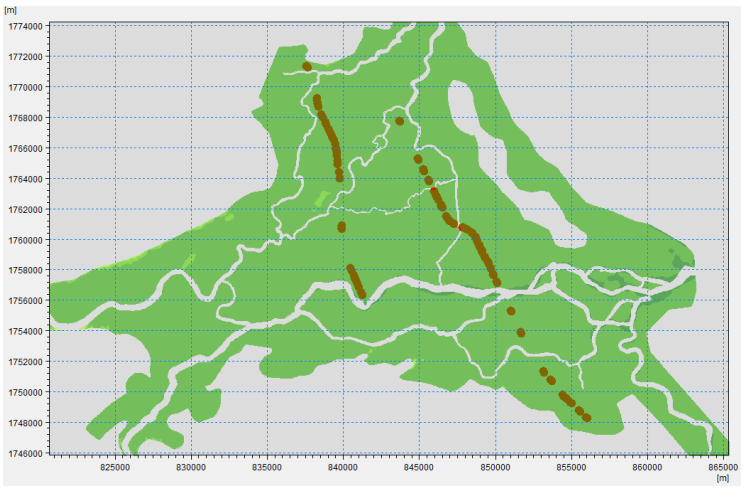


Fig 8. Location of extended drains on MikeFlood's domain

Using the MIKE model set that has been calibration and verification, determine the level of flood reduction according to the actual flood years on the synchronous terrain in 2020. In order to assess the degree of change in the plan, the report selects 58 points around the routes (upstream and downstream routes) to check and compare values.

+ For the case of the big flood in November 1999, the trend of the peak water level at the upstream test points decreased compared with the current situation, but the trend of the flood peak water level in the downstream increased, however. decrease - insignificant increase (less than 1%), the highest is 4.7cm and the highest is 3.9cm (Fig 9)

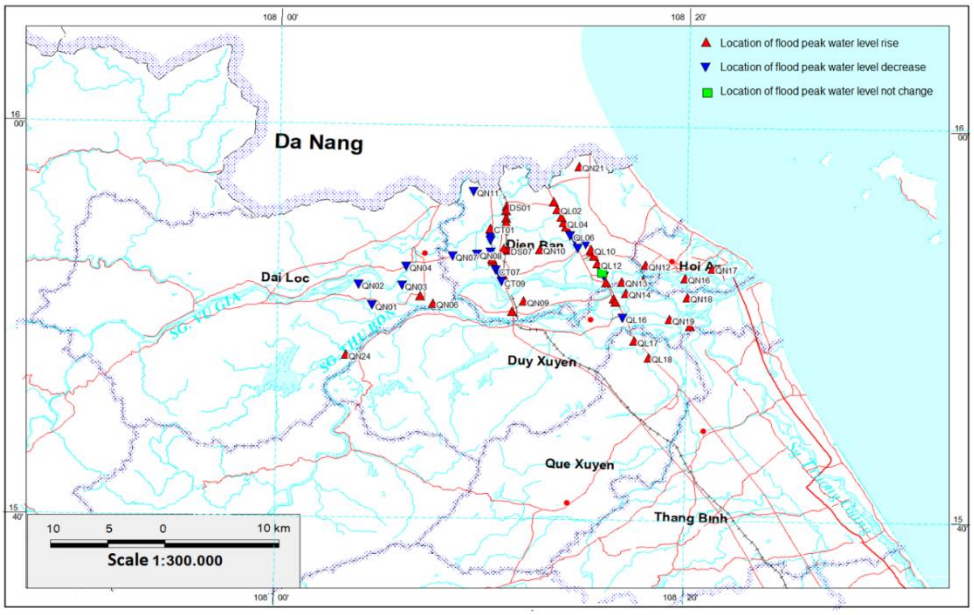


Fig 9. Change in flood peak water level in November 1999 at checkpoints according the sewer aperture expansion plan

Similar to water level fluctuations, flood areas to decrease but not high. The total flood area decreased by 131.3ha (about 0.2%), but the trend of increasing the flood area was less than 1m and reducing the depth of flooding area over 3m (table 6).

Table 6. Comparison of flood areas in 1999 (ha)

No.	**Flood level**	**1999 (with topographic 2020)**	**1999**	Difference
1	> 0,5 m	3.923,6	3.942,3	+ 18,7
2	0,5 - 1,0m	3.775,9	3.779,9	+ 4,0
3	1,0 - 1,5m	5.207,9	5.206,2	-1,6
4	1,5 - 2,0m	7.110,6	7.088,0	-22,5
5	2,0 – 2,5m	8.452,1	8.435,0	-17,0
6	2,5 - 3,0m	9.084,0	9.051,9	-32,1
7	3,0 - 3,5m	8.457,9	8.407,2	-50,7
8	3,5 - 4,0m	5.363,7	5.360,6	-3,1
9	> 4,0m	9.610,3	9.583,4	-26,9
Total flood area		60.985,8	60.985,8	- 131,3

+ For the case of the big flood in 11/2007, the trend of the flood peak water level value at the check points decreased (45 points out of 56 points) both up and downstream of Da Nang - Quang Ngai Highway had a decrease in the peak flood level, the highest decreased by 5.1cm. The increase in water level is mainly in Dien Ban, Hoi An areas due to the impact of the whole coastal route, but the increase is not much (the highest point is 3.1cm) (fig 10)

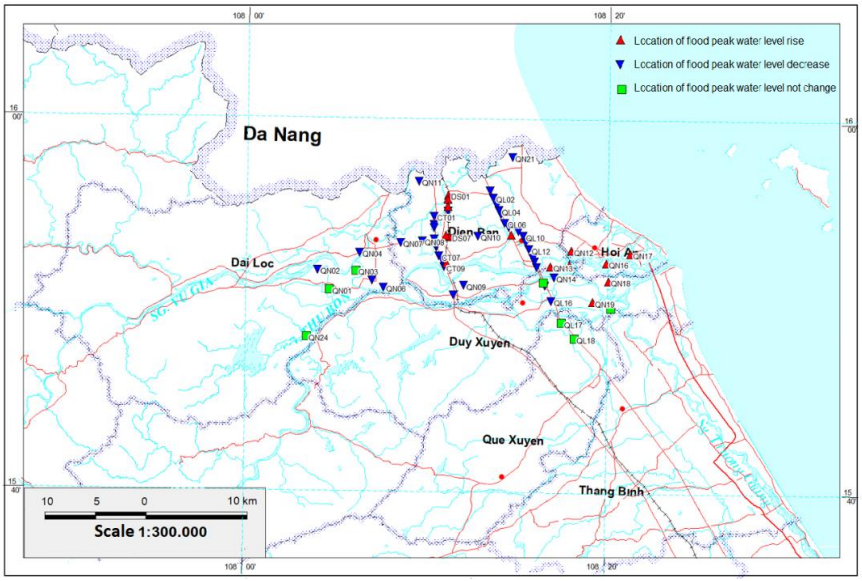


Fig 10. Change in flood peak water level in November 2007 at checkpoints according sewer aperture expansion plan

Similar to water level fluctuations, flood areas to decrease but not high. The total flood area decreased by 10.1ha, but the structure of flood area by depth has changed greatly. Flood area below 2m increases area and flood area over 2.5m decreases

Table 7. Comparison of flood areas in 2007 (ha)

No	Flood level	2007 (with topographic 2020)	2007	Difference
1	> 0,5 m	4.172,42	4.180,40	+7,98
2	0,5 - 1,0m	4.563,07	4.575,60	+12,53
3	1,0 - 1,5m	6.289,28	6.309,21	+19,93
4	1,5 - 2,0m	7.383,82	7.384,66	+0,84
5	2,0 – 2,5m	9.024,65	9.031,94	+7,29
6	2,5 - 3,0m	9.246,76	9.229,74	-17,02
7	3,0 - 3,5m	6.684,61	6.674,88	-9,73
8	3,5 - 4,0m	4.063,77	4.048,51	-15,26
9	> 4,0m	4.172,42	4.180,40	-16,63
Total flood area		**58.748.41**	**58.738.34**	**-10.07**

+ For the case of big flood in October 2020, the trend of the peak water level at the check points decreases (90% of the check points) both upstream and downstream of the Da Nang - Quang Ngai Expressway have low levels. Flood peak water decreased, the highest decreased by 3.2cm. The increase in water level is mainly in Hoi An area due to the impact of the whole coastal route, but the increase is not much (the highest point is 2.6cm) (Fig 11)

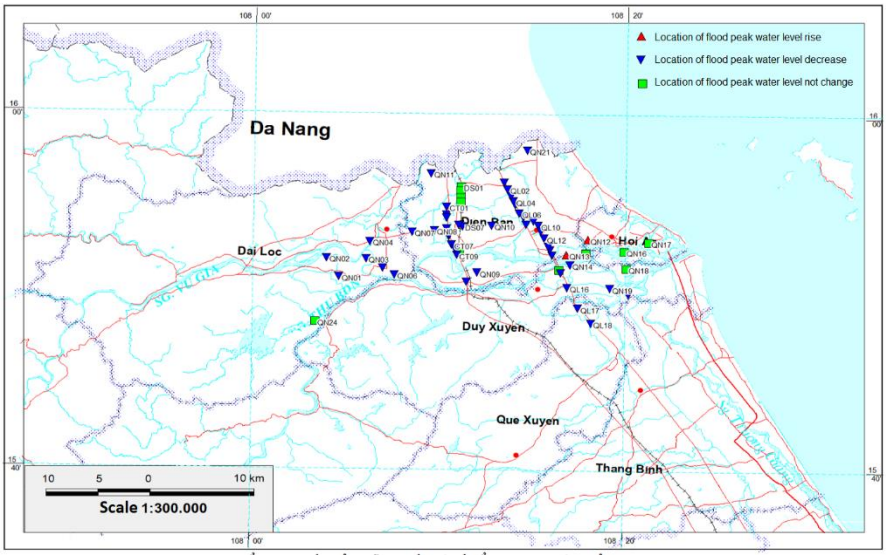


Fig 11. Change in flood peak water level in October 2020 at checkpoints according sewer aperture expansion plan

Similar to water level fluctuations, the flood areas tends to decrease. The total inundated area decreased by 102.2ha, but the structure of flooded area according to depth had a big change. The flood areas under 1.5m deep increases the area and sharply reduces the flood areas over 1.5m (table 8).

Table 8. Comparison of flood areas in 2020 (ha)

No	Flood level	2007 (with topographic 2020)	2007	Difference
1	> 0,5 m	6.715,89	6.701,59	-14,3
2	0,5 - 1,0m	7.793,62	7.817,1	23,48
3	1,0 - 1,5m	9.154,79	9.176,25	21,46
4	1,5 - 2,0m	9.367,09	9.327,56	-39,53
5	2,0 – 2,5m	6.805,58	6.752,09	-53,49
6	2,5 - 3,0m	3.280,22	3.247,67	-32,55
7	3,0 - 3,5m	1.673,66	1.668,61	-5,05
8	3,5 - 4,0m	1.072,57	1.072,31	-0,26
9	> 4,0m	6.715,89	6.701,59	-14,3
Total flood area		**49.223,92**	**49.121,7**	**-102,22**

As a result, the solution of expanding 3 times the drain aperture on highways, national highways 1 and railways did not reduce the flood peak, but the effect of changing the area and level of flooding was quite large (131.3ha) the flood levels from 1 to 4m were reduced, for the 1999, 2007 flood, the flood area decreased insignificantly, but the flood levels of upper 2.5m decreased, for the 2020 flood there was a similar trend in 1999.

5. Conclusion

The paper used MIKE model (NAM + 11 + 21FM + Flood) with synchronously evaluated data (riverbed topography, flood surface topography, road elevations as well as culvert apertures... as well as nautical hydro-meteorological datasets and data related to

reservoir operation in the river basin) for simulation results suitable to the situation of flooding and flooding in the lower reaches.

The paper conducted simulations for the solution of expanding the flood escape aperture in viaducts – the downstream location of the road without residential areas, the scenario of dredging the Yangtze River as well as when there is an additional route connecting provincial road 609C to National Highway 14B in Dai Loc district. For the current roads, the highway has the potential to increase flooding and flooding in the lower reaches of the Vu Gia - Thu Bon river basin, so in order to minimize flooding and flooding here, not only develop direct plans for traffic routes but also develop overall solutions and develop a total flood management plan. in order to meet the requirements of sustainable development, maximize benefits from flood deltas, mitigate flood damage, protect and maintain the stability of the river and ecosystem, establish appropriate flood drainage corridors throughout the Vu Gia - Thu Bon river route.

The research results of the paper can provide a scientific basis for the disposition of the population, the construction of infrastructure, the transformation of the appropriate land use structure to minimize damage, ensure the community is safe from natural disasters.

Acknowledgement

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References

1. Binh Thai Pham, Chinh Luu, Tran Van Phong, Huu Duy Nguyen, Hiep Van Le, Thai Quoc Tran, Huong Thu Ta, Indra Prakas, 2021. Flood risk assessment using hybrid artificial intelligence models integrated with multi-criteria decision analysis in Quang Nam Province, Vietnam. Journal of Hydrology, Volume 592, January 2021.
2. Vu Thị Thu Lan, 2011. Conducting field survey and setup hydraulic modeling of Thu Bon River basin, Quang Nam province. (Project Report). Report on handover of Quang Nam Disaster Prevention and Control Command.
3. Bui Anh Tuan and co-authors, 2015. Assessment of the impact of Da Nang - Quang Ngai highway on the Development of inundation in Da Nang province upon the multi-reservoir operation at Vu Gia - Thu Bon River basin. Scientific and Technical Hydro – Meteorological Journal, Volume 681, 37 - 46.
4. Hoang Thanh Son, Bui Anh Tuan, Nguyen Minh Thanh, Nguyen Thi Nhan, 2016. Geographical Institute – Vietnam Academy of Science and Technology Evaluate the Effectiveness of Downstream Area Flood Reduction of Hydroelectric System the Vu Gia – Thu Bon River Basin. Scientific and Technical Hydro – Meteorological Journal, Volume 661, 52 – 57.
5. Hoang Thanh Son, Bui Anh Tuan, Nguyen Thị Hai Yen, 2022. Mike Flood model application to simulate flooding in coastal area of Quang Nam province, 2020. Water Resources Journal, 07-2022.
6. Denmark Hydraulic Institute (DHI), 2014. MIKE FLOOD Reference Manual.
7. Pham Hong Nga, Kaoru Takara, Nguyen Hoang Son, 2015. Flood hazard impact analysis in the downstream of Vu Gia-Thu Bon river system, Quang Nam province, central Vietnam. Journal of Japan Society of Civil Engineers, Ser. B1 (Hydraulic Engineering), Vol. 71, No.4, I_157-I_162, 2015.
8. Thanh Tu Vu, Roberto Ranzi, 2017. Flood risk assessment and coping capacity of floods in central Vietnam. Journal of Hydro-environment Research, Volume 14, March 2017, Pages 44-60.

Assessing spatial relationship and analysis between urban greening and urban heat islands effect in Lahore, Pakistan

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Abstract. The conversion of urban natural vegetation landscapes into impervious surfaces causes a shift in the urban climate phenomenon known as the Urban Heat Island (UHI) Effect. Urban greenery plays a vital role in sustaining uniform land surface temperature in an urban environment. However, Cities are facing rapid urban expansion and land-use changes over the last few decades as urban greenery are being replaced by impervious structure. Therefore, LST is increasing in cities and developing the phenomenon of urban heat island (UHI) effects. From this perspective, this study aimed to understand the relationship between urban greenery changes and the urban heat islands' effect in Lahore. The effect of urban heat and urban green cover change have been studied through Landsat data for the years 2000 and 2020. The Radiative transfer method (RTM) was used to calculate the LST of Lahore. To describe how local heat has an impact on the microclimate of cities, the geographical variation of land surface temperature is retrieved. The relationship analysis between the LST, NDVI, and NDBI is investigated to explore the impact of the urban green spaces and impervious surfaces on the urban heat islands effect. The study establishes the fact that over the last two decades, the built-up area increased by 17.88% and the urban green area decreased by 13.95% from 2000 to 2020 of the study area. In the same way, a rapid expansion of the higher LST and UHI effects was also observed in the eastern and southern parts of Lahore. Moreover, a negative correlation between NDVI and LST, whereas a positive correlation between NDBI and LST. Therefore, it was determined that continuing to reduce urban greenery is extremely harmful since it may make the city more ecologically vulnerable. As a result, the study draws the attention of the relevant authorities to the need for appropriate actions to combat the ongoing loss of urban green cover in Lahore.

Keywords: urban greenery, urban heat, surface temperature, correlation, Lahore

1. Introduction

Cities generally experience the most significant urban heatwaves, and surface and air temperature increase, particularly in the phenomenon of urban heat islands (UHIs), whose products are intensified by urbanization and anthropological activities. Although UHI has been a recognized phenomenon for more than 200 years, it has gained media attention during the last few decades (Rida *et al*., 2021). In 1810, Luke Howard investigated and described for the first time the UHI phenomenon (Howard, 1820). The process of urbanization, in which the urban greenery is being replaced by the built-up area throughout urban development, is the primary cause of the UHI phenomenon (US EPA, 2018). The physical characteristics of the surface structure change as a result of the urbanization process, altering the thermal climate of metropolitan areas. Urbanization is currently a key factor influencing developing countries and their rapid urban growth and progress toward becoming developed nations (Yu *et al*., 2018). These rapid urban changes include the transformation of urban green spaces into impermeable surfaces, which increase LST and UHI (the region with a greater temperature than the surrounding environment) by shifting energy or radiation into the near-surface layer

of the atmosphere (Oke, 1982; Forman, 2016; Aflaki *et al*., 2017). These Land use (LU) changes adversely affect the urban air quality and homogeneity of land surface temperature. The change of green cover into built-up spaces results in the emergence and expansion of urban heat islands (Yu *et al*., 2018). Urban heat island also has a detrimental impact on the urban environment when energy use rises, despite efforts by people to lessen these negative consequences of temperature (e.g., air conditioning, private vehicle usage). Therefore, increased energy use based on coal-fired power plants may cause contamination of the air, water, and further climatic changes. More precisely, UHI negatively impacted individuals' health and quality of life (Zhang *et al*., 2017; Zhou *et al*., 2017; Varentsov *et al*., 2019; Wibowo *et al*., 2020). On the other side, urban vegetation reduces temperature, minimizes UHI effects, enhances air quality, conserves soil, reduces noise pollution, and cuts down wind speed (Lou *et al*., 2017). The urban green cover helps to mitigate climate change effects and provides a suitable environment for human and environmental well-being (Krellenberg *et al*., 2014).

The UN's 2030 Agenda's Sustainable Development Goal 11 focuses on creating inclusive, resilient, safe, and sustainable cities and human settlements (Unites Nations, 2018). Urban greenery is a crucial component of the urban ecosystem, providing important services and ecological functions in areas of urban growth. Urban green areas play an essential role in cities, which are projected to livelihood 68 percent of the world population by 2050 (United Nations, 2019). With the speeding up of urban problems, such as urban flash flooding, urban heat, air & noise pollution, and human health calamities, the necessity for observing the distribution of urban green spaces to support urban ecosystems and sustain human wellbeing has more and more been documented (Bertram & Rehdanz, 2015: Kremer *et al.,* 2019). Additionally, they execute a cooling function through shading effects and evaporation, which support alleviating the effect of UHI (Zhao *et al.,* 2015). Urban green spaces are a natural cooling method for cities. One of the most important components of the urban ecosystem, it can lessen the impact of UHI by modifying the microclimate, supplying thermal comfort, lowering energy use, and weakening the greenhouse gas (GHG) effect (Velasco *et al.,* 2016; Xu et al., 2017; Coccolo *et al.,* 2018). More urban greenery covers have a bigger cooling effect on cities (Li and Zhou, 2019; Morakinyo and Lam, 2016; Teshnehdel *et al.,* 2020). Several studies have been undertaken over a wide range of periods to evaluate the relationship between UHI and various LU indices for various types of study regions (i.e. Ma *et al*., 2010; Mathew *et al*., 2016; Estoque *et al*., 2017; Deilemai & Kamruzzaman, 2017; Tran *et al*., 2017; Mushore *et al*., 2017; Makinde & Agbor, 2019). Moreover, NDBI, NDVI, RVI, and SAVI are significant indicators of various land uses (built-up, bare, and vegetation), and they have been widely used to examine the relationship between vegetation density, built-up area, and LST. Yue *et al.,* (2007) described these indices as being particularly useful for identifying different types of land uses (Julien *et al.,* 2006; Wei and Zhou, 2011)

It is critical to further assess the association between NDVI and LST (Deng *et al.,* 2018; Ghobadi *et al*., 2015) because it is relatively multifaceted and is exacerbated by some factors (Zhou *et al*., 2011). Strong quantitative relationships between temperature and land usage have been found in these investigations (Cheng *et al.,* 2008). Lahore metropolitan face the rapid development of built-up areas instead of green-covered land is damaging the ecosystem of the study area, converting it from a highly suitable place for living to an unsuitable one. The negligent behavior of the management regarding the implementation of environmental guidelines in built-up areas and the lack of accurate data are the main causes of environmental issues. Therefore, the assessment of urban green cover changes is necessary to identify the right pulse of land modification in the study area and overcome future environmental consequences. Under these considerations, the specific objectives of this study are: (1) to recognize the land use change between 2000 and 2020; (2) to assess the urban greenery changes in Lahore and their impact on UHI (3) to correlate UHI with NDBI and NDVI of

Lahore. The results achieved from this study could be useful for urban planners and policymakers to devise properly sustainable policies and planning strategies for land use planning, mitigation of the UHI effect, and urban development of the city in the future.

2. Material and methods

Study area

Lahore is the second-largest metropolitan city in Pakistan (GoP, 2017). Its whole size is 1772 km^2 spanning between 74°-10'0"–74°-39'0"E longitudes and 31°-15'0"–31°-43'0"N latitudes (Figure 1). Historically, Lahore is famed as a city of gardens with vast urban vegetation cover. As shown in Figure 1, due to rapid urban expansion (about 18% growth of urban built-up area) in the last two decades, the urban greenery was gradually demolished and substituted with impervious surfaces. More than 11.12 million people live in the city as of 2017 last population census (GoP, 2000; GoP, 2017). The current density of the population of district Lahore is 6300 persons per sq. km which is projected to be increased to 16.88 million by the year 2030 (United Nations, 2018). The rapid urbanization of Lahore taking place since 1981 led to an increase in the surface and air temperatures. The average mean annual temperature of Lahore is recorded to vary from 12.8◦ C lowest in January to 33.9◦ C highest in July (PMD, 2022).

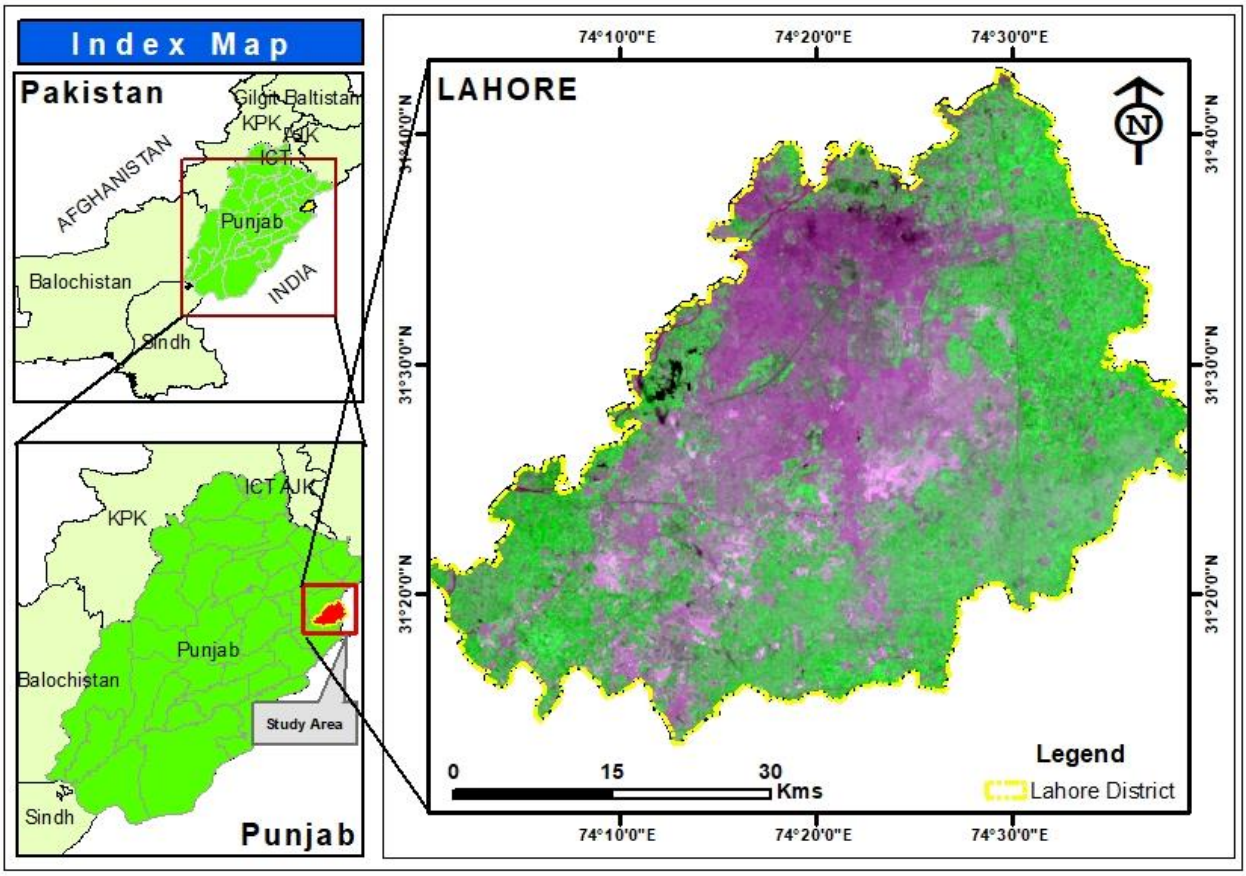

Fig. 1. Map showing the location of the study area regarding the administrative boundaries of districts and geography of Lahore.

Data source and pre-processing

The study was based on two Landsat satellite cloud-free imagery taken on March 19, 2000 (Landsat 5 TM) and on March 18, 2020 (Landsat 8 OLI-TIRS) for the Path/Row 149/38 were acquired from the USGS website. The terrain-adjusted surface reflectance images in this case are application-ready products that can assist in an observer and evaluation changes in LU (Vermote *et al.,* 2016). The research area includes urban vegetation as well as the

surrounding agricultural fields, which have been gradually turning into built-up land over the past few decades. Therefore, to avoid the impact of cooling and heating, the spring season was selected for the analysis as it is the most suitable season for land use classification. Table 1 provides information on the data sets used in the study.

Methodology

Land use (LU), Normalized Differential built-up Index (NDBI), Normalized Differential Vegetation Index (NDVI), and Land surface temperature (LST) were utilized to produce the relationship between essential variables. Figure 2 provides a detailed description of the study's approach.

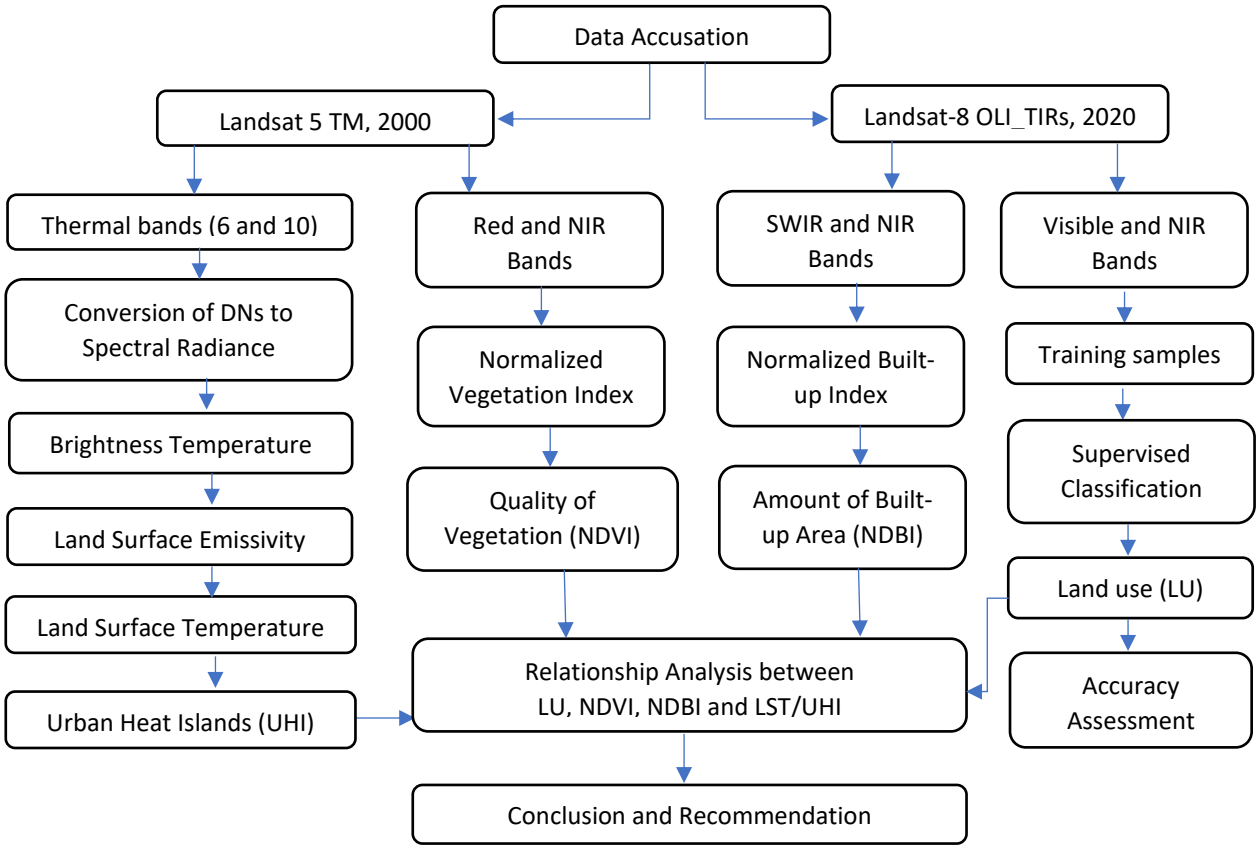

Figure 2. The methodological framework of the Study

Land use (LU) mapping

LU mapping describes an accurate figure about the resources of the land being used and its transformation in their spatiotemporal configuration. LU classes of the study area are drawn to study the urban expansion over the last two decades and the relationship between LST and urban greenery. The supervised image classification techniques are used to make the LU of the study area. Classification of the satellite image is a technique whereby all the pixels of imagery are categorized into various types of themes and LU classes (Lillesand *et al*., 2000). The classification scheme of LU used in this study implements ordering procedure level-I as specified by Anderson, (1976), which is used by the United States Geological Survey (USGS) in the LULC datasets. The study region was classified into four major land use classes' i.e. urban built-up area, urban greenery, vacant land, and water bodies. To extract built-up areas and urban greenery, Landsat data were used to carry out classification using supervised image classification algorithms. A better result was obtained by using a maximum likelihood approach. This Landsat image classification technique is characterized by the highest accuracy of the assessment (Barman *et al.*, 2016; Iqbal & Iqbal 2018). For the accuracy assessment, 500

random reference points were generated, after that, the confusion (error) matrix and kappa statistics were calculated. For Landsat 5 and Landsat 8, the overall accuracy and kappa coefficient values were calculated as 0.88 and 0.79 and 91.46 and 85.23 respectively. A post-classification comparison technique was applied to detect the change between two classified images.

Table 1. Details of Landsat imagery used in the study

S. No.	Date of Acquisition	Satellite	Sensor	Path/Row	Resolution	Cloud
1.	19 March 2000	Landsat 5	TM	149/38	30 m	
2.	18 March 2020	Landsat 8	OLI_TIRs	149/38	30 m	

Quantification of NDVI and NDBI

The NDVI is extensively used to perceive vegetation density. Red (visible) and near-infrared (NIR) bands from Landsat TM and OLI image data were used to produce the NDVI for the years 2000 and 2020. This index has a positive correlation with vegetation cover and ranges from -1 to +1 (Purevdorj *et al.*, 1998) Equation 1 is used to produce NDVI.

NDVI = (NIR – RED) / (NIR + RED)……1

The NDBI was utilized to extract impervious surfaces and built-up areas. The NDBI for 2000 and 2020 were generated using the Short-wave infrared (*SWIR*) and near-infrared (NIR) bands of Landsat TM and OLI image data using the equation. The Normalize Distinction The value of the build-up index ranges from -1 to +1. Higher NDBI values indicate built-up regions, while lower values indicate water bodies. The vegetation NDBI value is low. The following formula 2 use to extract the built-up areas.

NDBI = (SWIR − NIR) / (SWIR + NIR)……..2

Land Surface Temperature

The Mono-Window (MW) technique was used to determine the land surface temperature (Wang et al., 2015). This procedure uses thermal infrared band 6 of TM and bands 10 for OLI sensor with 60 and 30m resolution, respectively. To obtain LST, First, spectral radiance was produced using digital numbers (DNs) of bands 6 and 10 utilizing gain and offset information from the image's TXT metadata file. Second, the satellite-and band-specific thermal conversion constants K1 and K2 were used to convert the spectral radiance to at-satellite brightness temperature. The at-satellite brightness temperature was finally converted to land surface temperature using the values of land surface emissivity through equation 3. To do this, the surface emissivity was measured using an NDVI-based method suggested by Sobrino *et al.*, (2008). Additional information regarding LST, Qin *et al.*, (2001) and Wang *et al.*, (2015) provide more details on LST retrieval from Landsat imagery using the MW algorithm.

LST = (BT /1) +W * (BT /14380) * In(E)…….3

Regression Analysis

Through the use of appropriate threshold values, the aforementioned indices can also be utilized to categorize various land use types (Chen *et al.*, 2006). After that, the relationships of NDBI and NDVI with LST were analyzed. This study used linear regression to analyze the association of NDVI, NDBI, and LST, from 2000 to 2020. LST is regarded as a dependent variable, whereas NDVI and NDBI are independent variables. According to Seber (2012), linear regression is computed using equation 4. The random sample point sites were selected using the Feature Class "Create Random Point Tool" of ArcGIS to observe the correlation

between NDVI, NDBI, and LST. The values for NDVI, NDVI, and LST were then obtained using the ArcGIS tool "Extract Multi values to point."

$$Y = \alpha + \beta x \quad \text{.....4}$$

3. Results and Discussion

To access the environmental variables of cities, particularly metropolitan areas such as Lahore, can be evaluated by the understanding of different city components and their Spatio-temporal patterns such as land use (urban vegetation and built-up areas), and temperature variations. The underlying forces of land use change through time and define a city's capacity to successfully balance the expansion of the city and the preservation of its natural ecosystem. Spatio-temporal land use changes (built-up area, vegetation, and vacant land) in the urban area and the resultant growth of urban built-up areas are virtuous signs of urban growth but they also have negative effects on the urban landscape ecology and sustainability of the urban environment.

Land use (LU) changes

LU the years 2000 and 2020 in the study area were extracted from Landsat data using the techniques of image classification. It has been observed that during the last two decades, the urban built-up area increased and urban greenery decreased (Table 2 & Figure 3). As the percentage of the land area covered by urban built-up area increased from 25 to 43 percent over the past 20 years, the core urban region of Lahore has been getting denser with time. According to census data, Lahore's population density increased from 3,566 per square kilometer in 2000 to 6,275 per square kilometer in 2017 (GOP, 2000; 2017).

Table 2. Land use percentage of different years.

LU Classes	2000		2020		% Change
	km^2	%	km^2	%	2000-2020
Built-up area	445.12	25.12	756.44	43	17.88
Vacant land	243.23	13.67	175.10	10	-03.67
Urban Greening	1061.25	59.95	825.23	46	-13.95
Waterbody	22.40	01.26	15.23	0.86	-0.40

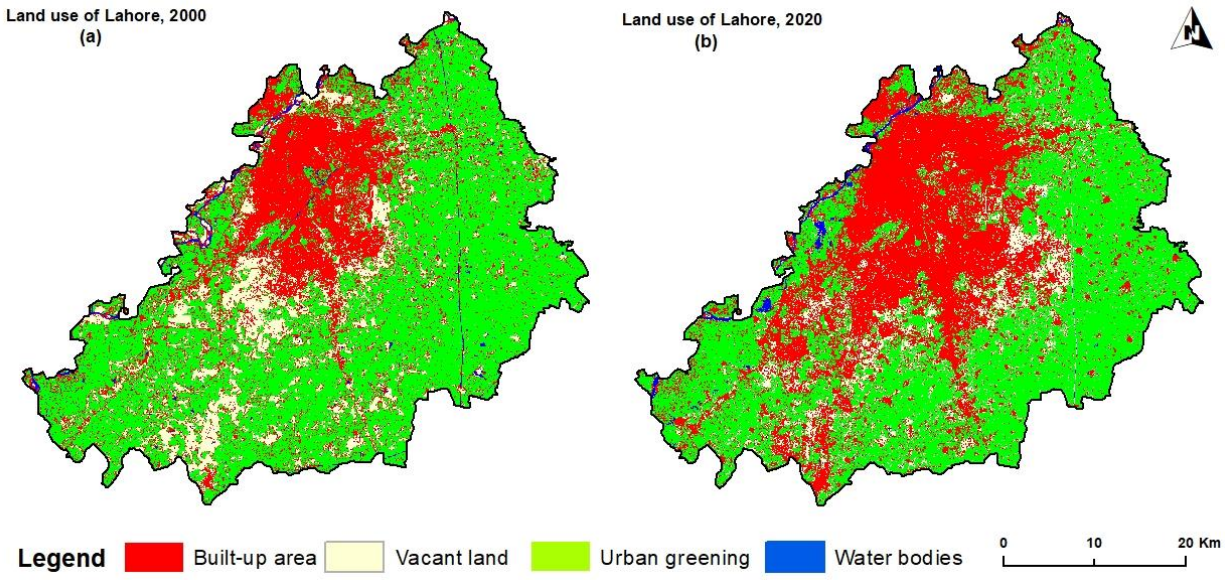

Figure 3. Depicting Land use of Lahore between 2000 and 2020

The Spatio-temporal distribution of land use classes for the last 20 years is revealed in Figure 3 and the study area has faced rapid LU changes in the last two decades. In 2000,

Lahore had 25.12% of built-up area, 13.67% of vacant land, 59.95% vegetation cover, and 1.26% water bodies. However, after twenty years, in 2020, the LU distribution of Lahore has been changed to 43% of built-up area, 10% of vacant land, 46% urban greening, and 0.86% of water bodies. Consequently, the share of vacant land, urban greening, and water bodies decreased by 3.67%, 13.95%, and 0.4 respectively, while built-up area increased by 17.88%. Finally, it was detected that rapid growth in the urban built-up area occurred along with a rapid reduction in urban greenery, which is the core concern of the study as it directly affects LST and UHI.

Spatio-temporal variation of NDVI, NDVI, and LST

The spectral-based indicators, i.e. normalized difference built-up index (NDBI), normalized difference vegetation index (NDVI), and Land surface temperature (LST) are used to assess the built-up area expansion, vegetation cover, and variation of surface temperature in the study region between 2000 and 2020. Table 3 provides access to the detailed statistics for the NDBI, NDVI, and LST of Lahore.

Table 3. Illustrate NDBI, NDVI, and LST descriptive statistics for Lahore

Year	NDBI		NDVI		LST	
	Min	Max	Min	Max	Min	Max
2000	-0.62	0.44	-0.53	0.58	14.32	27.53
2020	-0.44	0.38	-0.12	0.54	12.57	31.61

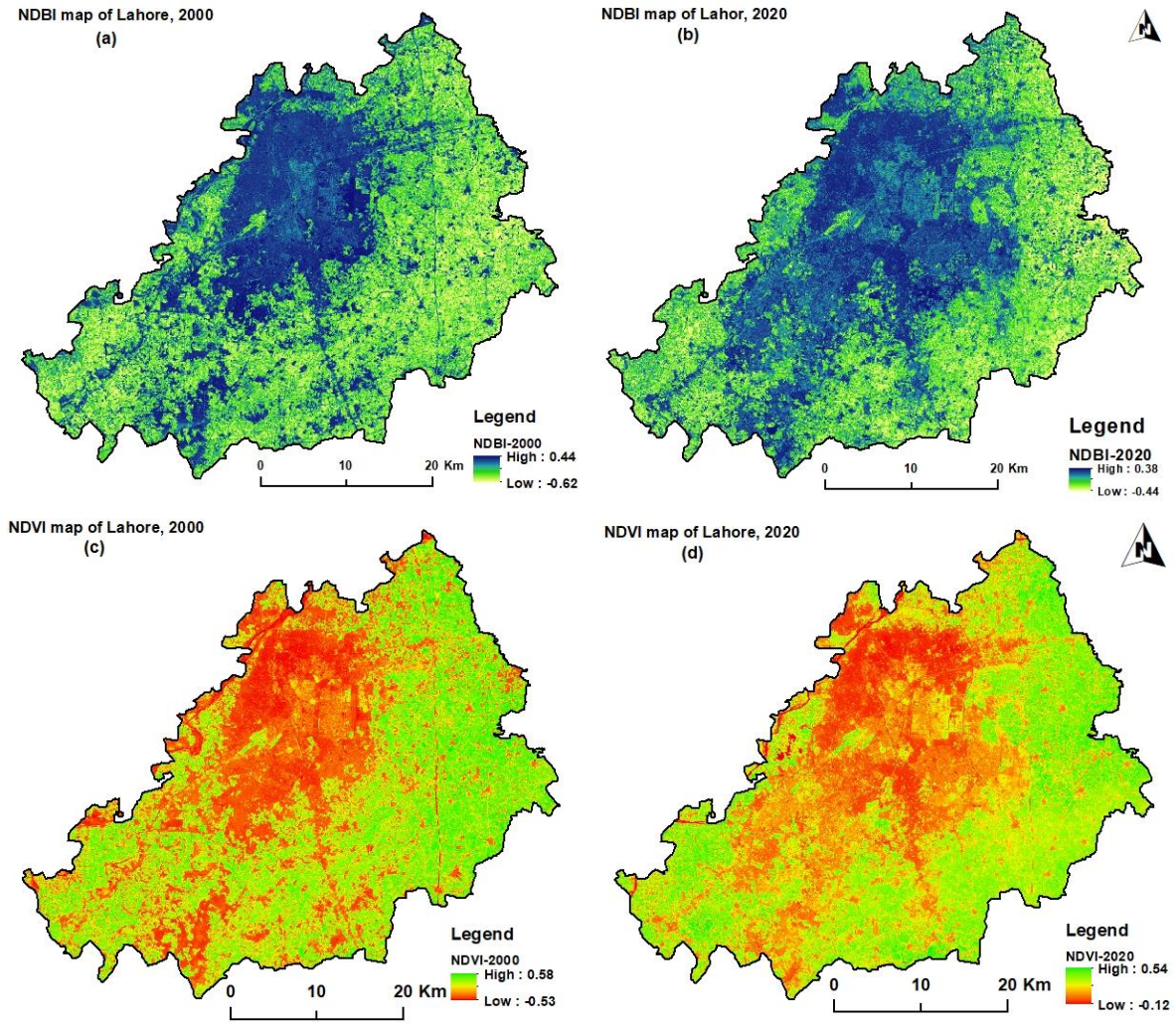

Figure 4. NDBI and NDVI map of Lahore between 2000 and 2020

It can be founded in Figures 4 (a & b), that the urban built-up area in Lahore has been continuously growing during that time. It becomes important to study the Spatio-temporal changes, for urban ecologists and geographers to determine the sustainability of the living and ecological settings of Lahore. The same is seen in Figure 3's LU representation, which shows how urbanization has grown over the last 20 years. The NDBI high and low values are 0.44 and -0.62 respectively for the year 2000, while the high and low values of NDBI are 0.38 and -0.44 respectively for the year 2020. The areal extent of vegetation cover of Lahore is reduced from 2000 to 2020 as shown in Figure 4 (c & d) and Table 3. The overall urban vegetation cover decreased due to the rapid growth of urbanization and expansion of built-up areas. The highest and lowest values of NDVI in Lahore for the year 2000 are 0.58 and -0.53, while for 2020 are 0.54 and -0.12 respectively.

LST variation of Lahore is categorized into high and low values as shown in Figure 5, and urban thermal environment patterns of Lahore are depicted through appropriate color symbology. The mean LST values for Lahore are 18.87°C and 22.53°C, respectively, for the years 2000 and 2020, indicating an increase in the city's surface temperature during the last 20 years.

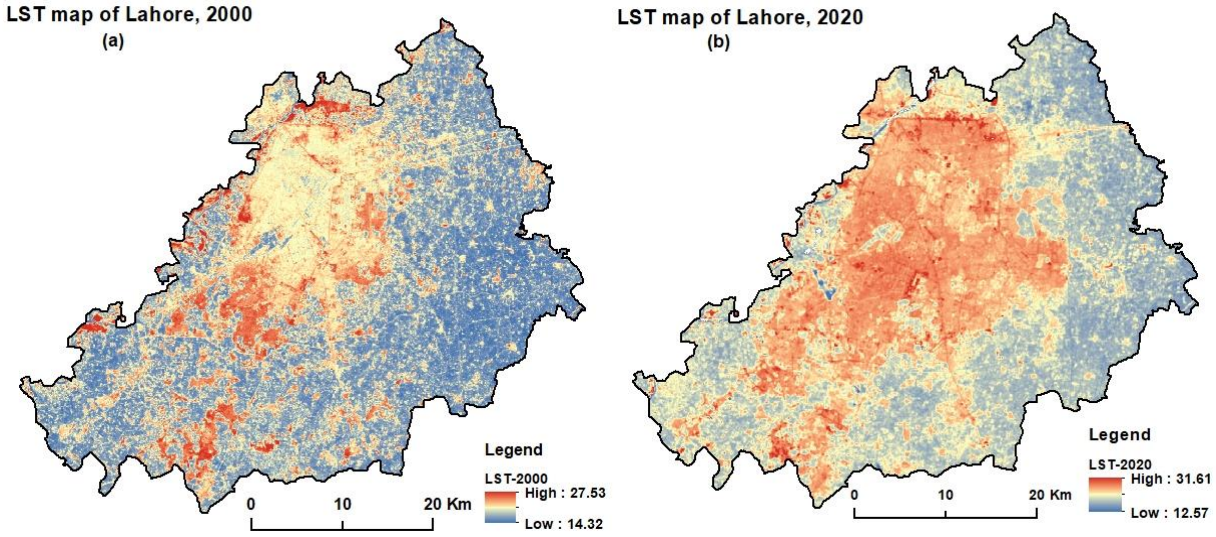

Figure 5. Land Surface Temperature Distribution of Lahore between 2000 and 2020.

Correlation between NDBI, NDVI, and LST

The association analysis has been calculated to examine the relationship trend between the NDBI, NDVI, LU, and LST, to establish a sustainable correlation between the different derived parameters (Figure 6 (a-c)). The results show a higher degree of positive correlation between NDBI and LST, whereas a negative relationship was found between LST and NDVI. These relations indicate that higher NDVI values cause lower LST and lower NDVI values cause higher LST. It is identified that the NDVI values decreases from 2000-2020 due to the massive expansion of urban built-up areas and drastic reduction of urban vegetation cover in Lahore. Spatio-temporal NDVI patterns are not only subjective to the reduction of urban greenery but they can also be recognized to the accessibility of solar radiation, topography, and supplementary factors. On the other hand, if LST and NDBI have a positive relationship, then LST rises when NDBI rises and decreases when NDBI decreases. Rapidly increased urbanization or a decrease in the amount of urban greenery in a city has can be linked to rising LST. The current research work demonstrates the noteworthy correlation between high LST and an abundance of built-up areas and low surface temperature with an abundance of urban greenery. These correlations between LST and NDVI and NDBI demonstrate how urban greenery might contribute to LST decrease and maintain thermal homogeneity in urban areas.

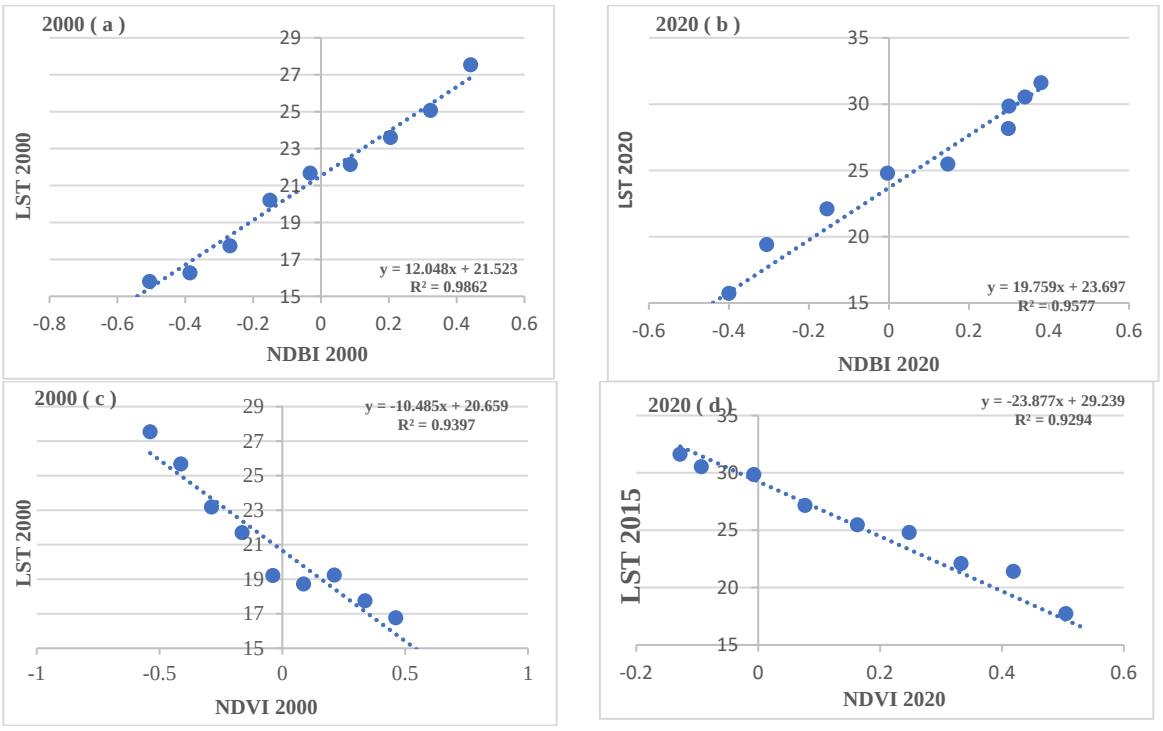

Figure 6. Correlation between LST, NDBI & NDVI for 2000 and 2020

4. Conclusion

The present study explored the drastic reduction of urban greenery in Lahore due to LU transformation and unplanned urban growth and its spatial association between NDBI, NDVI, and LST and observed its significant impact on LST and expansion of UHI effect in Lahore. The results show that urban sprawl and LU change in the city are originating from the expansion of urban heat islands as comprehended in the consequence of urban areas having surface higher temperatures compared to the nearby rural area. Rapid urbanization has led to a large-scale increase in the area of impervious surfaces in the city, which is accelerating land surface temperature increase and enhancing the UHI effects towards the eastern and southern parts of the study area. The study proposed that the natural environment, urban greenery, and temperature must be measured when the process of urbanization takes place. Therefore, more research is required to determine the amount of vegetation that is necessary for the city's sustainable ecosystem and the micro-level mitigation of the consequences of climate change. Additionally, studies are needed to find ways to use modern technology like green roofs, vertical gardens, and green walls, to transform highly hot built-up territory into sustainable and thermally uniform places. To prevent the continued deterioration of urban health and greenery, it is also advised that the area needs further study by taking high-resolution thermal data sets into account to appraise the UHI hot spot areas of Lahore. Finally, the study urges management to restrict the loss of urban greenery and increase the quality and quantity of urban green spaces in high built-up areas, which would aid in lowering UHI effects. Additionally to biophysical factors, the ecological valuation of UHI zones may also be addressed in future studies.

References

1. Anderson, J.R. (1976). A Land Use and Land Cover Classification System for Use with Remote Sensor
2. Data (Vol. 964): US Government Printing Office, Washington DC., The USA.
3. Aflaki, A., Mirnezhad, M., Ghaffarianhoseini, A., Ghaffarianhoseini, A., Omrany, H., Wang, Z. H., & Akbari, H. (2017). Urban heat island mitigation strategies: A

state-of-the-art review on Kuala Lumpur, Singapore, and Hong Kong. Cities, 62, 131-145.
4. Barman T., Ghongade R., & Ratnaparkhi A. (2016). Rough set-based segmentation and classification model for ECG. 2016 Conference on Advances in Signal Processing (CASP), 18–23.
5. Bertram, C., & Rehdanz, K. (2015). The role of urban green space for human well-being. Ecological Economics, 120, 139-152.
6. Cheng, K.S., Su, Y.F., Kuo, F.T., Hung, W.C., Chiang, J.L. (2008). Assessing the effect of land cover changes on air temperature using remote sensing images-A pilot study in northern Taiwan. Landscape and Urban Planning, 86: 297-297.
7. Coccolo, S., Pearlmutter, D., Kaempf, J., & Scartezzini, J.-L. (2018). Thermal Comfort Maps to estimate the impact of urban greening on outdoor human comfort. Urban Forestry & Urban Greening, 35, 91-105.
8. Deilami, K., Kamruzzaman, M. (2017). Modeling the urban heat island effect of smart growth policy scenarios in Brisbane. Land Use Policy, 64: 38-55.
9. Deng, Y., Wang, S., Bai, X., Tian, Y., Wu, L., Xiao, J., Qian, Q. (2018). Relationship among land surface temperature and LUCC, NDVI in typical karst area. Scientific Reports, 8: 641.
10. Estoque, R.C., Murayama, Y., Myint, S.W. (2017). Effects of landscape composition and pattern on land surface temperature: An urban heat island study in the megacities of Southeast Asia. Science of the Total Environment, 577: 349-359.
11. Forman, R. T. (2016). Urban ecology principles: are urban ecology and natural area ecology really different? Landscape ecology, 31(8), 1653-1662.
12. GOP, (Government of Pakistan). 2000. District Census Report of Lahore 1998. Islamabad: Population
13. Census Organization, Statistics Division. Govt. of Pakistan.
14. GOP, (Government of Pakistan). 2017. Provisional Summary of Census 2017. Islamabad: Population
15. Census Organization, Bureau of Statistics. Govt. of Pakistan.
16. Ghobadi, Y., Pradhan, B., Shafri, H.Z.M., Kabiri, K. (2015). Assessment of the spatial relationship between land surface temperature and land use/cover retrieval from multi-temporal remote sensing data in South
17. Karkheh Sub-basin, Iran. Arabian Journal of Geosciences, 8: 525-537.
18. Iqbal M. Z., & Iqbal M. J. (2018). Land use detection using remote sensing and gis (A case study of Rawalpindi Division). American Journal of Remote Sensing, 6(1), 39–51.
19. Howard, L. (1820). The Climate of London: Deduced from Meteorological Observations Made at Different Places in the Neighborhood of the Metropolis. In Two Volumes. Vol. II (Vol. 2): W. Phillips.
20. Julien, Y., Sobrino, J.A., Verhoef, W. (2006). Changes in land surface temperatures and NDVI values over Europe between 1982 and 1999. Remote Sensing of Environment, 103: 43-55.
21. Kremer, P., Haase, A., & Haase, D. (2019). The future of urban sustainability: Smart, efficient, green, or just? Introduction to the special issue. Sustainable Cities and Society, 51, 101761.
22. Krellenberg, K., Welz, J., & Reyes-Päcke, S. (2014). Urban green areas and their potential for social interaction–A case study of a socio-economically mixed neighborhood in Santiago de Chile. Habitat International, 44, 11-21.
23. Li, X., & Zhou, W. (2019). Optimizing urban greenspace spatial pattern to mitigate urban heat island effects: Extending understanding from local to the city scale. Urban Forestry & Urban Greening, 41, 255-263.

24. Lillesand, T., Kiefer, R. (2000). Remote Sensing and Image Interpretation, 724 pp., Willey and Sons, New York, USA.
25. Lou, H., Yang, S., Zhao, C., Wang, Z., Liu, X., Shi, L., Cai, M. (2017). Combining multi-source data to explore a mechanism for the effects of micrometeorological elements on nutrient variations in paddy land water. Paddy and Water Environment, 15(3), 513-524.
26. Ma, Y., Kuang, Y., Huang, N. (2010). Coupling urbanization analyses for studying urban thermal environment and its interplay with biophysical parameters based on TM/ETM+ imagery. International Journal of Applied Earth Observation and Geoinformation, 12: 110-118.
27. Makinde, E., Agbor, C. (2019). Geoinformatics assessment of urban heat island and land use/cover processes: a case study from Akure. Environmental Earth Sciences, 78: 483.
28. Mathew, A., Sreekumar, S., Khandelwal, S., Kaul, N., Kumar, R. (2016). Prediction of surface temperatures for the assessment of urban heat island effect over Ahmedabad city using linear time series model. Energy and Buildings, 128: 605-616.
29. Morakinyo, T. E., & Lam, Y. F. (2016). Simulation study on the impact of tree configuration, planting pattern, and wind condition on street canyons' micro-climate and thermal comfort. Building and Environment, 103, 262-275.
30. Mushore, T.D., Mutanga, O., Odindi, J., Dube, T. 2017. Assessing the potential of integrated Landsat 8 thermal bands, with the traditional reflective bands and derived vegetation indices in classifying urban landscapes. Geocarto International, 32: 886-899.
31. Oke, T. R. (1982). The energetic basis of the urban heat island. Quarterly Journal of the Royal Meteorological Society, 108(455), 1-24.
32. Purevdorj, T., Tateishi, R., Ishiyama, T., Honda, Y (1998). Relationships between percent vegetation cover and vegetation indices. International Journal of Remote Sensing, 19: 3519-3535.
33. Qin, Z., Karnieli, A., & Berliner, P. (2001). A mono-window algorithm for retrieving land surface temperature from Landsat TM data and its application to the Israel-Egypt border region. International Journal of Remote Sensing, 22(18), 3719–3746.
34. Rida, A., KOUMETIO, C. S. T., DIOP, E. B., & Chenal, J. (2021). Exploring the relationship between urban form and land surface temperature (LST) in a semi-arid region Case study of Ben Guerir city-Morocco. Environmental Challenges, 5, 100229.
35. Seber, G.A.F., Lee, A.J. 2012. Linear Regression Analysis, 2nd (eds.). vol. 329, John Wiley & Sons.
36. Sobrino, J.A., Jiménez-Muñoz, J.C., Sòria, G., Romaguera, M., Guanter, L., Moreno, J., Martínez, P. (2008). Land surface emissivity retrieval from different VNIR and TIR sensors. IEEE Transactions on Geoscience and Remote Sensing, 46: 316-327.
37. Teshnehdel, S., Akbari, H., Di Giuseppe, E., & Brown, R. D. (2020). Effect of tree cover and tree species on microclimate and pedestrian comfort in a residential district in Iran. Building and Environment, 178, 106899.
38. Tran, D.X., Pla, F., Latorre-Carmona, P., Myint, S.W., Caetano, M., Kieu, H.V. (2017). Characterizing the relationship between land use land cover change and land surface temperature. ISPRS Journal of Photogrammetry and Remote Sensing, 124: 119-132.
39. Varentsov, M. I., Grishchenko, M. Y., & Wouters, H. (2019). Simultaneous assessment of the summer urban heat island in Moscow megacity based on in situ observations, thermal satellite images, and mesoscale modeling. Geography, Environment, Sustainability, 12(4), 74-95.

40. Velasco, E., Roth, M., Norford, L., & Molina, L. T. (2016). Does urban vegetation enhance carbon sequestration? Landscape and urban planning, 148, 99-107.
41. UN, 2018. World urbanization prospects the 2018 revision highlights, New York: Population Division, Department of Economic and Social Affairs, United Nations, New York, NY, USA.
42. UN, 2019. World urbanization prospects the 2019 revision highlights, New York: Population Division, Department of Economic and Social Affairs, United Nations, New York, NY,
43. USAWang, F., Qin, Z., Song, C., Tu, L., Karnieli, A., & Zhao, S. (2015). An improved mono-window algorithm for land surface temperature retrieval from Landsat 8 thermal infrared sensor data. Remote Sensing, 7(4), 4268–4289.
44. Wei, M., Zhou, J. (2011). Quantitative analysis of land surface temperature vegetation indexes relationship based on remote sensing. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, vol. XXXVII, part B6b. Beijing, 261-264.
45. Wibowo, A., Yusoff, M. M., Adura, T. A., & Zaini, L. H. (2020). A spatial model of air surface temperature using Landsat 8 TIRS. Paper presented at the IOP Conference Series: Earth and Environmental Science.
46. Xu, X., Sun, S., Liu, W., García, E. H., He, L., Cai, Q., Zhu, J. (2017). The cooling and energy saving effect of landscape design parameters of an urban park in summer: A case of Beijing, China. Energy and Buildings, 149, 91-100.
47. Yue, W., Xu, J., Tan, W., Xu, L. (2007). The relationship between land surface temperature and NDVI with remote sensing: application to Shanghai Landsat 7 ETM + data. International Journal of Remote Sensing, 28: 3205-3226.
48. Yu, Z., Guo, X., Zeng, Y., Koga, M., & Vejre, H. (2018). Variations in land surface temperature and cooling efficiency of green space in rapid urbanization: The case of Fuzhou city, China. Urban Forestry & Urban Greening, 29, 113-121.
49. Zhang, X., Wang, D., Hao, H., Zhang, F., & Hu, Y. (2017). Effects of land use/cover changes and urban forest configuration on urban heat islands in a loess hilly region: a case study based on Yan'an City, China. International Journal of Environmental Research and Public Health, 14(8), 840.
50. Zhou, Y., Shi, T., Hu, Y., Liu, M. (2011). Relationships between land surface temperature and normalized difference vegetation index based on urban land use type. Chinese Journal of Ecology, 30: 1504- 1512.
51. Zhou, B., Rybski, D., & Kropp, J. P. (2017). The role of city size and urban form in the surface urban heat island. Scientific reports, 7(1), 1-9.

The impact of natural hazards on the distribution of ecosystem in Pu Mat natural Park, Nghean province, Vietnam

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Abstract. Natural risks are constantly rising as a result of climate change, especially in Vietnam's mountainous region and the west mountain range in Nghe An province. This paper aims to quantify the effect of natural hazards (erosion, landslide, droughts) on the distribution of ecosystem in the research area. These disasters have a negative influence on biodiversity in forests, agricultural plant systems, and ecosystems at first by causing the spread of invasive species, widespread species mortality, and habitat loss. The major approach used to assess the impact of these risks on ecosystems and the efficacy of related policies is the integration of the fuzzy analytic hierarchy process (FAHP) with geographic information systems (GIS). The results show the areas affected by natural hazards at various levels for planning a region that would serve to lessen the effects of risks and promote biodiversity.

Key words: Natural hazard, ecosystem, Pu Mat natural park

1. Introduction

Natural hazards are phenomena that happen naturally but turn disastrous when they cause numerous casualties and significant property damage, impeding social and economic progress. Globally, natural disasters happen regularly. They pose a threat to human society, ecological systems, and important infrastructure. It is well recognized that disasters caused by natural hazards (hence referred to as "natural disasters") have a devastating impact on economies and communities. Natural disasters typically affect a limited area of a country, hence these effects are typically localized rather than national (Vassilis Tselios, 2021). Natural hazards and local governments are mutually dependent. Major considerations for scientists include not only what local measures might be utilized to lessen the danger of hazards and the local effects of hazards, but also what happens to the authority of local governments following a natural hazards.

Natural disasters caused an annual loss of up to 520 billion USD in 2016, which is 60% more than what is often reported, according to World Bank statistics ((World Bank, 2016).).

A multidisciplinary and interdisciplinary approach is necessary for the study of natural hazards and disaster risk to achieve its goal of explaining the spatial-temporal pattern, process, and mechanism, emergency response, and risk mitigation of natural hazards. There are many different kinds of hazards, and they are influenced by many different things, including geodynamics, climate change, weather patterns, and underlying surface conditions. Seismology, geology, meteorology, hydrology, and other basic sciences are among the academic disciplines that are related to natural disasters. In the past, the discipline concentrated on a single danger or particular kind of hazard and produced significant advances. A thorough discipline framework that takes into account various threats has not yet been devised (PengCui et al., 2021).

The widely accepted idea of wellbeing has given the socioeconomic measurements of susceptibility to environmental hazards that are currently used several new aspects. Stronger

integration of what is primarily a socio-economic concept into the natural hazards domain is required given the wellbeing concept's relevance in many policy agendas (Juan J. Monge et al., 2022).

2. Materials and methodology

2.1. Study area

Pumat National Park is a part of the Western Nghean Biosphere Reserve and is situated in three districts of Anh Son, Con Cuong Tuong Duong, Nghean province, around 130 kilometers from Vinh City. A total of 194,804ha make up the park, originally known as the Pumat National Reserve. Of that, 94,804ha are in the core zone and 100,000ha are in the buffer zone. (Figure 1)

Nearly 1,000 animal species and 2,500 plant species from 160 families can be found in Pumat National Park, which also protects unique and wild genetic sources.

The values and cultural aspects of the ethnic communities in Nghe An's western region are being conserved, and numerous programs and projects on conservation, scientific research, sustainable livelihood development, and environmental education are being carried out.

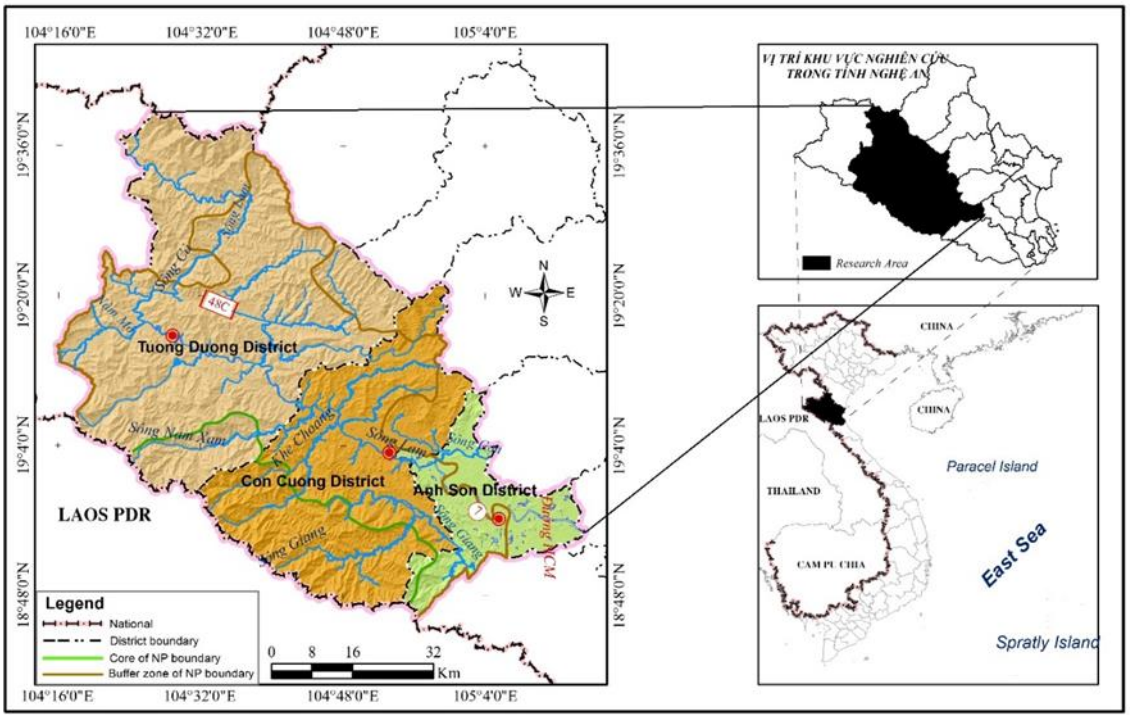

Figure 1. Map of the research area

2.2. Materials

The following information is used as input to determine the distribution of natural hazards, as well as information connected to it, like ecological changes: 1) The USGS website's Digital Elevation Model (DEM) of the study area was downloaded (to create slope and terrain side length), 2. Rainfall data, 3. A soil map, and 4. A landuse/land cover map. To produce an erosion map, this data is used. Additionally, to build landslide and flood maps, combine the data mentioned above with fault, river system, and rock input data.

2.3. Methodology

Using the updated universal soil loss equation (RUSLE), the soil erosion modulus was computed (Jiang et al., 2012).

$$A = R * K * LS * C * P \quad (6)$$

Where

A = estimated average soil loss in tons per acre per year

R = rainfall-runoff erosivity factor

K = soil erodibility factor

L = slope length factor

S = slope steepness factor

C = cover-management factor

P = support practice factor

AHP-based weight calculations are used to build a land-slide map using a mix of input data. These components are Elevation, Aspect, Slope, Lineament (Fault), StreamDensity, Rock, Landuse landcover, Soil, Max precipitation

Landslide = "Elevation.tif" * 0.020 + "Aspect.tif" * 0.021 + "slope3.tif" * 0.036 + "Faults_Density.tif" * 0.152 + "RiverDensity.tif" * 0.035 + "Rock.tif" * 0.144 + "LULC.tif" * 0.067 + "Soil.tif" * 0.097 + "Rainfall4.tif" * 0.158 (7)

3. Results and discussion

3.1. Ecosystem classification

Ecosystem categorization is created by combining the distribution of forest status and the landcover types in the study area.

Covering 262337.39 hectares (54.62%) of the total area, Ecosystem 1 is the largest. Ecosystem 2 is next, with a lesser area of 126140.26 hectares (24.50%). Agricultural ecosystem contains 26440.16 hectares (count 5.14% of total area), whereas other ecosystems make up roughly 5% of the total area.

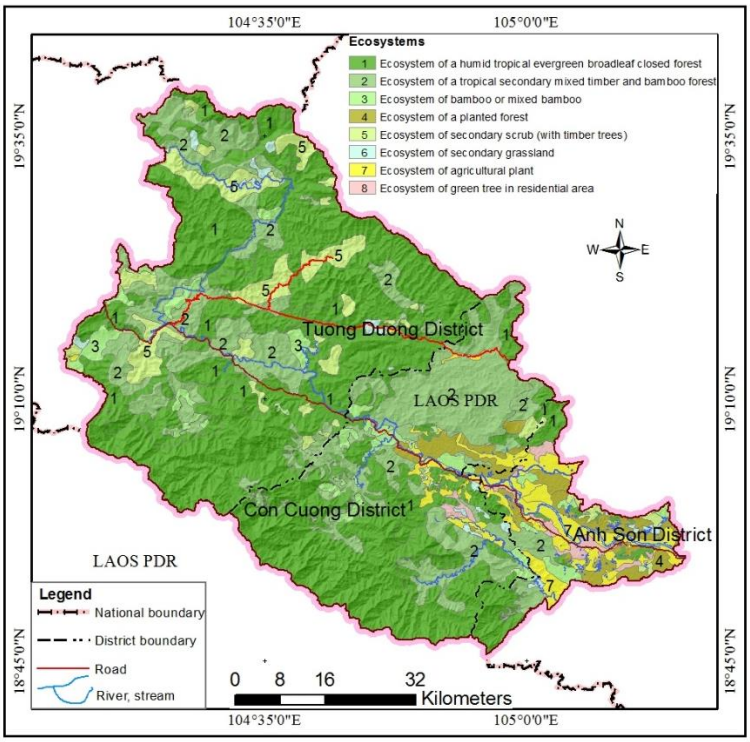

Figure 2. Map of ecosystem distribution in Pu Mat NP, Nghean province, Vietnam

Table 1. Ecosystem distribution based on elevation

Ecos-ystem	Elevation	Area (hectares)	Scale (%)	
1	< 200	18860.04	*3.66*	*54.62*
	200-700	177874.09	*34.55*	
	700-1200	68485.22	*13.30*	
	> 1200	15978.08	*3.10*	
2	< 200	23081.49	*4.48*	*24.50*
	200-700	94674.14	*18.39*	
	700-1200	7708.02	*1.50*	
	> 1200	676.61	*0.13*	
3	< 200	9183.28	*1.78*	*3.85*
	200-700	10613.52	*2.06*	
	700-1200	16.31	*0.00*	
4	< 200	18376.47	*3.57*	*3.61*
	200-700	192.95	*0.04*	
5	< 200	4255.03	*0.83*	6.32
	200-700	26181.73	*5.09*	
	700-1200	2061.06	*0.40*	
	> 1200	52.42	*0.01*	
6	< 200	1528.75	*0.30*	0.90
	200-700	2712.64	*0.53*	
	700-1200	389.02	*0.08*	
7	< 200	25449.04	*4.94*	5.14
	200-700	991.12	*0.19*	
8	< 200	5125.11	*1.00*	1.06
	200-700	328.56	*0.06*	
Total		**514794.71**	**100.00**	

3.1. Distribution of soil erosion classification on ecosystem

The classification of soil erosion in Pu Mat NP is divided into 4 levels: Very High – High – Medium – Low – Very low. This map is created from five components following equation 6.

Table 2. Distribution of erosion classification levels

ECOSYSTEM	AREA (hectares)	STD	VARIETY	MAJORITY	MINORITY	MEAN
1	281157.24	0.71	5	2	5	2.24
2	126151.60	0.63	5	2	5	2.01
3	19816.21	0.66	4	2	4	1.88
4	18572.40	0.54	4	1	4	1.49
5	32560.09	0.62	5	2	5	2.00
6	4628.81	1.07	5	2	5	2.25
7	26452.82	0.76	5	1	5	1.38
8	5455.53	0.94	5	1	5	1.54

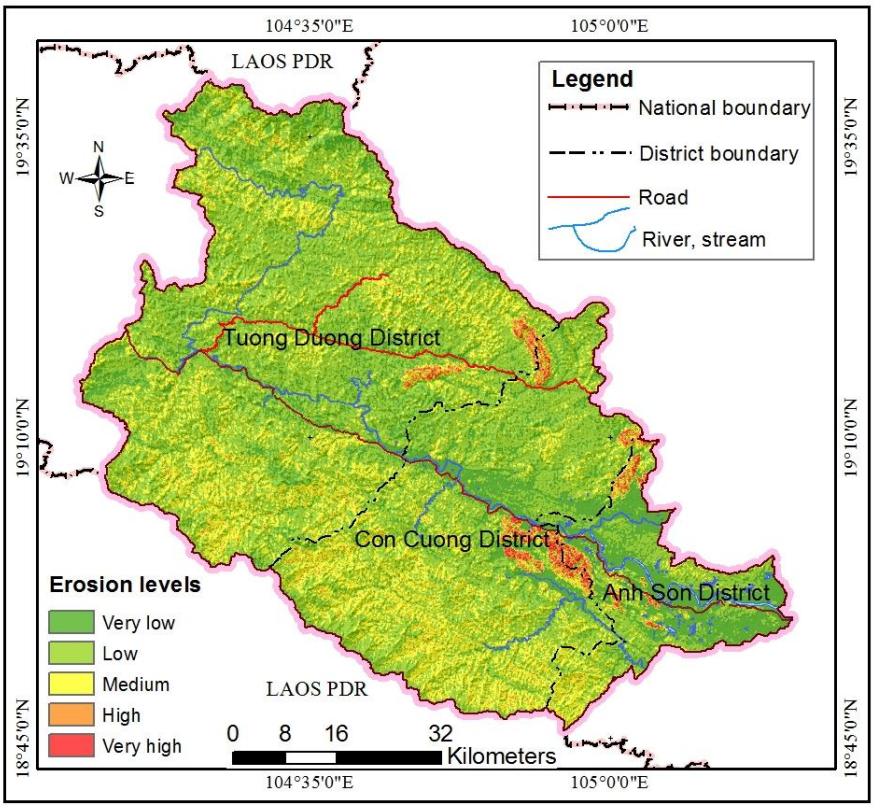

Figure 3. Map of erosion in Pu Mat NP, Nghean province, Vietnam

The highest value is found on the hills along the Ca River and in the western section of the research region, where the mean value of soil erosion ranges from 1.58 to 2.25. The mountainous area to the north-west of the research area is where the median value of soil erosion is found.

3.2. Distribution of landslide classification on ecosystem

The classification of landslide in Pu Mat NP is divided into 5 levels: Very High – High – Medium– Low – Very low. This map is created from five components following equation 7.

Table 3. Distribution of landslide classification levels

ECOSYSTEM	AREA (hectares)	STD	VARIETY	MAJORITY	MINORITY	MEAN
1	280676.4	1.19	5	2	5	2.89
2	126186.8	1.16	5	4	1	3.64
3	19871.18	1.15	5	5	1	3.76
4	18607.23	1.00	5	4	1	3.68
5	32782.64	0.98	5	3	1	2.97
6	4575.811	0.98	5	2	5	2.76
7	26702.9	1.29	5	2	5	2.62
8	5391.777	1.03	4	1	3	1.70

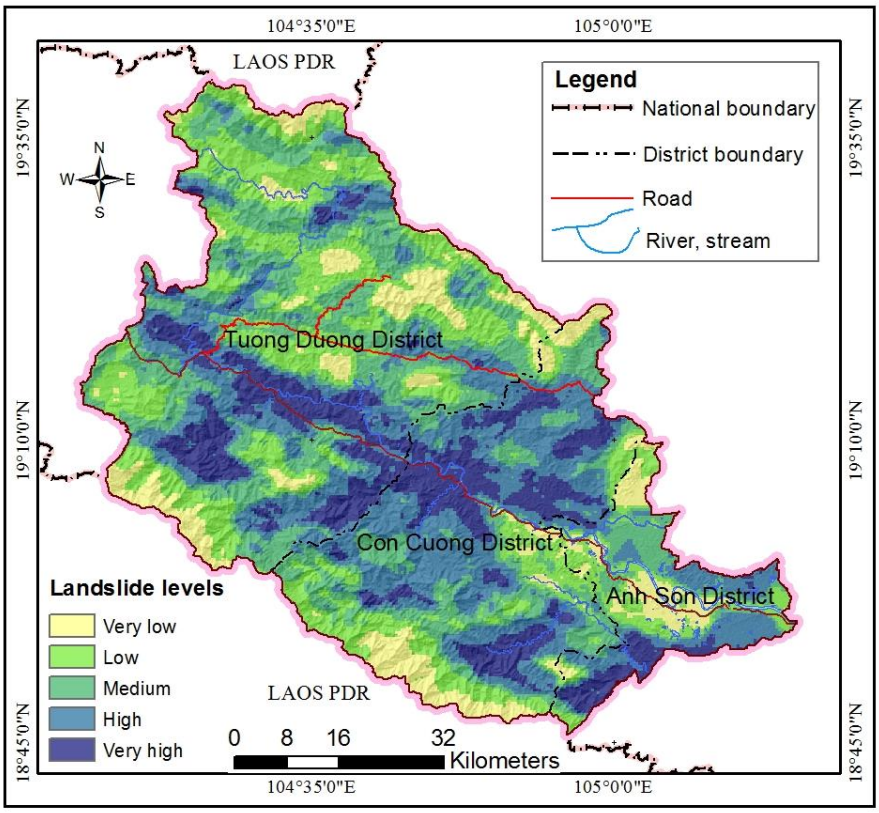

Figure 4. Map of landslide in Pu Mat NP, Nghean province, Vietnam

The largest value is found on hills along the Ca River and in a portion of the southwesterly and eastern parts of the research region, where the mean value of landslides ranges from 1.70 to 3.76.

3.3. Distribution of drought classification on ecosystem

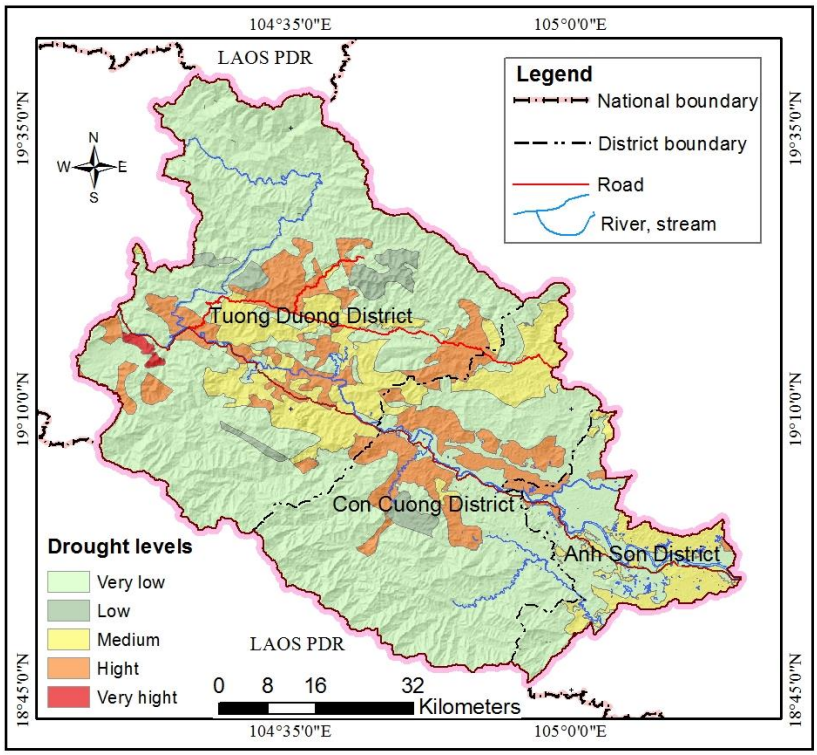

Figure 5. Map of drought in Pu Mat NP, Nghean province, Vietnam

According to the drought map, the area with the highest level of drought is situated northwest of the research area, in the hills along the Ca River, in the Tuong Duong and Ky Son districts.

Table 4. Distribution of drought classification levels

ECOSYSTEM	AREA (hectares)	STD	VARIETY	MAJORITY	MINORITY	MEAN
1	280676.39	1.19	5	2	5	2.89
2	126186.78	1.16	5	4	1	3.64
3	19871.178	1.15	5	5	1	3.76
4	18607.23	1.00	5	4	1	3.68
5	32782.644	0.98	5	3	1	2.97
6	4575.8108	0.98	5	2	5	2.76
7	26702.896	1.29	5	2	5	2.62
8	5391.777	1.03	4	1	3	1.70
Total	514794.71					

3.4. Distribution of natural hazard classification on ecosystem

The natural hazard is created by combining maps of soil erosion, drought, and landslides, which are considered the main dangers in the research area. The classification of soil erosion in Pu Mat NP is divided into 4 levels: Very High – High – Medium – Low – Very low.

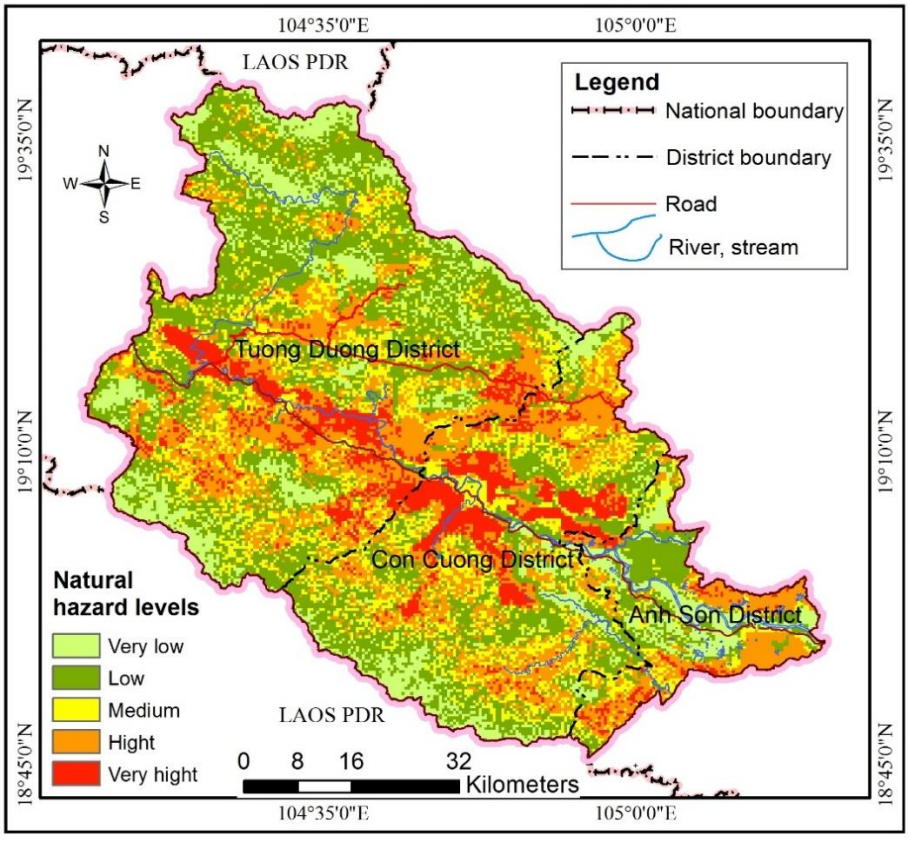

Figure 6. Map of natural hazard in Pu Mat NP, Nghean province, Vietnam

The highest value of natural hazard levels are located along the Ca river and a part of the eastern region. Then the high and medium levels of natural hazard levels are concentrated in the western region and a part of the eastern region.

Table 5. Distribution of natural hazard classification levels

ECOSY-STEM	AREA (hectares)	Scale (%)	STD	VARIETY	MAJORITY	MINORITY	MEAN
1	280439.84	*54.48*	1.16	5	2	5	2.69
2	126432.93	*24.56*	1.24	5	2	1	3.16
3	19890.49	*3.86*	1.22	5	4	1	3.17
4	18543.07	*3.60*	1.26	5	4	1	3.29
5	32835.35	*6.38*	1.17	5	2	5	2.77
6	4587.64	*0.89*	1.11	5	2	5	2.55
7	26659.67	*5.18*	1.03	5	1	5	1.92
8	5405.72	*1.05*	1.03	4	1	3	1.98
Total	**514794.71**	**100.00**					21.53

The mean value of natural hazards in the research area ranges from 1.98 to 3.29. Which, the largest' value is located in ecosystems 4; 3 and 2 at the value of more than 3. Then the smaller value is located in ecosystems 1; 5 and 6 with values of 2.5 to 2.7.

4. Conclusion

Accurate hazard-related information is necessary for natural hazard forecasting and early warning. The early detection and prediction of earthquakes, tropical cyclone track monitoring and prediction, and extreme weather and climate warning systems have all benefited from technological advancements to date (Huang, 2015; Obara and Kato, 2016; Cochran and Husker, 2019). (Schiermeier, 2018). The outcome of this study demonstrates the distribution of 5 classification levels of a natural hazard (made up of 3 components: landslides, erosion, and drought) throughout the 8 ecosystems. The statistic table of one ecosystem hazard will help in developing a plan for the protection of biodiversity in ecosystems, in addition to the maps of these components and natural hazards.

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References

1. M.M. Yagoub, Abdulla Amed Al Yammahi, 2022, Spatial distribution of natural hazards and their proximity to heritage sites: Case of the United Arab Emirates,

International Journal of Disaster Risk Reduction, Volume 71, 2022, ISSN 2212-4209.

2. Jiang z, Su S, Jing C, Lin S, Fei X, Wu J (2012). Spatiotemporal dynamics of soil erosion risk for Anji County, China. Stochastic Environ Res Risk Assess, 26(6): 751–763
3. Juan J. Monge, Nicola McDonald, Garry W. McDonald (2022), A review of graphical methods to map the natural hazard-to-wellbeing risk chain in a socio-ecological system, Science of The Total Environment, Volume 803, ISSN 0048-9697.
4. K. Obara, A. Kato (2016), Connecting slow earthquakes to huge earthquakes, Science, 353 (6296) (2016), pp. 253-257.
5. Peng Cui, Jianbing Peng, Peijun Shi, Huiming Tang, Chaojun Ouyang, Qiang Zou, Lianyou Liu, Changdong Li, Yu Lei, 2021, Scientific challenges of research on natural hazards and disaster risk, Geography and Sustainability, Volume 2, Issue 3, 2021, Pages 216-223.
6. World Bank, 2016, The World Bank Annual Report 2016, World Bank, Washington D.C (2016)
7. Y. Huang, Z. Tian, Q. Ke, J. Liu, M. Irannezhad, D. Fan, M. Hou, L. Sun (2020), Nature-based solutions for urban pluvial flood risk management, Wiley Interdiscip. Rev. Water, 7 (3) (2020), p. e1421
8. Vassilis Tselios (2021), Does the shock of natural hazard-associated disasters affect the authority of regional governments? Applied Geography, Volume 134, ISSN 0143-6228.

Evaluation for qualify of Nghen river, Ha Tinh province (Viet Nam) according to the VN_WQI index

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Abstract. The Nghen River has a length of over 60 km. The river's water is now being exploited and used for socio-economic development in the northern part of Ha Tinh province. The content of the article presents the results of river water quality assessment according to the VN_WQI index on the basic document of river water quality monitoring in 2021 through 36 water samples of 6 typical cross-sections with selected criteria including pH, As, Cd, Pb, Cr^{6+}, Cu, Zn, Hg, DO, BOD_5, COD, TOC, N-NH_4, N-NO_3, P-PO_4 and Coliform. The results showed three zones of water qualified: in the period from January-September, zone 1, limited from the M1 to M5 cross-section, has very very good water quality to good; in the period from October to December, the section from M3 to M4 has reduced water quality to a medium level, classified as Zone 2 with very good to medium quality. The remaining parts of M1-M3, and M4-M5 water still ensure good to very good quality, which can supply water for domestic purposes; and Zone 3 from M5 to M6 (downstream of the Nghen river) has stable water quality at an average level throughout the year. This water quality is only used for the purpose of supplying water for agriculture, industry, and river traffic.

Key words: water quality, VN_WQI, Nghen river, pollution, Ha Tinh province

1. Introduction

Methods of assessing water quality according to the water quality index (WQI) is a "combined" parameter calculated from many water quality parameters according to a defined method (or mathematical formula). WQI was first proposed and applied in the US in the 70s of the 20th century. After that, WQI was quickly accepted and applied in many countries around the world and is considered an effective tool for environmental managers in the monitoring and evaluation of water quality. In this paper, WQI is used for quantitative description of quality and is usually expressed on a scale from 0 (corresponding to worst quality) to 100 (corresponding to best quality), in some cases using a scale of 10–100 or 0–1000 [5].

Today, there are many types of WQI in use in the world, notably Canada's WQI (CCME). WQI-CCME is built on a variety of metrics using a statistical process with a minimum of 4 parameters and 3 key coefficients (F1-range, F2-frequency, and F3-amplitude of the results). The results do not meet the standard limit (water quality targets). WQI-CCME is a very quantitative and easy-to-use formula with parameters and their standard values (water quality target) can be easily fed into WQI-CCME for automatic calculation. The National Sanitation Foundation (NSF) WQI is one of the most commonly used sets of water quality indicators. The WQI-NSF is built by using the Delphi technique of Rand Corporation, collecting and synthesising the opinions of a large number of experts from all over the US to select the decisive quality parameters and then establish the weighting. We first define the contribution of each parameter (the important role of the parameter-wi) and then proceed to build conversion graphs from the measured values of the parameter to the sub-index (q_i).

In Vietnam, there have been many studies and proposals for the application of water quality indicators such as WQI-2 and WQI-4 used to assess water quality in a number of rivers

such as the Saigon river at Phu Cuong, Binh Phuoc and Phu An during the period from 2003 to 2007, Dong Nai river [1], Bo river (Thua Thien - Hue) and some rivers in Quang Tri province [2], Ray river [5]. In order to unify how to calculate the water quality index, the Vietnam Environment Administration has officially issued the Technical Manual for calculating the water quality index according to Decision No. 1460/QĐ-TCMT on November 11, 2019. This applies to the monitoring data of the continental surface water environment [5].

The Nghen river is the main water source for agricultural production, aquaculture, and domestic water supply for the people, and at the same time, it is responsible for flood drainage for most of the agricultural land and population in the basin. However, the Nghen river is also a place to receive many untreated wastewater sources, such as domestic wastewater, aquaculture wastewater, wastewater from industrial and agricultural activities, livestock wastewater, health care, etc. Natural activities such as floods, droughts, and saltwater intrusion from the sea also affect the quality of the river. Meanwhile, so far, there has been almost no research work to fully evaluate and classify river water quality for the purposes of use [6].

2. Material and methods

2.1. Study area

The Nghen river basin is located in the north of Ha Tinh province in the geographical range from 18°17' to 18°55' North latitude and from 106°33 to 106°55' East longitude. The Nghen river originates from Trung Luong sluice and joins with the Rao Cai river at Ho Do commune with a basin area of about 556 km^2. The Nghe river passes through Duc Tho district, Hong Linh town, Can Loc district, Loc Ha district, and some northern communes of Thach Ha district with a total length of about 60 km.

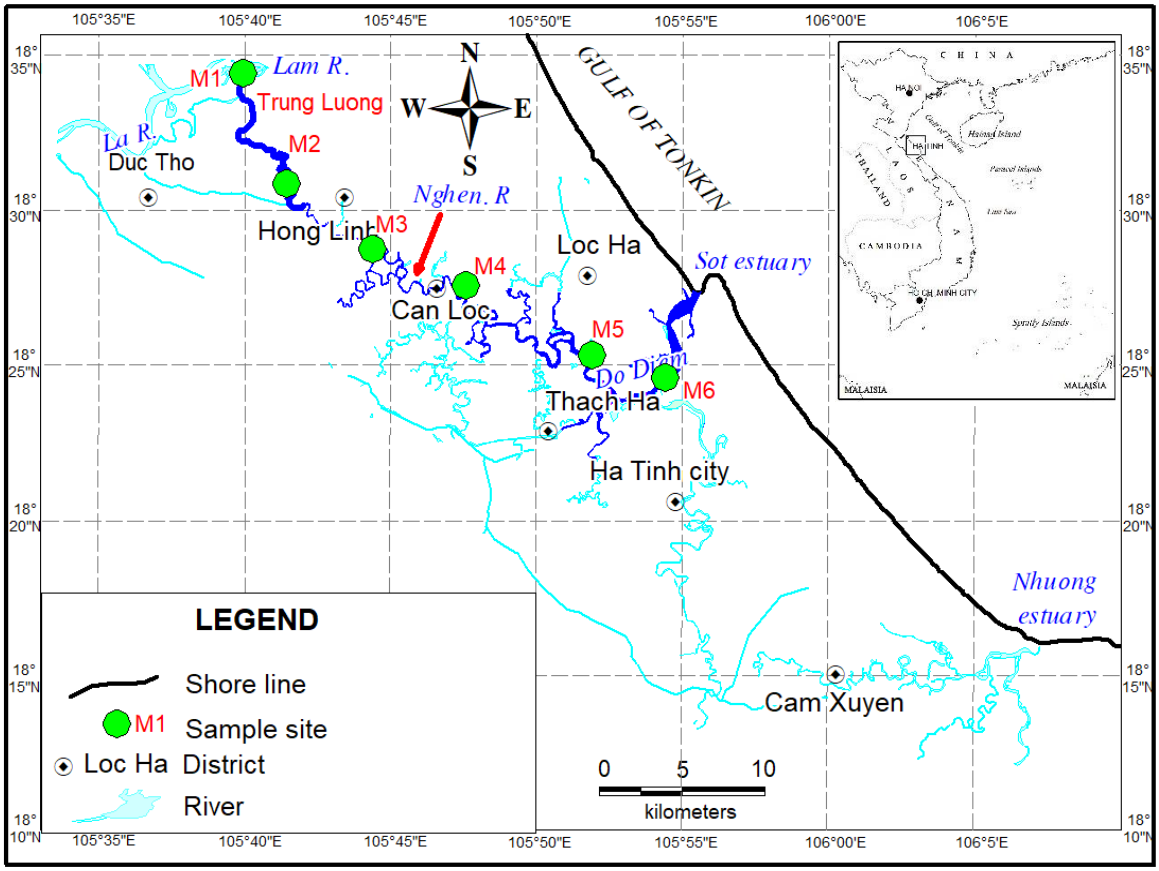

Fig 1. Location map and cross-sectional study of water quality in the Nghen river

2.2. The VN-WQI method to assess water quality

Water samples were determined four times a year, including phase 1: March; phase 2: June; phase 3: September; and phase 4: December. The number of samples taken is 24 samples according to 6 representative cross-sections of the river (Fig. 1).

On the basis of the guidelines for assessment of surface water quality issued by the Vietnam Environment Administration [7], the method of assessing water quality by WQI indicators is a general model (symbolized as VN-WQI). calculated from 16 water quality parameters, including pH parameters (group 1), As, Cd, Pb, Cr^{6+}, Cu, Zn, Hg (group 2), DO, BOD_5, COD, TOC, $N\text{-}NH_4$, $N\text{-}NO_3$, $P\text{-}PO_4$ (group 3), Coliform (group 4). The VN-WQI is calculated separately for the data from each monitoring point.

a. Calculating VN-WQI parameters

* For parameters As, Cd, Pb, Cr^{6+}, Cu, Zn, Hg, BOD_5, COD, TOC, $N\text{-}NH_4$, $N\text{-}NO_3$, $P\text{-}PO_4$, Coliform is calculated according to the following formula:

$$WQI_{SI} = \frac{q_i - q_{i+1}}{BP_{i+1} - BP_i}\left(PB_{i+1} - C_p\right) + q_{i+1} \quad (1)$$

In there:

BP_i: Monitoring parameter value i's lower limit concentration.

BP_{i+1}: Concentration of monitoring parameter value i+1's upper limit.

q_i: The WQI value at level i that corresponds to the BPi value.

q_{i+1}: At i+1, the WQI value corresponds to the BP_{i+1} value.

C_p: The observed parameter's value.

* For the DO parameter, the WQI_{DO} value is calculated as the percentage DO value of saturation (C_p):

$$Cp = 100*DO_{dissolve}/DO_{saturation}$$

In there:

$DO_{saturation} = 14{,}652 - 0{,}41022T + 0{,}0079910T^2 - 0{,}000077774T^3$

T: the temperature of the surrounding water (in degrees Celsius).

$DO_{dissolve}$: DO value (mg/L) was measured.

$$WQI_{DO} = \frac{q_{i+1} - q_i}{BP_{i+1} - BP_i}\left(C_p - BP_{i+1}\right) + q_i \quad (2)$$

* For pH parameters: WQI_{pH} = 10 if pH is 5.5 or greater than 9; 5.5 ≤ pH < 6, WQI_{pH} is calculated using Equation 2; 6 ≤ pH ≤ 8.5, WQI_{pH} is 100; 8.5 < pH < 9, WQI_{pH} is calculated using Equation 1.

b. The calculated VN-WQI value

After calculating the WQI for the four parameter groups, the final VN-WQI value is applied according to the following formula:

$$\text{VN-WQI} = \frac{WQI_1}{100} \times \frac{\left(\prod_{i=1}^{n} WQI_2\right)^{1/n}}{100} \times \left[\frac{1}{m}\sum_{i=1}^{m} WQI_3 \times \frac{1}{k}\sum_{i=1}^{k} WQI_4\right]^{1/2} \quad (3)$$

In there:

WQI_1: The pH parameter's calculated WQI value;

WQI_2: The calculated WQI value for the parameters of group 2, n = 7: As, Cd, Pb, Cr^{6+}, Cu, Zn, Hg;

WQI_3: The calculated WQI value for the parameters of group 3, m = 7: BOD_5, COD, TOC, $N\text{-}NH_4$, $N\text{-}NO_2$, $N\text{-}NO_3$, $P\text{-}PO_4$;

WQI_4: The calculated WQI value for the parameters of group 4, l = 1, is coliform.

2.3. Classification and zoning of river water quality

According to the WQI, river water quality is classified into 5 levels according to VN-WQI values [7]: Very Good (VN-WQI: 91-100), Good (VN-WQI: 76-90), Medium (VN-WQI: 51-75), Bad (VN-WQI: 26-50) and Polluted (VN-WQI: 0-25). The extent of a river's water quality area is based on two adjacent survey cross-sections in the river with the same water quality level.

3. Results and discussions

3.1. Nghen river water quality in 2021

The results of water quality monitoring in the Nghen River with 24 water samples taken in 2021 of 16 parameters evaluated according to Vietnamese national technical regulation for surface water quality (QVN08-MT:2015/BTNMT: the A1 level for drinking water purposes; the B1 level is acceptable for irrigation and transportation or other activities that do not require a high quality standard) are as follows:

-PH: The pH value of the river water ranges from 6.0 to 7.8, within the limits of A1, A2. Due to the influence of tides, the upstream area usually has a higher pH value than upstream.

-DO: DO concentration ranges from 4.0-8.8 mg/L with cv =8.9-22.4%. DO concentrations at the cross-sections are all within the limits of A1 levels.

-BOD_5: BOD_5 concentration fluctuates in the range of 3.4-26 mg/L with cv =23.4 - 64.2%. Most of the cross-sections have BOD5 values exceeding the limit of A1, A2. Specifically, at M6 (phase 2, phase 3) BOD5 exceeded 4 times the A2 level; at cross-section M1, in phase 1 and phase 3, the BOD_5 value is 1.75 times higher than the A1 level. At the M3, M5 cross-section, the BOD5 value is over 2 times higher than the A1 level.

Water quality downstream of the river (under Do Diem dam) tends to decrease in quality in the dry season. Water only reaches B2 level. At cross-section M6, in phase 3, the BOD_5 value exceeds 1.67 times higher than the B1 level, the water's only response for the purposes of irrigation and navigation.

-COD: COD concentration ranges from 10–40 mg/L with a CV of 20–44%. Most of the values exceed the A1 level. The upstream sections M1-M4 (accounting for 70%) reach the A2 level, the rest reach the B1 level (30%).

-$N\text{-}NO_3$: $N\text{-}NO_3$ concentration ranges from 0.1-0.6 mg/L with cv = 24-77%, spatially about 0.2-0.6 mg/L and over time about 0.34-0.5 mg/L. The concentrations of $N\text{-}NO_3$ at the cross-sections were all within the limit of A1.

-$N\text{-}NH_4$: The concentration of $N\text{-}NH_4$ fluctuates in the range of 0.01-0.4 mg/L with cv = 9.1-90.5%. The spatial average is about 0.02-0.6 mg/L and over time, about 0.06-0.073 mg/L. Some locations have N-NH4 values exceeding the A1 level by 1.4 times (sample phase 1-M4) to 1.5 times (sample phase 4-M1).

-$P\text{-}PO_4$: $P\text{-}PO_4$ concentration ranges from 0.088-0.02 mg/L with cv=0.1-75%. The concentrations of $P\text{-}PO_4$ at the cross-sections were all within the limit of A1.

-Coliform: Total coliform of river water ranges from 100–1600 MPN/100 ml with cv = 33.3–104.3%. Most of the cross-sections had concentrations within the A1 level limit (97%). Only at the M6 section, phase 2, the coliform concentration is 1.04 times higher than the A1 level.

Indicators of heavy metals (Cu, Pb, Zn, Hg, As) have concentrations lower than the allowable limit in response to the requirements of water supply for domestic purposes.

3.2. Assessment of river water quality according to VN-WQI

The results of calculating VN-WQI of the Nghen river according to 4 monitoring times in a year with six cross-sections are shown in Table 1. In which, av: average WQI value; s: standard deviation; cv: coefficient of variation.

Table 1. VN-WQI results of Nghe river in 2021

Section	Time				av±s	cv(%)
	Phase 1	Phase 2	Phase 3	Phase 4		
M1	90	92	92	80	74±4.57	6.18
M2	98	91	89	94	93±3.92	4.22
M3	93	93	95	66	87±13.87	15.94
M4	91	99	92	93	94±3.59	3.82
M5	94	100	96	89	95±4.57	4.81
M6	75	75	73	69	85±5.26	6.19
av±s	91±7.28	90±9.27	87±9.34	84±9.67		
cv (%)	8.0	10.3	10.74	11.51		

The results in Table 1 show that, in 2021, VN-WQI belongs to the very good type (level I), accounting for 66.6% of the samples, the good type (level II) accounts for 29.1%, and the medium type has only one sample. phase 4 at cross-section M3.

To consider the VN-WQI values between the cross-sections and the survey time, the ANOVA statistical method is applied for 2 non-repeating factors [8] (Table 2).

Table 2. Results of ANOVA analysis for VN-WQI of the Nghen river in 2021

Source of Variation	SS	df	MS	F	P-value	$F_{(0,05;3;23)}$
Rows	1319.71	5	263.94	7.94	0.00	2.90
Columns	348.46	3	116.15	3.49	0.04	3.29
Error	498.79	15	33.25			
Total	2166.96	23				

According to the data, the average VN-WQI at different cross-sections on the Nghen river in 2021 is different: F = 3.49 > F (0.05) = 3.29, or the water quality of the river at different cross-sections, and VN-WQI is also different according to the survey time, F = 7.94 > F (0.05) = 2.9.

3.3. Classification and zoning of water quality

From the VN-WQI assessment results according to six cross-sections arranged in the direction of the river's flow, from upstream to downstream, with 4 surveys in 2021, there are 3 main areas of water quality in the Nghen river as follows:

- Area of good to very good water quality: According to the cross-section, the water quality from the upstream of the river (M1) to the Do Diem dam (M5) meets the water supply standards for living. Only at M3, phase 4, the water sample only reached the average level. Here, the BOD_5 content was higher, from 5.2 to 8.9, the DO content was from 4.5 to 6.2, and the N-NH4 content was 1.5 times higher than that of the M3, phase 4. The reason is that the river receives many sources of waste from livestock in the area. Except for the M3 area, river water is less affected by waste sources.

- Area of medium water quality: from M5 to M6 is the part of the river located under Do Diem dam. The river is affected by tides, agricultural farming activities, livestock activities and water sources of other tributaries. Especially in the rainy season, the VN-WQI index decreased sharply, ranging from 66 to 87. Water has a high BOD_5, COD concentration (BOD_5=25-26 mg/L, COD=20-40 mg/L), high TOC concentration (4.1-5.7 mg/L), and DO content (4-6.7). The M6 area, the river has a large basin, is the place to receive many sources of domestic wastewater in Thach Son commune, Ho Do commune and Thach Ha commune, wastewater from aquaculture activities on both sides and the impact of the saltwater intrusion from the sea, while the flow rate is low, the self-cleaning capacity of the river is lower. Water quality can only be used for aquaculture, navigation.

Zoning will support the planning and licensing of water exploitation for environmental management purposes such as: monitoring and monitoring; monitoring the evolution of water quality in each region through the assessment of each individual parameter; and assessment. based on VN-WQI.

4. Conclusion

The VN-WQI model is applied to 16 water environment parameters to assess and partition the water quality of the Nghen river in 2021. The number of samples for analysis of water quality through six cross-sections, representing water environment points with 24 water samples. By time of year, over the entire length of the river, there are 3 types of water quality zones: Zone 1, limited from the M1 to M5 cross-section, has very good water quality (level I) to good (level II) in the period from January-September, The water quality is adequate for domestic purposes. Particularly in the period from October to December, the section from M3 to M4 has reduced water quality to a medium level, classified as Zone 2 with very good to medium quality; The remaining parts of M1-M3, M4-M5 water still ensure good to very good quality; Zone 3 from M5 to M6 (downstream of the Nghen river) has stable water quality at an average level throughout the year. Water can be used to supply water for agricultural cultivation, industry, and navigation.

The results of water quality zoning by time of the year have scientific significance for intervention in adjusting and supplementing the planning of the water quality monitoring network on the Nghen river and contributing to the planning of exploitation and use of water in the Nghe river for various purposes. for the socio-economic development of the region.

References

1. Pham, M. Rahman, N. Nguyen, P. L. Vo, T. L. Van, and H. Ngo (2017). Assessment of surface quality using the water quality index and multivariate statistical techniques A case study: The upper part of the Dong Nai river basin, Vietnam, Journal of Water Sustainability, vol. 7, pp. 225-245.
2. Nguyen Van Hop (2005). Research and evaluate the current state of surface water quality on the basis of a water quality index (WQI) in some key areas of Quang Tri province for water resource management and sustainable development. Quang Tri province, Department of Natural Resources and Environment, Quang Tri.

3. Ministry of Natural Resources and Environment (2015Vietnamese Standard No. 08-MT:2015/BTNMT.
4. Miller, J. C., and Miller, J. N. (1988). Statistics for Analytical Chemistry, 2nd Ed. Ellis Horwood Limited, Great Britain.
5. Phan Thi Thanh Thuy, Nguyen Van Viet, Nguyen Kieu Lan Phuong, Chun-Hung Lee, 2021. Water quality evaluation using a water quality index: a case study of the Ray River in Vietnam226(06): 38-47 in TNU Journal of Science and Technology.
6. Phan Van Truong, Nguyen Van Kien (2019). Pollution load of wastewater in the Nghen river basin, Ha Tinh province. Journal of Water Resources and Environmental Engineering, No. 65, pp. 95–102.
7. Vietnam Environment Administration (2019).Technical guidance for the calculation and publication of Vietnam's water quality index (VN-WQI).
8. Reeve, R. N. (2002). Introduction to Environmental Analysis John Wiley & Sons Ltd.

Migration and Emotion: A Study of Migrants in Rehabilitation Camp of Dinhata after Enclave Exchange along Indo-Bangladesh Border

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Abstract. Migrants often feel few negative and positive emotions about their place of origin and place of destination during migration. In this paper, an attempt has been made to highlight the geography of emotion that the migrants of rehabilitation camp of Dinhata, India have expressed after the enclave exchange along the Indo-Bangladesh border. The study reveals how do multiple factors like place dependence, place identity, economy and culture influence human emotion as well as alter human behaviour. In order to carry out the study, both primary and secondary data have been collected from India and Bangladesh by using a structured questionnaire and Focus Group Discussions (FGDs) with informed consent from the respondents. Subsequently, statistical techniques like Correlation, Regression and Emotional Score have been used to assess the perception. Result shows that migrants of the rehabilitation camp have been experiencing significant psychological pain which is related to the physical and social environment that they have left behind.

Keywords: Emotion, Migration, Human Behaviour, Topophilia, Topophobia, Adaptation

1. Introduction

There is a close relationship between migration and emotion. Migration commonly refers to permanent or semi-permanent movement of people from one place to another. On the other hand, emotion is referred to as a feeling in respect of a situation, may it be positive or negative like love, hate, fear, anger etc. (Brewer & Hewstone, 2004). It is controlled by the physical and cultural environment wherein that particular situation exists. Emotion is one of the important factors of human migration where it plays both push and pull factor for movement of people (Datta, 2004) and both the factors of movements are associated to a place which further initiates a process of attachment to that place.

'Place' is a broad concept and may be of two types viz. Social place and Physical place. '*Process*' refers to cognitive relationship between man and environment and **'***Person***'** is an individual or a group of people (Casakin & Kreitler, 2008). The place attachment may have positive, negative and neutral quality in terms of emotional expression (Chow & Healey, 2008). Positive sense comes into force when a place exerts some or all of its good qualities on human mind and such certain aspects of a place are commonly considered as positive emotion to a place or 'Topophilia' (Tuan, 1990). On the contrary, negative sense emerges from weakness and threat associated to a particular place which bring an adverse image to humans resulting out negative emotion of place or 'Topophobia' (Albrecht, 2019).

Enclaves, one of the main components of this study are actually fragmented territory from the mainland. An enclave is a territory whose geographical boundaries lie entirely within the boundaries of another territory where as, Exclave is a portion of the territory of one state completely surrounded by the territory of another or other states, as viewed by the home country.

Along the Indo-Bangladesh border, few people (922) migrated from erstwhile Indian enclave inside Bangladesh to India after the enclave exchange (Datta, 2002). Out of them, only 245 migrants were sheltered in temporary rehabilitation camp of Dinhata. Remaining 198 and 479 were sheltred in rehabilitation camps of Mekhliganj and Haldibari respectavily. But, all of them used to feel discomfort in the new environment of the camp because in reality, they were socially isolated from both sides of the country i.e. India and Bangladesh. Almost all of them belonged to poor economic background and they migrated from rural part of Bangladesh to rural part of India during enclave exchange because of 'topophilia' to indian part. Subsequently, migrants have been facing various socio-cultural and economic problems in the temporary rehabilitation camp of Dinhata. They also feel themselves away from their own places leaving their land, home, relatives, domestic pets and invisible relationship with neighbour (Cons, 2013). Even, there is found a social distance in the field of utilisation of facilities available at their new place i.e. the rehabilitation camp. Therefore, they are away from place dependence where they have been sheltered. In general, place dependency forms gradual attachment to a place which ultimately initiates the process of emotion generation (Brown & Perkins, 1992). In this case, although they have been shifted to a new place but their emotion is persisting to that place where from they have migrated, but not whereto they have been rehabilitated because of loss of place identity and few abstract ideas like love, relation etc. which the new place cannot provide.

Migrants have migrated from Bangladesh to India after exchange of enclave, which is related to the international arrangement of migration. At that time of international migration, geographical site and situation played significant role for the enclave dwellers which made a relationship between dwellings or a group of dwellings and the immediate physical and social environment. Consequently, a few of them migrated from Bangladesh to India, there was non-migrant population also. Thus, it was a fact that both migration and non-migration were regulated by emotion (Löckenhoff & Carstensen 2004), which is evident in this study.

India with its multi-cultural, multi-lingual, multi-religious and multi-racial population represents federal government system. But, Bangladesh is basically considered as monoculture, monolingual, monotheistic religion based country with unitary government system. Therefore, there is a structural difference in terms of place of origin i.e. Bangladesh and the place of destination i.e. India (Shewly, 2013). Consequently, there has been existing problems in adapting new situation from so called 'mono' to 'multi' field of landscape. Such kind of social processes influence migrants' emotion and they remind what they had, what they left and so many other feelings which are significantly controlled by physical and socio-geographical components (Jones, 2009). In this juncture, emotion connects Geography, and the study of Emotional Geography may be considered for policy perspectives.

2. Objectives of the study

To know about the causes of migration along Indo-Bangladesh border.

To understand the role of selected geographical domains in influencing emotion.

3. Materials & Methods

To conduct the study, both primary and secondary data have been collected from the study area. A well-structured questionnaire has been prepared focusing on various aspects of geographical elements that regulate emotion and the same has been applied over 188 people.

Subsequently, reliability test has been done followed by Cronbach's α test (.821) in SPSS software. In order to justify the answers of the questions asked, Focus Group Discussion has also been conducted. An Emotional Score (ES) has been developed on the basis of four domains i.e… 'Place dependence', 'Place identity', 'Emotional economy' and 'Emotional culture' in order to understand the level of influence of emotion on migration under each geographical domain. These four indicators consist of eight sub-indicators which are closely related to emotion. Some weightages have been assigned by the respondents as per their opinions to each sub-indicator. Here, higher weightage has been given if the respondents strongly agree with the statement and vice versa.

After getting the weightage of each sub-indicator, the emotional Score (ES) has been calculated by using formula of simple mean at Rehabilitation Camp of Dinhata, Cooch Behar district, India. The Emotional Score (ES) has been calculated by using the following formula-

$$ES = \sum (\sum V_1 + \sum V_2 + ... \sum V_4)$$

Here,

ES - Emotional Score

V_1 to V_4 - Domains 1 to 4

To understand the association between Emotion Score (ES) and Geographical elements, Spearman's correlation has been applied.

4. Result and Discussion

Causes of migration

After the exchange of enclaves in 2015 between India and Bangladesh, only 1.74% people migrated to India from Bangladeshi exclave and they were given shelter three in temporary rehabilitation camps in Cooch Behar district. Out of a total of 201 families migrated to India, 58 families were sheltered in Dinhata block, 47 families in Mekhliganj block and remaining 96 families were sheltered in Haldibari block. In the rehabilitation camp of Dinhata, 47 families consisting of 245 migrants were sheltered. Out of 245 migrants, 115 were female and 130 were male population. Apart from that, there was highest concentration of Muslim population (56.73%) among the migrants. The migrants of rehabilitation camp of Dinhata lived at Dasiyachara and Garaljhora enclave of kurigram district of Bangladesh before enclave exchange.

Place dependence

The barbed wire along the Indo-Bangladesh boundary of the study area is a new feature of the boundary, but there was of war fencing till a few decades ago. One participant (sex: male, age: 82) said that, '*people of enclave of both the sides could easily move one place to another. People from Bangladesh, i.e. both enclave dwellers and non enclave dwellers used to come at Dinhata of India because of its available civic services like Medical facilities, Business and Marketing and to build up social relations and to work throughout India via Dinhata'*. This is because of very rural nature of adjacent parts of Dinhata which were inside the Bangladesh. That means, the rehabilitated people were connected to Dinhata and they have already utilized the services as mentioned earlier from Dinhata, before the exchange of enclaves. Therefore, emotion existed in the form of place dependence, which after enclave exchange was reflected through their migration among some of the erstwhile enclave dwellers.

Place identity

One respondent (sex: female, age: 49) has described 'before the enclave exchange, the enclave dwellers were Indians nationals but there residences were surrounded by Bangladesh. Hence they were in stateless situation. So, they had always a tenacity to come and reside in

India to get back their identity which was not properly recognised for locational difficulties. Thus, exchange of enclave helped them to get back their identity of Indian'. It is true that they could avail the Bangladeshi citizenship instead of taking Indian identity as per the decision of both the countries, but they chose India as their destination instead of Bangladesh for strong sentiment of place identity.

Emotional Economy

India is one of the fastest growing countries since independence, in terms of economic development. After the partition between India and Bangladesh, enclave dwellers of India were economically isolated from the main land. Yet, the people of Dashiyarchara and Garoljhora enclave located within Bangladesh were dependent to adjacent parts of India. One respondent (age:72, sex: male), a dweller of the temporary rehabilitation camp, said '*few years ago, there was not any hard and fast rule for the movement from Bangladesh to India and at that time, he used to remain engaged himself either in business activity or worked as a daily labour particularly in Delhi and Calcutta and Dinhata was used as a passage for his movement to other parts of India'.* In this way, he was dependent on Indian part economically.

In the subsequent time, when enclave dwellers were offered to be shifted to Indian part, they realised strong positive feeling of socio-economic benefit which was not available due to their locational disadvantages for being surrounded by territory of Bangladesh. Hence, they thought their migration to India might a be fruitful decision for betterment of their living in comparison to their earlier settlement in the erstwhile Indian enclaves surrounded by Bangladesh.

Emotional culture

'People of the undivided West Bengal, a state of India, enjoyed a homogenous culture that consisted of shared affective values, norms, artifacts, and assumptions which governed their emotion uniformly. But after partition in 1947, when International boundary was demarcated, Rangpur, presently a town of Bangladesh, was included in eastern part of the then Bengal or East Pakistan (now Bangladesh) and Cooch Behar was included in India. In 1972, East Pakistan was turned into a separate and new nation known as Bangladesh. Indian enclaves were surrounded by the territory of Bangladesh. Consequently, Indian enclave dwellers became socio-culturally isolated' one of the participants said (sex: male, age, 27), during field study at Dinhata temporary rehabilitation camp. It is very clear that, due to their inherited socio-cultural feelings to India, they started migrating to India from Dashiyarchara and Garoljhora enclave after enclave exchange. Such emotional culture is one of the important factors of migration noticed in the study.

Table1: Emotional Score of Geographical Domains

Geographical Domains			Emotional Score
Spearman's rho	Place Identity	Correlation Coefficient	.878**
		Sig. (2-tailed)	.000
		N	188
	Place Dependence	Correlation Coefficient	.896**
		Sig. (2-tailed)	.000
		N	188
	Emotional Economy	Correlation Coefficient	.875**
		Sig. (2-tailed)	.000
		N	188
	Emotional Culture	Correlation Coefficient	.887**
		Sig. (2-tailed)	.000

		N	188
**. Correlation is significant at the 0.01 level (2-tailed).			

Source: Calculated by Authors

It is clear that, there is significant positive correlation between geographical domains and emotion at '0.01'significant level (Table-1). It is found that place dependence and emotional culture influence more than that of place identity and emotional economy in case of migrants' emotion.

Migrants' Hope and Despair

As stated earlier, Geographical entities have significant contribution in emotion generation. Migrants of the temporary rehabilitation camp of Dinhata were suffering from a lot of socio-economic, social-cultural and administrative difficulties after migration. But, the social-cultural difficulties were of too much painful for them in terms of social adaptation in a new place. Most of the time, migrants of the rehabilitation camp are ignored by local Indian people. They even, feel discomfort to participate in social events thinking themselves as socially isolated. Most of the migrants work as daily labourer in different parts of Dinhata block and get miminum wages. Not only that, they have already left land, love, relation, from the erstwhile Indian enclave surrounded by Bangladesh. Thus, they feel an emotional pain from both ends, India and Bangladesh.

Older respondents under the study are found with strong emotional sufferings in comparison to younger because, they could not adapt themselves with the new environment. But, younger generation express neutral emotion as they can adjust themselves in easier way in comparison to the older people. The study highlights that there is positive relationship between age and emotion.

Table 2. Correlation between Age and Emotion

Component			**Emotional Score**
Spearman's rho	Age	Correlation Coefficient	.871**
		Sig. (2-tailed)	.000
		N	188
**. Correlation is significant at the 0.01 level (2-tailed).			

Source: Calculated by Authors

In order to find out the correlation between age and emotion, Spearman Rank correlation has been conducted (Table 2). At 0.01 level of significance, there is found strong positive significant relationship between age and emotion (.871) which indicates, with increasing age emotion also gets increased.

Table 3. Gender, Religion and Emotional Expression

Response of emotion				
Gender	**Religion**	**Emotion**	**Frequency**	**Percentage**
Male	Hindu	Neutral Emotion	28	63.6
		Positive Emotion	16	**36.4**
		Total	**44**	**100.0**
	Muslim	Neutral Emotion	54	91.5
		Positive Emotion	5	**8.5**
		Total	**59**	**100.0**
Female	Hindu	Neutral Emotion	36	81.8

		Positive Emotion	8	**18.2**
		Total	**44**	**100.0**
	Muslim	Neutral Emotion	38	92.7
		Positive Emotion	3	**7.3**
		Total	**41**	**100.0**

Source: Field Survey

Like age, emotion varies on the basis of gender and religion. From table 3, it is found that 36.4% Hindu male migrants have expressed their strong positive emotion to their new place after migration. whereas 8.5% of Muslim male migrants have expressed the same. In case of Hindu female migrants, 18.2% and in case of Muslim female migrants, 7.3% have been identified with positive emotion to their place of new destination. It is found that 17% people of temporary rehabilitation camp of Dinhata express their positive emotion and remaining 83% people express their neutral emotion.

5. Conclusion

From the entire study, it is clearly realized that human emotion is significantly controlled by the geographical elements. Migrated people often suffer from place attachment which is left behind by them. But not always, a place exerts positive emotion to its migrants; sometimes negative emotion also acts as push factors of migration. But whatever, the positive or negative emotion working behind migration, it is significantly influenced by geographical factors, like, landscape, locational values or social bonding. Therefore, it is essential to study 'emotion' from the angle of a geographer in order to perceive the nature of emotion-induced human decision. This too is important in the formulation of strategic decision making as may be required for resolving socio-political issues.

References

1. Albrecht, G.A. (2019). Earth Emotions: New Words for a New World. Cornell University Press.
2. Brewer, M.B. & Hewstone, M.E. (2004). Emotion and motivation. Blackwell Publishing.
3. Brown, B.B. & Perkins, D.D. (1992). Disruptions in place attachment. In: I. Altman & S. M. Low (Eds.) *Place attachment*, New York: Plenum Press. pp. 279–304.
4. Casakin, H.P. & Kreitler, S.(2008). Place attachment as a function of meaning assignment. Open Environmental Sciences Journal, 2(1). pp 80-86.
5. Chow, K. & Healey, M. (2008). Place attachment and place identity: First-year undergraduates making the transition from home to university. Journal of Environmental Psychology, 28(4), pp.362-372.
6. Cons, J. (2013). Narrating boundaries: Framing and contesting suffering, community, and belonging in enclaves along the India–Bangladesh border. Political Geography, 35, pp.37-46.
7. Datta, P. (2004). Push-pull factors of undocumented migration from Bangladesh to West Bengal: A perception study. The Qualitative Report, 9(2), 335-358.
8. Datta, S. (2002). Indo Bangladesh relations: An overview of limitations and constraints. Strategic Analysis, 26(3), 427-440.
9. Jones, R. (2009). Sovereignty and statelessness in the border enclaves of India and Bangladesh. Political Geography, 28(6), 373-381.
10. Löckenhoff, C. E., & Carstensen, L. L. (2004). Socioemotional selectivity theory, aging, and health: The increasingly delicate balance between regulating emotions and making tough choices. *Journal of personality*, 72(6), 1395-1424.
11. Shewly, H. J. (2013). Abandoned spaces and bare life in the enclaves of the India–Bangladesh border. Political Geography, 32, 23-31.

12. Tuan, Y. F. (1990). Topophilia: A study of environmental perceptions, attitudes, and values. Columbia University Press.

The Influence of Socio-demographic variables on Empowerment of Rural Left-behind Women for Male Out-migration: Evidence from Rural India

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Abstract. The purpose of this study is to focus the influence of socio-demographic variables on the empowerment of rural left-behind women when male members of their families migrate from their native places. In order to carry out the study, 398 married women aged between 21 to 55 years who are either wives or mothers of the migrants have been purposively chosen by snowball sampling technique followed by an interview using a structured questionnaire. Inclusion in family decision-making, financial decision-making and social participation have been considered as major indicators for assessing the empowerment of left-behind women. Ordinal regression has been run to determine the influence of socio-demographic variables on their inclusion in family decision-making; financial decision-making; and social participation. Results show that Education level of the women, Type of the family, De-facto Headship of the family, Type of dependency on remittances and Level of dependency in the family appear as significant determinants of empowerment of women left-behind for male labour migration.

Keywords: Left-behind women;f amily decision-making ; financial decision-making ; social participation ; empowerment score

1. Introduction

Indian agriculture is predominantlycontrolled by Monsoon climatic conditions and restricted in the rainy season (Prasanna, 2014), whenpoor labourers, particularly who do not have land of their ownremain engaged in the agricultural fields for income (Kantor, 2020). Such temporal engagement with agricultural fields does not fulfil their objectives to lead a desired quality of life and all the needs they aspire to remain discontented (Devika, 2002). Therefore, they move about locally searching for work, yet remain jobless on account of lack of native works (Fields, 1975), particularly during non-monsoonal months. Consequently, they migrate away from their home to distant places having earning opportunities (Awasthiand Mehta, 2020). Under these circumstances, the migration of rural males compels women of their families to handle new responsibilities apart from the traditional services (Torosyan*et al.*, 2016). In this way, long-standing rural male-dominated society encounters an alternate administrative touch headed by the females rather than males for their migration. Moving of such power elements in the family from male to female headship thus changes the monotony of living among the women (Gulati, 1992; Khaled, 1995; Hugo, 2002). The absence of male members in the family explores capacity of the women in family management and decision making by empowering them from the long-established subordination in many cases.The physical absence of male members creates an opportunity for the left-behind women in the family to remain less constrained within patriarchal domination (FakirandAbedin, 2020).Such

out-migration happening each year from the study areai.e. CoochBehardistrict,India has opened up entrances for the women of migrants' families to be enabled, who were not permitted to uncover their abilities for male-driven nature of the Indian society.Thus, an endeavor in this study has been made to assess the role of socio-demographic variables influencing the empowerment of women left-behind for male labour migration.

2. Material & Methods

Sample Size & Sampling Technique

The size of the sample has been determined by Cochran's Alpha (Cochran, 2007)formula based on total numbers of the rural female population as per Census of India, 2011 of the district. Respondents were selected by snowball sampling technique. The obtained sample size as determined by Cochran's Alpha for the study is 398 rural women, belonging to the age group of 21-55 years of different socio-demographic backgrounds. They are either wives or mothers of the migrants and belong to joint or nuclear families with different educational level. A well-structured translated schedule comprising of three indicators and fourteen items has been used to get the primary data. A reliability test for the fourteen items has been conducted and the Cronbach's Alpha value (0.689) is found acceptable (Taber, 2018).

Determination of Independent Variables

The socio-demographic independent variables of the study are: Age group, Position of women in a family, Type of family, Level of dependency on family, Type of dependency on remittances,De-facto headship of left-behind women and Education Level of the individual left behind woman. Firstly, the age of the left-behind women has been categorized into four groups i.e., <=30 years (young), 31 to 40 (middle), 41 to 50 years (upper middle) and >=51 years (old). The position of the women left-behind in the family has been grouped into two viz. mother and wife of the migrant.Family type of the same women has also been categorized into two groups viz. Joint and Nuclear. The family size of the left-behind women has been divided into three groups viz. (>= 6), (4 to 5) and (<=3). The level of dependency in the family has been grouped as low dependency (>=3) and high dependency (<3). The type of dependency of the left-behind women on remittances has been divided into two categories viz. fully dependent and partially dependent. De-facto headship of left-behind women in the family in absence of males has also been categorized into two viz. left-behind women themselves or others. The education level of them has been grouped into four levels viz. Illiterate, Primary (up to class IV), Secondary (Class V-X), Higher Secondary and above (beyond Class X) (Table 1).

Table 1: Respondents' Characteristics

Variables	Frequency	Percentage
Age Group		
< =30 years old	143	35.9
31 to 40 years old	84	21.1
41 to 50 years old	99	24.9
> =51 years old	72	18.1
Religion		
Hindu	298	74.9
Muslim	98	24.6
Others	2	0.5
Caste		
General	26	6.5
SC	266	66.8
ST	5	1.3

OBC	101	25.4
Position of women		
Mother	184	46.2
Wife	214	53.8
Type of Family		
Joint	192	48.2
Nucleated	206	51.8
Family Size		
Small (<=3)	46	11.6
Medium (4-6)	206	51.8
Large (>6)	146	36.7
Level of		
Low	161	40.5
High dependency	237	59.5
Type of		
Full	225	56.5
Partial	173	43.5
De-facto headship		
Self	222	55.8
Others	176	44.2
Education Level		
Illiterate	188	47.2
Primary	106	26.6
Secondary Level	64	16.1
Higher Secondary	40	10.1

Source: Field survey,2021

Determination of Dependent Variable

Inclusion in family decision-making

Inclusion in family decision-making has been utilized to quantify the dynamic limit and inclusion of a left-behind woman in her consistently family practices including the decision in the family purchase, child education, and health management without male people. It consists of three items includingregular family purchase and maintenance, the decision in health management, child education,all ofwhich have been measured in a five-point Likert Scale where 1 represents 'Never' and 5 represents 'Always'. The value of the indicator has been calculated by adding the values of the decision-making in the family purchase, child education, and health management. The individual score of inclusion in family decision-making ranges from 3 to 15, where a higher score represents a higher level of inclusion in family decision-making and vice-versa. Further, the score of inclusion in family decision-making has been divided into three categories viz. Low (>=7), Medium (8 to 11) and High (<=12).

Inclusion in financial decision-making

Inclusion in financial decision-makinghas been considered to quantify the ability of the left-behind women to make choices and deal with the financial matters of their family likedecision in purchasing land or other assets, the decision in agricultural production,control of bank account, management of financial crisis during the absence of male members. It consists of seven items includingthe decision in expenditure in agriculture; expense in household other than agriculture; investment; maintenance of savings; handling bank account; management of financial crisis, if any; engagement in paid works in absence of male members, where 1 represents 'Never' and 5 represents 'Always'. The individual score of inclusion in financial decision-makinghas been calculated by adding the value of each item. The individual

score ranges from 7 to 35 where a higher score represents a higher level of inclusion in financial decision-makingof left-behind women and vice-versa. The score value of inclusion in financial decision-makinghas been further categorized into three groups i.e., Low (>=15), Medium (16 to 25) and High (<=26).

Inclusion in Social participation

Inclusion in Social participation has been utilized to assess the social engagement of the left-behind women considering their opportunity of mobility, medical help to the family, involvement in self-help groups and participation in social activities. This indicator has been prepared with the help of four items including ability to go to market, ability to consult a doctor, ability to participate in social activity andinvolvement with self-help group.All the items have been measured in a five-point Likert Scale ranging from 1 (Never) to 5 (Always).The inclusion in social participation score has been calculated by adding the individual value of these four items. The range of inclusion in social participation score is from 4 to 20 where a higher score shows a higher level of social participation of left-behind women and vice-versa. The score of the indicator has been further divided into three groups i.e., Low (>=10), Medium (11 to 15) and High (<=15).

Calculation

Empowerment Score

The empowerment score of the individual has been calculated to assess the level of empowerment of the left-behind women. The empowerment score has been calculated by adding the values of the above three dependent indicators where a higher score indicates a higher level of empowerment and vice versa.

$$\text{Empowerment Score} = \sum(x + y + z)$$

Where, x= Inclusion in family decision-making

y= Inclusion in financial decision-making

z= Inclusion in Social participation

The empowerment score has been divided into three groups i.e., least empowered, (>=30), moderately empowered (31 to 44), and highly empowered (<=45) left-behind women. Thereafter, to estimate the predictive strength of the independent variableson each dependent variable i.e. inclusion in family decision-making (Model 1), inclusion in financial decision-making (Model 2), inclusion in social participation (Model 3)and empowermentscore of left-behind women (Model 4), ordinal logistic regression has been carried out for each dependent variable in SPSS20. The Exponential β value has been calculated in Excel 2016 for each independent variable to evaluate their influence on each orderly distributed dependent variable.The ordinal logistic regression model helps to estimate the probability of being at or below a specific outcome level given in a collection of explanatory variables. The model has been expressed in the logit form (Liu, 2009) as follows:

$$In(Y'j) = logit\,[\pi(x)]$$

$$= In[\frac{\pi(x)}{1} - \pi(x)]$$

$$= \alpha j + (\beta 1X1 - \beta 2X2 \ldots\ldots\ldots \beta pXp)$$

Where, $\pi j(x) = \pi(Y \leq j \mid x1, x2 \ldots\ldots xp)$is the probability of being at or below category j, given a set of predictors $j = 1,2 \ldots\ldots, J-1, \alpha j$ are the cut points and $\beta 1, \beta 2 \ldots\ldots\ldots, \beta p$ are logit co-efficients. When there are j categories, the Probability Ordinal (PO) model estimates $J-1$ cut points. This PO model assumes that the logit co-efficient of any predictor is independent

categories, i.e., the co-efficients for the underlying binary models are the same across all cut points.

3. Results

Spearman's Co-relation Matrix

Table 2 shows that most of the independent variables and dependent variables have significant inter-correlation among them.

Table 2: Inter-correlation among independent variables and dependent variables (N=398)

	Age-Group	Position in family	Level of dependency in family	Head of the Family	Type of Dependency on remittances	Education Level	Type of Family	Empowerment Score
Age Group		-.751**	-.048	-.161**	.133**	-.675**	-.133**	-.445**
Position in family			-.016	.159**	-.224**	.696**	.144**	.457**
Level of dependency in family				.517**	.072	-.031	.570**	-.004
Head of the Family					-.025	.088	.912**	.129**
Type of Dependency on remittances						-.150**	-.016	.198**
Education Level							.068	.468**
Type of Family								.136**
Empowerment Score								1

**p shows a significant level at 0.05

Model Fitness information

Table 3 shows that all the four Models i.e., inclusion in family decision-making, inclusion in financial decision-making, inclusion in social participation and empowerment score have a significant difference from the Base Model (Intercept Only) and Final Model (Containing the full set of predictors) as $p<0.001$ in all four Model fitting summaries. It is also observed that the Goodness-of-fit (Pearson) in all the four models is insignificant i.e., $p>0.05$, which suggests that the observed data of all the Models is having goodness-of-fit with the final model (Petrucei, 2009; Field, 2013). The Nagelkerke Pseudo R-Square value (Table 3) of inclusion in family decision-making is 0.392, inclusion in financial decision-making is 0.400, inclusion in social participation is 0.326, and empowerment is 0.432. These Pseudo-R-Square values are treated as rough analogues to the R-Square value in OLS regression (Smith and McKenna, 2013; Osborne, 2015; Pituch and Stevens, 2016).

Table 3: Model Fitness Information

	Model fitting	**Goodness-of-fit (Pearson)**	**Pseudo R- Square (Nagelkerke)**

Model 1 (Inclusion in family decision-making)	$X^2(13)$ =167.458, p<0.001**	$X^2(223)$ =194.778, p=0.333>0.05	0.392
Model 2 (Inclusion in financial decision-making)	$X^2(13)$ = 169.858, p<0.001**	$X^2(223)$ =196.302, p=0.306>0.05	0.393
Model 3 (Inclusion in Social participation)	$X^2(13)$ =129.727, p<0.001**	$X^2(223)$ =193.371 p=0.359>0.05	0.318
Model 4 (Empowerment Score)	$X^2(13)$ =186.570, p<0.001**	$X^2(223)$ =192.209, p=0.382>0.05	0.431

Link Function: Logit** **p shows significant level at 0.01

Table 4: Ordinal Logistics Regression to estimate determinants on different Models (N=398)

Independent Variables	**Model 1** (Inclusion in family decision-making)			**Model 2** (Inclusion in financial decision-making)			**Model 3** (Inclusion in Social participation)			**Model 4** (Empowerment Score)		
	B	Expβ	Sig	B	Expβ	Sig	B	Expβ	Sig	β	Expβ	**Sig**
Age-Group<=30 years	0.499	1.647	**0.259**	0.351	1.420	**0.425**	0.560	1.750	**0.196**	0.709	2.031	**0.119**
31to40 years	0.648	1.911	**0.103**	0.255	1.290	**0.523**	0.160	1.173	**0.676**	0.485	1.624	**0.231**
41to50 years	0.275	1.316	**0.400**	0.714	2.042	**0.027****	0.060	1.061	**0.843**	0.430	1.537	**0.183**
>=51years #		1			1			1			1	
Position in family(Mother)	-0.900	0.406	**0.017****	-0.804	0.447	**0.028****	-0.232	0.792	**0.535**	-0.746	0.474	**0.053***
(Wife)#		1			1			1			1	
Type of Family (Joint)	-2.413	0.089	**0.000*****	0.084	1.087	**0.869**	-0.568	0.566	**0.260**	-0.899	0.406	**0.090***
(Nucleated)#		1			1			1			1	
Level of dependency on family (=<3)	0.348	1.416	**0.182**	0.667	1.948	**0.011****	-0.455	0.634	**0.076***	0.542	1.719	**0.043****
(>3)#		1			1			1			1	
Type of Dependency on remittances (Full)	-0.921	0.398	**0.000*****	-0.327	0.721	**0.123**	-2.196	0.111	**0.000*****	-1.550	0.212	**0.000*****
(Partial)#		1			1			1			1	
Head of the family (Self)	1.830	6.067	**0.001*****	-0.519	0.595	**0.289**	0.468	1.596	**0.335**	0.304	1.355	**0.549**
(Others)#		1			1			1			1	
Education level(Illiterate)	-1.309	0.270	**0.007****	-2.683	0.068	**0.000*****	-0.027	0.973	**0.955**	-2.090	0.123	**0.000*****
(Primary)	-0.023	0.977	**0.954**	-1.288	0.275	**0.001*****	0.666	1.946	**0.090***	-0.478	0.620	**0.239**

(Secondary)	0.773	2.166	**0.063 ***	-0.343	0.709	**0.416**	0.776	2.172	**0.066***	0.305	1.356	**0.483**
(Higher Secondary & above) #					1			1			1	

Link Function: Logit

Reference Category, * p shows significant level at 0.10, ** p shows significant level at 0.05, ***p shows significant level at 0.001

Model 1

The study result reveals that the position of left-behind women in the family, types of their families, types of dependency on remittances, de-facto headship in the family and education level have significant impact to predict the dependent variable in the field of inclusion in the family decision-making model. The coefficients of the position of left-behind women in the family as mother, joint family type, full dependency on remittances and illiteracy are found negative (β-.900, β -2.143,β -0.921, β-1.309) but significant (p= 0.017,0.00,0.00,0.001,0.007<0.05) as compared to wife, nuclear family type, partial dependency on remittances andthe higher literacy level of left-behind women. De-facto headship in absence of male (β= 1.830) and secondary level of education of left-behind women (β= 0.773) are the significant positive variables (p=0.001<0.01 & p= 0.063<0.1) compared to the headship of any other member in the family, higher secondary and above level (Table 4). The result predicts that with each unit increase in the levels of independent variables having negative estimation can decrease log odds of inclusion in family decision-makingof left-behind women from higher to lower or moderate and for positive estimation, there shall be a direct relationship.

Model 2

It is found that age-group, positionof left-behind women in the family, level of dependencyon the family and education level of the left-behind women are the significant variablesin the financial decision-makingmodel. The co-efficients of the upper-middle age-group (41-50 years) of the women and their higher level of dependency in the family show positive estimation (β= 0.714, β= 0.667) which are significant (p=0.027, 0.011<0.05). Mothers of the families show negatively significant estimation (β= -0.804, p=0.028<0.05) compared to wives and also illiteracy and primary level of education, which are negatively significant (β= -2.683, β=-1.288; p=0.000, 0.001<0.01) compared to other levels of education (Table 4). The result reveals that with the increase in each unit of independent variables having positive estimation can increase log odds of inclusion in financial decision making from lesser or moderate to higher, whereas for negative estimation, it shall be inverse and vice-versa.

Model 3

In case of inclusion insocial participation model, the level of dependency on the family, their type of dependency on remittances, education level are the significant variables to predict their influence on the dependent variable.The co-efficient of the lower level of dependency on the family along with full dependency of the left-behind women on remittances show significant negative estimation (β= -0.455, β= -2.196) (p=0.076<0.1, p=0.000<0.01) compared toa higher level of dependency on the family and partial dependency on remittances. Primary or secondary level of education show positive estimation (β= 0.666, β= 0.776) which are significant (p=0.090<0.1, p=0.066<0.1) compared to higher secondary and above level (Table 4). The result predicts that an increase in the levels of independent variables having positive estimation can increase log odds of inclusion in social participation from lesser or moderate to higher whereas, for negative estimation, it shall be inverse and vice-versa.

Model 4

For the model based on the Empowerment Score of left-behind women among seven independent variables, the position of left-behind women in the family, types of the family, level of dependency on the family, type of dependency on remittances and education level predict their influence on the dependent variable. Here, co-efficients of the position of left-behind women in the family as mothers, joint family type, full dependency on remittances and illiteracy of left-behind women show negative estimation (β=-0.746, β=-0.899, β=-1.550, β= -2.090) which are significant (p=0.053<0.1 p=0.90<0.1, p=0.043<0.05, p=0.000<0.01,) compared to wives, nuclear family type, partial dependency on remittances and a higher level of literacy. The only lower level of dependencyon a family shows positive estimation (β=0.542) which is significant (p=0.043<0.05) (Table 4). The result predicts that an increase of each unit in the levels of independent variables having negative estimation can decrease log odds of empowerment of left-behind women from higher to loweror moderate, whereas for positive estimation, there shall bea direct relationship.

4. Discussion

The study expresses that out of seven, five variables i.e. position of left-behind women in the family, type of their family, level of dependency on the family, type of dependency on remittances and education level have been found as significant determinants of empowerment of left-behind women (Table-4).

Illiteracy of left-behind women is found as the most significant variable determining their empowerment which decreases their empowerment score. On the other hand, primary and secondary level of education of those women enhances their inclusion in family decision-makingas well as in social participation. This study is consistent with the studies of Vijayanthi (2002) and Nikkah *etal.* (2010) where it has been stated that women with lower educational backgrounds tend to support traditional gender roles and inequality in the family with a lower level of empowerment. Here, the left-behind women belonging to secondary level of education are mostly included in family decision-making,especially in children education. Social participation of the left-behind women having primary or secondary level education is more than that of illiterates e.g. involvement in SHG, outdoor works such as marketing, visiting doctors or banking (Gartuala, *etal*.,2012). Full dependency of left-behind women on remittances is found as one of the significant predictors of women empowerment. Their engagement in any type of paid work determines their level of dependency on remittances i.e., full or partial. The study also reveals that left-behind women who are not engaged in any type of paid work are fully dependent on remittances that reduce their level of empowerment along with inclusion in family decision-makingand social participation (Khan and Awan,2011). Left-behind women who are partially dependent on remittances may also effectively use the remittances by increasing their savings, improving their standard of living by removing the age-old rural patriarchal dominance over financial issues.

The type of family of left-behind women has also asignificant impact on their empowerment and inclusion in family decision-making. Despite patriarchal norms where the women are considered as dependent and don't have inclusion in family decision-making (Batool *etal*, 2017), left behind women of the nuclear family enjoy more empowerment and inclusion in family decision-making. Left-behind women living with their in-laws are found with lower mobility and lesser confidence due to involvement and control by their male members over them (Kaur, 2017). However sometimes, these women get support from other male individuals from the families by sharing their workloads, responsibilities in unfavorable circumstances (Rashid, 2017; Maity, 2018), but results show that women prefer to live independently and enjoy better mobility in their life in absence of male members.

The position of left-behind women in a family is another major determinant of empowerment. The models of empowerment score, inclusion in family decision-making and

inclusion in financial decision-makingdetermine that left-behind mothers are less engaged in family decisions, in case of paid work and social activities compared to the wives of the migrant males. Therefore, it seems that the mother is lesser empowered than the wives of the migrants (Biao, 2007; Liu *etal*., 2021). These mothers are partial left-behind as their husbandsremain present at home, and therefore, their inclusion and empowerment are lesser than the wives.

The study result also shows that a lower level of dependency on the family has a significant positive impact onthe level of empowerment and inclusion in financial decision-makingof left-behind women (Archambault, 2010). Women are compelled to take part in paid jobs in absence of males to meet the family needs and for financial crisis management that makes them empowered (Vanway, 2004; Haans and Rooij, 2010). On the other hand, there is found a lower level of dependency in case of small families (>=10), and social participation is also found less to some extent as they have to take care of their dependents (Desai and Banerjee, 2008).

The study of inclusion in family decision-makingmodel has identified another important significant variable for predicting dependent variable i.e. de-facto headship of left-behind women in the family in absence of male members which is a positive variable and increases inclusion in family decision-making and financial decision-makingof women left behind in the family (Lei and Desai, 2021). In general, wives of the migrants carry out the de-facto headship instead of mothers of the migrants. Consequently, they enjoy more space in decision making and financial management, health and other family related matters.Also, it is observed that higher middle age group (41-50 years) of the women is positively significant in case of inclusion in financial decision-making as they need to bear lesser liabilities towards their children, which allow them to remain busy with paid works (Mason and Smith, 2003).

5. Conclusions

The study explores an insight into the factual reality that migration of male individuals in a family prompts the women of the family to expose themselves effectively in familymatters and taking decisions, to go out to meet family needs and to manage finance and generally stay occupied with paid works for money to meet the family needs. The idea of empowerment of left-behind women is beyond the liberal feminist approach because their empowerment is controlled by several socio-demographic factors. The survey unfurls that illiteracy, joint family type, non-involvement in paid works are the hindrances of their empowerment while a higher level of education of left-behind women and lower level of dependency on the family may raise their level of empowerment. Less numbers of dependent in the family enable women to decide various matters whether family related or financial. The study lets out that most of the more prominent respectably matured left behind women can't continue with their further education rather express their yearning to be financially independent through any kind of income-generating work during the absence of their male members to raise the level of empowerment. Therefore, the study indicates to introduce few tangible steps from governmental, non-governmental organizations to motivate left behind women to enhance women empowerment. Therefore, the policy of the government should be oriented in such ways so that left-behind women are absorbed in productive economic works suitable for them. Though migration of male members somewhat empowers left behind women by providing them opportunities to manage family, finance, assets and social relations, there should be the willingness to be motivated for getting empowered by themselves. Without such internal will, induced byfemales themselves, migration may not be valuable in exploring their capacity to be empowered. In addition to the variables recognized in the study, there may be some other variables also required to be identified in further research.

References

1. Archambault, C. S. (2010). Women left behind? Migration, spousal separation, and the autonomy of rural women in Ugweno, Tanzania. Signs: Journal of Women in Culture and Society, 35(4), pp. 919-942. https://doi.org/10.1086/651042
2. Awasthi, I., & Mehta, B. S. (2020). Forced Out-Migration from Hill Regions and Return Migration During the Pandemic: Evidence from Uttarakhand. The Indian Journal of Labour Economics, 63(4), pp. 1107-1124. https://doi.org/10.1007/s41027-020-00291-w
3. Azra Batool, S., Ahmed, H. K., & Qureshi, S. N. (2018). Impact of demographic variables on women's economic empowerment: An ordered probit model. Journal of women & aging, 30(1), pp. 6-26.https://doi: 10.1080/08952841.2016.1256734.
4. Biao, X. (2007). How far are the left-behind left behind? A preliminary study in rural China. Population, Space and Place, 13(3), pp. 179-191. https://doi.org/10.1002/psp.437.
5. Cochran, W. G. (2007). Sampling techniques. John Wiley & Sons.
6. De Haas, H., & Van Rooij, A. (2010). Migration as emancipation? The impact of internal and international migration on the position of women left behind in rural Morocco. Oxford development studies, 38(1), pp. 43-62. https://doi.org/10.1080/13600810903551603.
7. Desai, S., & Banerji, M. (2008). Negotiated identities: Male migration and left-behind wives in India. Journal of Population Research, 25(3), pp. 337-355.https://doi.org/10.1007/BF03033894
8. Devika, J. (2002). Domesticating Malayalees: Family planning, the nation and home-centered anxieties in mid-20th century Keralam.
9. Fakir, A., & Abedin, N. (2021). Empowered by absence: does male Out-migration empower female household heads left behind?. Journal of International Migration and Integration, 22(2), pp. 503-527.https://doi.org/10.1007/s12134-019-00754-0
10. Field, A. (2013). Discovering statistics using IBM SPSS statistics. Sage.
11. Fields, G. S. (1975). Rural-urban migration, urban unemployment and underemployment, and job-search activity in LDCs. Journal of development economics, 2(2), pp. 165-187. https://doi.org/10.1016/0304-3878(75)90014-0
12. Gartaula, H. N., Visser, L., & Niehof, A. (2012). Socio-Cultural Dispositions and Wellbeing of the Women Left Behind: A Case of Migrant Households in Nepal. Social indicators research, 108(3), pp. 401–420. https://doi.org/10.1007/s11205-011-9883-9
13. Gulati, L. (1995). Migration and Social Change in Kerala. India International Centre Quarterly, 22(2/3), pp. 191-202. https://doi.org/ 10.2307/23003946
14. Hugo, G. (2002). Effects of international migration on the family in Indonesia. Asian and Pacific migration journal, 11(1), pp. 13-46.https://doi.org/10.1177%2F011719680201100102
15. Kantor, H. S. (2020). Locating the farmer: ideologies of agricultural labor in Bihar, India. Anthropology of Work Review, 41(2), pp. 97-107. https://doi.org/10.1111/awr.12208
16. Kaur, A. (2017). Male Migration and Challenges to Gender Equality? https://gcids2017.org/wp-content/uploads/2017/09/Atinder-Pal-Kaur-Full-Paper.pdf
17. Khaled, L. (1995). Migration and women's status: the Jordan case. International Migration (Geneva, Switzerland), 33(2), pp. 235-250. https://doi: 10.1111/j.1468-2435.1995.tb00027.x.
18. Khan, S. U., & Awan, R. (2011). Contextual assessment of women empowerment and its determinants: Evidence from Pakistan.https://mpra.ub.uni-muenchen.de/30820/1/Contextual_Assessment_of_Women_Empowerment_and_Its_Determinants_Evidence_from_Pakistan.pdf

19. Lei, L., & Desai, S. (2021). Male out-migration and the health of left-behind wives in India: The roles of remittances, household responsibilities, and autonomy. Social Science & Medicine, 280, 113982.https://doi.org/10.1016/j.socscimed.2021.113982
20. Liu, C., Eriksson, T., & Yi, F. (2021). Offspring migration and nutritional status of left-behind older adults in rural China. Economics & Human Biology, 41, 100996.https://doi: 10.1016/j.ehb.2021.100996.
21. Liu, X. (2009). Ordinal regression analysis: Fitting the proportional odds model using Stata, SAS and SPSS. Journal of Modern Applied Statistical Methods, 8(2), 30. https://10.22237/jmasm/1257035340
22. Lokshin, M., & Glinskaya, E. (2009). The effect of male migration on employment patterns of women in Nepal. The World Bank Economic Review, 23(3), pp.481-507.https://doi.org/10.1093/wber/lhp011
23. Maity, K. (2018). Male Out-Migration and its impact on women empowerment in West Bengal. Economic Affairs, 63(2), 295389. https://10.30954/0424-2513.2.2018.23
24. Mason, K. O., & Smith, H. L. (2003). Women's empowerment and social context: Results from five Asian countries. Gender and Development Group, World Bank, Washington, DC, 53(9).
25. Nikkhah, H. A., Redzuan, M., & Abu-Samah, A. (2010). The effect of women's socio-demographic variables on their empowerment. Journal of American Science, 6(11), pp. 426-434.https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.1053.6224&rep=rep1&type=pdf
26. Osborne, J. W. (2014). Best practices in logistic regression. Sage Publications. https://doi.org/10.4135/9781483399041
27. Petrucci, C. J. (2009). A primer for social worker researchers on how to conduct a multinomial logistic regression. Journal of social service research, 35(2), pp. 193-205.https://doi.org/10.1080/01488370802678983
28. Pituch, K. A., & Stevens, J. P. (2015). Applied multivariate statistics for the social sciences: Analyses with SAS and IBM's SPSS. Routledge.https://doi.org/10.4324/9781315814919
29. Prasanna, V. (2014). Impact of monsoon rainfall on the total foodgrain yield over India. Journal of earth system science, 123(5), pp. 1129-1145.https://doi.org/10.1007/s12040-014-0444-x
30. Rashid, S. R. (2013). Bangladeshi women's experiences of their men's migration: Rethinking power, agency, and subordination. Asian Survey, 53(5), pp. 883-908. https://doi.org/10.1525/as.2013.53.5.883
31. Smith, T. J., & McKenna, C. M. (2013). A comparison of logistic regression pseudo R2 indices. Multiple Linear Regression Viewpoints, 39(2), pp. 17-26. https://www.glmj.org/archives/articles/Smith_v39n2.pdf
32. Taber, K. S. (2018). The use of Cronbach's alpha when developing and reporting research instruments in science education. Research in science education, 48(6), pp. 1273-1296.https://doi.org/10.1007/s11165-016-9602-2
33. Torosyan, K., Gerber, T. P., & Goñalons-Pons, P. (2016). Migration, household tasks, and gender: Evidence from the Republic of Georgia. International Migration Review, 50(2), pp. 445-474. https://doi.org/10.1111/imre.12147
34. Vanwey, L. K. (2004). Altruistic and contractual remittances between male and female migrants and households in rural Thailand. Demography, 41(4), pp. 739-756. https://doi: 10.1353/dem.2004.0039.

35. Vijayanthi, K. N. (2002). Women's empowerment through self-help groups: a participatory approach. Indian Journal of Gender Studies, 9(2), pp. 263-274.https://doi.org/10.1177%2F097152150200900209

Assessment of cultural tourism resources in Phu Yen province

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Abstract. Synthetic exploitation of resources for tourism development is an inevitable trend and cultural resources play a very important role in that process. To determine the potential of cultural resources for tourism development in Phu Yen province, this paper uses a synthetic scoring method to analyze and assess the following criteria: attractiveness, tourist capacity, location and accessibility, infrastructure for tourism, time of exploitation, rated value, and combination of tourism resources with infrastructure, facilities, resource-environment sustainability and resources location-accessibility. The assessment results show that the potential for cultural tourism development in Phu Yen province is quite favorable. This is an important basis for the province to promote exploitation, strengths and overcome limitations to construct tourist attractions, tourist clusters and tourist routes towards sustainable tourism development in the integration period.

Keywords: cultural tourism resources, assessment, Phu Yen.

1. Introduction

The exploitation of cultural tourism resources in Phu Yen is currently limited compared to its potential. Tourism products are still monotonous; tourism activities are concentrated in some coastal localities; tourism potential has not been turned into tourism resources (Pham, 2016). Over the years, there have been a number of researches focused on assessment cultural resources for tourism development. However, most researches discussed general assessment, preliminary assessment on a large scale, not focused on specific cultural tourism resource sites to make a comparison or to make a ranking. To bridge this gap, our paper focuses on assessment on the potential of cultural tourism resources in Phu Yen province. Based on calculating the point of cultural tourism sites, we estimated the potential to make a ranking of all sites. The results of this paper contribute to the data and serve as a research basis in planning as well as building specific and effective cultural tourism products in Phu Yen province.

2. The results

2.1. Synthetic assessment method

Assessment is the estimation of the role or value of the research object. On the other hand, assessment is to determine the degree of convenience (good, average, not good) of the object for a certain socio-economic requirement. Assessment tasks are associated with objectives, specific research objects. And it is important to select or define an appropriate assessment method. Among different kinds of assessment, we choose synthetic point assessment method, combining qualitative and quantitative assessment to make scientific judgments about the potential of cultural tourism resources in Phu Yen.

The process of synthetic assessment of tourist resource sites

Step 1: Building assessment scale

This is an important step that is decisive to the assessment results, including the selection of assessment criteria, classification of criteria, scoring at all levels, and weighting of each criterion.

The construction of the assessment scale is carried out as follows:

Select assessment criteria: Criteria are selected based on the required characteristics of the tourist destination. The criteria must clearly affect the assessment subject and there must be differentiation in the research territory. It is necessary to determine the main, the secondary criteria, and additional values to get the most accurate assessment results. Criteria are determined based on research results through surveys, expert consultation and the author's experience accumulation in the research process.

To assess the potential of tourism sites, there are eight commonly used criteria, including: attractiveness, synchronous combination of tourism resources and infrastructure, facilities, value of resources, tourism exploitation time, tourist capacity, infrastructure and facilities, resource and environmental sustainability, location and accessibility of tourist destinations.

(1) Attractiveness is the most important factor to assess tourism resources because it determines the attraction to tourists. Attractiveness has a very high aggregate nature and is often determined by the beauty of the landscape, the suitability of the climate, the uniqueness natural and cultural tourism resources.

(2) The synchronous combination between tourism resources and infrastructure, facilities for tourism in order to exploit the resource sites effectively while ensuring environmental sustainability.

(3) The value and efficiency of exploitation is also a very important factor to consider, to assess in order to come up with appropriate exploitation and adjustment measures for each tourism site. It is necessary to base on the purpose, requirements as well as specific conditions to select the appropriate assessment factors.

(4) The time of exploiting tourism activities determines the regularity or seasonality of tourism activities, which is directly related to the method of exploitation, investment and business for tourism. The duration of tourism activities depends closely on the characteristics of the climate, festivals and living habits.

(5) Tourist capacity is closely related to the activity characteristics of tourists (such as number and time), to the tolerance of the natural and social environment. Therefore, the tourist capacity is assessed not according to the trend as many as possible but as appropriate as possible.

(6) Infrastructure and facilities are very important, directly affect the exploitation of resources and serving tourists. Infrastructure and facilities for tourism are assessed by quantity, quality, uniformity with national and international standards.

(7) Sustainability shows the ability to survive and maintain tourism resource exploitation activities against the challenges of time, human activities and complex natural developments.

(8) The location and accessibility of tourist attractions are very important in attracting tourists, they are assessed through indicators of distance, travel time, road quality and means of transport which are convenient to use.

Hierarchy of criteria, determining scores: Each criterion in the assessment is divided into 4 levels, each level corresponds to a certain number of criteria, and determined with a different level score as follow: 4 points – very favorable (very attractive); 3 points– favorable (attractive); 2 points – relatively favorable (relatively attractive); 1 point – little favorable (little attractive).

Determine the weight for each criterion: Each selected criterion will have a different degree of influence on the subject of the assessment, so determining the weight in the assessment is very necessary. Weighting will give a more objective and accurate assessment result.

To define the weights, we applied both qualitative and quantitative analysis methods. For example, with the criterion of landscape attractiveness, people have different aesthetic perceptions, so they will make different judgments, the assessment results will be accepted according to the majority. On the basis of assessing the scores of each criterion with a weight multiplier, we finally summarize the scores of the criteria to obtain objective, quantitative assessment results and ensure the appropriate level of accuracy for each tourism site as well as scientifical results.

The weights can be determined by different ways, such as the triangular matrix method, the expert method, the AHP hierarchical analysis method, etc. In this paper, we determined the weight by applying the expert method. The assessment weights are determined as integers. It corresponds to the value of each assessment criterion according to the previous works such as (Nguyen, 2005; Ngo, 2016; Nguyen 2015). In addition, we based on results of the field research in Phu Yen to choose the appropriate coefficient.

Step 2: Conduct an assessment

Scoring for each criterion (according to the assessment standard table), multiplying by weight, calculating the total score, calculating the percentage compared to the maximum score and decentralizing the convenience level of each tourism site.

Step 3: Present the assessment results

The results of the assessment are presented in a statistical table. The assessment results will be the basis to propose and discuss the rational use of cultural tourism resources for sustainable tourism development in Phu Yen.

Table 1: Criteria for assessing tourism site (8 criteria), rating scale (4 levels)

Criterion	*4 points*	*3 points*	*2 points*	*1 point*
1-Attractiveness of tourism resources	Very attractive	Attractive	Averagely attractive	Little attractive
2 -The synchronous combination between tourism resources and infrastructure, facilities	Very good combination	Good combination	Average combination	Weak combination
3- Value of rated tourist destination	Very high value	High value	Average value	Low value
4- Travel time (seasonal)	Very long	Long	Average	Short
5- Tourist capacity	Very high	High	Average	Low
6- Infrastructure and facilities for tourism	Very good	Good	Average	Bad
7- Sustainability of tourism environment	Very sustainable	Sustainable	Average	unsustainable
8- Location and accessibility of tourist attractions	Very convenient	Convenient	Average	Inconvenient

**** Select the coefficient and assessing the composite score for the criteria***

In reality, the selected criteria have different important degrees of for the assessment score. Therefore, to ensure that the assessment results are accurate and objective, it is necessary to determine coefficients for the more important factors. Based on field survey in Phu Yen and previous research results, we determine the coefficients as follows:

Coefficient 3 includes 4 criteria: Attractiveness of tourism resources, location and accessibility, synchronization of tourism resources and infrastructure, facilities, ranking value.

Coefficient 2 includes 3 criteria: Tourism operation time, tourist capacity, infrastructure and facilities.

Coefficient 1 includes 1 criterion: Environmental sustainability.

Table 2: Criteria, level and weight of tourist attractions synthetic assessment

Criterion (Cr.)	**Coefficient**	**Degree**			
		4	**3**	**2**	**1**
(Cr. 1) The attractiveness of tourism resources	3	12	9	6	3
(Cr. 2) Combination of tourism resources and infrastructure, facilities	3	12	9	6	3
(Cr. 3) Rated value	3	12	9	6	3
(Cr. 4) The time of exploiting tourism activities	2	8	6	4	2
(Cr. 5) Tourist capacity	2	8	6	4	2
(Cr. 6) Infrastructure and facilities	2	8	6	4	2
(Cr. 7) Environmental sustainability	1	4	3	2	1
(Cr. 8) Location and accessibility	3	12	9	6	3
Total		**76**	**57**	**38**	**19**

With the above summary table, the score is divided into 3 levels i.e. Level 1 from 54-72 points; Level 2 from 36-53 points, Level 3 from 18-35 points. Each tier has a different level of convenience and meaning. Maximum score is 72 points, minimum score is 18 points. Thus, tourism site will be rated from 18 to 72 points. Each tier has a different meaning. The significance of tourism site is determined as shown in Table 2.

Table 2: Criteria for assessing the convenience of tourist attractions (Tran, 2005)

No	Assessment degree	Point
1	Very favorable (with national, international significance)	54 – 72
2	Favorable (with regional significance)	36 – 53
3	Unfavorable (with local significance)	18 – 35

2.2. The assessment results

After assessing and calculating the scores of 8 criteria, the assessment results of some cultural tourism sites in Phu Yen province are presented in Table 3.

Table 3: Total score of tourism sites

Tourist destination	**Cr. 1**	**Cr. 2**	**Cr. 3**	**Cr. 4**	**Cr. 5**	**Cr. 6**	**Cr. 7**	**Cr. 8**	**Total**	**Result**
1-Road Number 5	3	6	9	8	2	2	4	12	46	Favorable
2-Go Thi Thung Tunnels	12	12	3	2	8	4	4	6	51	Favorable
3-Tomb And Temple Of Le Thanh Phuong	12	12	9	4	4	2	4	9	56	Very favorable
4-Tomb And Temple Of Luong Van Chanh	12	9	9	8	8	4	2	12	64	Very favorable
5-Ho Citadel	9	6	9	8	2	2	4	12	52	Favorable

6-O Loan Swamp	9	9	9	8	6	4	3	6	54	Favorable
7-Nhan Tower	9	12	9	8	6	6	4	12	66	Very favorable
8-White Stones Pagoda (Tu Quang Pagoda)	9	9	9	8	6	4	3	6	54	Favorable

Source: The author's survey (2020)

The assessment results of 8 cultural tourism sites showed that 3 out of eight reaches very favorable level; 5 out of eight reached favorable level. The highest score is Nhan Tower, with 66 points; the second is Tomb and Temple of Luong Van Chanh, with 62 points; the third is Tomb And Temple Of Le Thanh Phuong, with 56 points; the lowest score is Road Number 5, with 46 points.

In general, the biggest limitation of cultural tourism sites in Phu Yen is the limited infrastructure and facilities for tourism. Although many tourism sites recognized as the national level, they are still exploited in a spontaneous, sketchy manner, lacking strict management in the stages of marketing, advertising, passenger transportation, food service, environment protection, etc. Thus, the efficiency is not high. The high efficiency is the sites concentrated in Tuy Hoa City and its vicinity.

3. Discussion and conclusion

The research result shows that Phu Yen has many advantages for cultural tourism development. The rich and diverse tourism resources are the strength of Phú Yen. Most of the tourism resources still are unspoiled, and the environment has not been seriously degraded. However, the greatest weakness is that the infrastructure and facilities have not been met with each other, and the source of high quality labor is still small. Thus, Phú Yen need a good investment, especially in infrastructure and facilities, as well as training for high quality human resources. The tourism will develop strongly and bring much more socio-economic benefits than present.

The research results show the strengths and disadvantages of the tourism resources for sustainable tourism development. On that basis, the locality will build suitable specific tourism products, increasing the competitiveness with other provinces in the region.

The results of this paper also demonstrate the need for a synthetic assessment of all kind of tourism resources for sustainable tourism development in Phu Yen. And, the research method, combining both qualitative and quantitative assessment, helps to achieve the most accurate results. Especially, these results will contribute to stable and sustainable tourism development of Phu Yen in the upcoming years.

References

1. Bay, P. V, (2016), Scientific basis and practice of developing marine tourism products in Xuan Dai Bay and its vicinity, Provincial scientific research project, Phu Yen.
2. Dinh, N, (2015), Preserving and promoting the value of historical - cultural - scenic sites in Phu Yen for tourism development activities, Provincial scientific research project, Phu Yen.
3. Huan, N. C, (2005), Landscape assessment according to eco-economic approach, Hanoi National University Publishing House.
4. Phu Yen Provincial People's Council, (2015), Phu Yen tourism development project for the period 2015 - 2020 and orientation to 2025.
5. Department of Culture, Sports and Tourism of Phu Yen, (2012), Tourism development planning of Phu Yen province in the period to 2020 with a vision to 2025.

6. Thanh, T. D, (2005), Assessment of tourism resources Thanh Hoa, University of Social Sciences and Humanities, Hanoi.
7. Prime Minister, Decision 665/QD-TTg in 2018 approving the adjustment of the general socio-economic development plan of Phu Yen province to 2020, with a vision to 2030.
8. Tu, N. A, (2016), Building webgis to serve Phu Yen tourism promotion, Provincial scientific research project, Tourism Association of Phu Yen, Phu Yen.
9. Phu Yen Provincial People's Committee, (2004), Phu Yen Geography, National Political Publishing House.

Urbanisation and environmental vulnerabilities in India: Combating the climate change

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Abstract. By the middle of this century, cities will hold 3/4th of the world population. Half of India's total population is estimated to live in urban centres by this period. India, together with China and Nigeria, will account for over a third of the future global urban population.

Urbanisation has been relentless with magnified carbon footprint and greenhouse gas (GHG) emissions. The environmental vulnerabilities are a flipside and may potentially disrupt the future economic growth of cities.

The monster of climate change is knocking at the door and the world seems ill-equipped to deal with it. Strategies for climate change mitigation and adaptation are unequivocally obligatory, and so are the strategies to contain urbanisation. The consequences of climate change are tremendous and the cost implications are enormous.

India and the entire world desire a sustained and cohesive climate action plan with assigned responsibilities, targets and a monitoring mechanism. What is also called for are key performance indicators to gauge the performance and combat climate change.

Keywords: urbanisation, urban planning, vulnerability, sustainability, greenhouse gases, climate change

1. Introduction

Urban centres provide avenues for business and investments and create employment opportunities for millions of people who increasingly migrate and converge on them with the hope of employment and a higher standard of living. Urbanisation has radically transformed the dynamics of urban-based manufacturing. Over the last past five decades or so, employment in cities has stabilised around a diverse and vibrant business assortment, from subsistence and traditional activities to technology-driven production. The rapid pace of urbanisation has made cities vulnerable to adverse climate change (CC) and it is expected to further catch up challenging the governments and city administrations to act or face the music.

The urban planning processes have been revolutionised by advances in technology. The urban planning practice now, therefore, advocates for sustainable ways of development with vibrancy and resilience at heart, and smart technologies as the key to planning and development. The vibrancy, sustainable development, and climate resilience are the objectives of future urban planning and development.

This paper is an attempt to evaluate trends in urbanisation, challenges and vulnerabilities, efforts, and costs of CC. It is concluded that India needs a sustained climate action plan with clear targets, a monitoring mechanism, and key performance indicators (KPIs) for all sectors contributing to climate deterioration.

2. Urbanisation trends

Over 55% of the world's population lives in urban areas, and it is expected to grow to 75% by 2050. It has been estimated that urbanization combined with the overall growth of the world's population would add up a further 2.5 billion people to urban areas by 2050. It is striking to note that 90% of this increase is projected to come from Asia and Africa *[UNDESA, 2018]*.

An estimated one-third of India's total population lived in cities in 2010 *[Census, 2011]*, which is estimated to grow to 35% by 2030, and further to 50% by 2050 *[UNDESA, 2018]*. India has been projected to add up 416 million urban dwellers, China 255 million and Nigeria 189 million *[UNDESA, 2018]*. The three countries would together account for 35% of the projected growth of the world's urban population by 2050.

It is further projected that the number of cities with populations of 1+ million will grow to 68 by 2030 *[McKinsey, 2010];* Ahmedabad, Bangalore, Chennai, and Hyderabad would be the new megacities *[UNDESA, 2018]*. The urban population in India contributed about 63% to the national GDP in 2010 *[Census, 2011]*; this contribution would grow much higher to 75% by 2050 *[UNDESA, 2018]*. What is worrisome is that India was ranked 7th worst-hit country in

2019 *[GCRI, 2019]* with 70% of GHG emissions coming from cities. 2.8% of India's GDP could be the CC cost for India (refer to Section 4.5 for inaction costs/ CC mitigation costs).

3. Environmental vulnerabilities

The growth of cities puts additional pressure on resources and environmental assets such as forests, water, and air that support the needs of their inhabitants. People living in cities are particularly at risk from changes in the price of and disruption in the flow of resources such as energy, water, and food. Around 44 million people were pushed into poverty, and many of these were in urban areas by food price increases in 2010 *[Atkins, 2012]*.

The environmental vulnerabilities are a flipside of urbanisation and have the potential to disrupt the future economic growth of cities. There has been an estimated total annual damage worth USD 140 billion between 2005 and 2014 as a result of CC *[CDP]*. There are expected to be huge economic losses in the future due to CC. The world has been estimated to suffer an average GDP loss of 20%+ by 2050. The breakdown is – North America 1.1%, Latin America 3.8%, West Europe 1.7%, East Europe 3%, Africa 4.7%, the Middle East 3.7%, and Asia Pacific 2.6% *[EIU]*. An estimated USD 158 trillion worth of assets are at risk from CC by 2050; this is twice the total annual output of the global economy *[CDP]*.

Some of the largest cities in South Asia, including Kolkata and Mumbai, have the most significant numbers of people vulnerable to environmental risks. There are an estimated 70 million people in Indian cities living in multi-dimensional poverty in 2011, with roughly half of them being in Kolkata and Mumbai alone *[Atkins, 2012]*.

The world has been experiencing natural hazards and devastations with increased frequency with largescale devastations. Globally and nationally, cities are faced with risks, *viz.* – climate hazards, resource scarcities, and damage to vital ecosystems. These risks are multiple, interlinked, and they are growing; and cannot be addressed in isolation. CC can impact the frequency, intensity or severity of extreme weather events.

CC is leading to erratic distribution of rainfall and an increased probability of flash/ urban floods. In India, the frequency of heavy rainfall events (> 15 cm in 24 hrs) is increasing. The rise in average temperature is increasing the frequency of heat waves, mostly in heat-prone areas of northern India *[Business Standard, 2022]*.

India has experienced some strong cyclones along either side of the coast, a deadly

glacier collapse (in the Himalayas) and flash floods, landslides, lightning strikes, sweltering heatwave, and ravaging monsoon/ flash floods across states over the past two years or so. The impoverished nation of 1.3 billion people has been encountering floods and cyclones with increased frequency over the past years.

Risks to food security may be expected to intensify with demographic pressures, water scarcity, and CC. Given that 95% of this urban expansion is projected to take place in the developing world, it is cities in developing countries, including India, which will be at the front line of managing this challenge.

4. CC events

CC leaves a significantly large number of people highly vulnerable to the stresses and shocks associated with natural hazards, resource scarcities, and degradation of ecosystems such as forests. This section covers select events in India relating to – cyclones, melting of glaciers, flash floods, lightning strikes, heat & cold waves, and monsoon floods.

4.1. Cyclones

Cyclones have not been rare in the Northern Indian Ocean but they are becoming more frequent and severe with rising in sea temperatures *[Business Standard, 2022]*. In May 2021, Cyclone Tauktae claimed 155 lives in western India including dozens working on oil rigs off Mumbai. It was the fiercest storm to hit the area in several decades *[The First Post, 2021]*.

That there was a total of 8 tropical cyclones means 2019 was one of the most active cyclone seasons on record. Six of them intensified to become 'very severe'. The worst was Cyclone Fani in May 2019 which affected a total of 28 million people, killing nearly 90 people in India and Bangladesh, and causing economic losses of $8.1 billion (Rs.59,066 crore) *[Frontline, 2021]*.

A week after Tauktae in May 2021, Yaas struck with winds the equivalent of a category two hurricane, killing at least nine people and forcing the evacuation of more than 1.5 million in the east. With waves the height of double-decker buses, hundreds of thousands lost their everything including their homes and belongings.

4.2. Melting glaciers & flash floods

As global temperatures rise, about 10,000 glaciers are said to be receding at a rate of 30-60 metres (100-200 feet) per decade *[Business Standard, 2022]* in the Indian Himalayas.

There has been a deluge of disasters during the 2021 monsoon. In February 2021, a ferocious flash flood hurtled down a remote Indian Himalayan valley, sweeping away homes, a hydro plant and around 200 people. Barring 60, bodies of the majority could not be found. A massive chunk of glacier *[The First Post, 2021]*, the size of 15 football fields long and five across broke off high in the mountains causing flash floods. The catastrophe was a fallout of CC showing a bleak future. The flash flood of 2013 that killed 6,000 people also happened in the area.

4.3. Lightning strikes

The monsoon season from June to September brings danger from the skies in the form of lightning. Lightning happens to be the single biggest contributor to accidental deaths due to natural causes in India. Deaths due to lightning have become frequent in the country with CC becoming more pronounced. There are, on average, 2,000-2,500 lightning deaths every year *[The Indian Express, 2021]* in the country. Lightning strikes are said to have increased 34% over the past year.

In 2019, lightning strikes killed almost 3,000 people *[The Indian Express, 2021]*. The newspaper reported at least 30 deaths in separate incidents of lightning in various parts of the

country in a single say, with Rajasthan and Uttar Pradesh reporting 18 and 12 deaths respectively. A month earlier, i.e. June 2021, 20 persons were reported killed in lightning strikes in South Bengal. Lightning in May-June 2021 killed not just people, it is also blamed for the deaths of 18 elephants in Assam.

4.4. Heat & cold waves

The India Meteorological Department (IMD) has declared a heatwave almost every year over the last decade with temperatures sometimes touching 50^0C (122^0F). India's average temperature rose around 0.7^0C (1.3^0F) between the beginning of the 20th century and 2018. It is expected to rise another 4.4^0C by 2100, according to IMD *[The First Post, 2021]*. In early July 2021, tens of millions of people sizzled in heatwaves across northern India. A newspaper, quoting meteorologists, reported over 17,000 deaths in India due to heatwaves since 1971 *[The First Post, 2021]*.

Cold waves killed more Indians than heat waves over 1980-2018. In 2011, nearly 60-times more deaths were recorded in comparison to heat waves *[Down to Earth, 2021]*. Cold waves claimed 722 lives and heat waves 12. There were as many as 152 deaths recorded due to cold waves in 2020 in comparison to just two deaths as a result of heat waves. In 2020, deaths from cold waves in proportion to that from heat waves recorded officially were the highest in 20 years, the report mentioned. India recorded 99 days of cold waves in 2020, according to IMD *[GOI, 2021]*.

There has been 2.7 times increase in the number of cold wave days over the period 2017-2020. The number of cold wave days have been consistently on the rise since 2017. In 2018, the country witnessed 63 days of cold waves, which increased 1.5 times to 103 in 2019 *[Down to Earth, 2021]*. For a change, the long lockdown effected due to the COVID-19 pandemic has proved good in a way that India recorded the least deaths due to heat waves in 2020.

4.5. Monsoon floods

Floods caused by heavy rains in 2019 took 1,800 lives across 14 states in India and displaced 1.8 million people *[GCRI, 2019]*. Overall, the intense monsoon season affected 11.8 million people, with the economic damage estimated to be USD 10 billion (Rs.72,900 crore at USD 1=Rs 72.9) *[Frontline, 2021]*.

The year 2021, especially the second half, was dominated by heavy rains, large-scale flooding, and destruction in many states across India. From Uttarakhand to Kerala, Tamil Nadu, and Karnataka the rains were heavier and the subsequent floods were more devastating than usual.

Intensifying CC means that opposite disasters - droughts and monsoon floods are manifesting at the same time across the South Asian region. As many parts of India, Nepal and Bangladesh faced floods, drought continued to affect large swathes of Pakistan and some areas of India *[The Third Pole, 2021]*. It was both bizarre and ironic that parts of India that faced drought until August end were flood affected only weeks later.

Throughout the 2021 monsoon, there have been so many cloudbursts in the Himalayas – with consequent flash floods and landslides – that it is difficult to keep count. There have been unprecedented landslides and flash floods in the Western Ghats of Maharashtra as well *[The Third Pole, 2021]*. The hillside resort of Mahabaleshwar experienced a record 60 cm of rain within 24 hours *[The First Post, 2021]*. Goa too reeled under its worst floods in decades.

Flooding and landslides are common during India's treacherous monsoon season, which also often sees poorly constructed buildings buckle after days of non-stop rain. CC however seems to be making the monsoon ferocious.

5. Combating CC

As the world continues to urbanize, sustainable development increasingly depends on the successful management of urban growth. It is imperative that cities undertake sustained actions to remain and/ or become vibrant given the challenges of CC.

5.1. The footprint

The ecological footprint of cities significantly contributes to CC, as they consume two-thirds of the world's energy and produce approximately 70% of the GHG emissions. At the same time, cities are ideal focal points for strategies for reducing GHG emissions. With their dense populations and often fragile infrastructures, cities are vulnerable to the effects of CC, such as storms and flooding.

Cities often lack the capacity to quickly develop measures to combat the effects of CC, thus leaving residents vulnerable to CC's negative effects. In respect of CC mitigation, the ability of cities to actually implement climate actions depends *[Tomlinson, 2021]* on whether – (a) the CC action is located inside or outside of the city's jurisdiction and regulatory authority, (b) the city owns buildings, provides transport services, generates electricity and undertakes waste management, (c) the city has the capacity to finance its own climate actions and to attract investors, and (d) the intergovernmental divisions of roles and responsibilities within metropolitan areas and between metropolitan areas and other levels of government enable climate actions by cities.

5.2. Sustainability development

The United Nations (UN) Agenda for Sustainable Development (also, Sustainable Development Goals; SDGs) for the year 2030 *[SDG, 2015]* is a plan of action for people (society), the planet (environment), and prosperity (economy), by seeking to strengthen peace and eradicating poverty. There are 17 SDGs and 169 targets in this universal Agenda that will stimulate action over the next fifteen years, starting in 2015, in areas of critical importance for humanity and the planet.

SDG 11 in the Agenda targets to 'make cities and human settlements inclusive, safe, resilient and sustainable. Sustainability, therefore, is seen at the heart of the future development framework and would imply meeting the needs of the present in a manner that the needs of future generations are not compromised.

5.3. Paris Agreement

The Paris Agreement (PA) *[UNFCCC, 2015]* is a legally binding international treaty on CC. It was adopted by 196 parties in Paris *[COP, 2015]*, on December 12, 2015, and entered into force on November 4, 2016. Its goal is to limit global warming to well below 2, preferably to 1.5^0C, compared to pre-industrial levels.

In order to achieve this long-term temperature goal, countries aim to reach global peaking of GHG emissions as soon as possible so that climate neutral world is achieved by mid-century. The PA is a landmark multilateral CC process and is a binding agreement that brings all nations into a common cause to undertake ambitious efforts to combat CC and adapt to its effects.

To be aligned with the PA 1.5^0C limit, India has outlined policies, actions and targets with deadlines to meet targets/ NDCs. A recent rating suggests that India's overall rating is 'highly insufficient' *[Climate Action Tracker, 2021]*, and India should do more toward nationally determined contributions (NDCs).

5.4. Climate-informed planning

With CC leaving regions of the world uninhabitable, starvation, poverty and warfare are outcomes that will drive millions to cities in search of livelihood opportunities. It is

challenging to reconcile the need for rapid migration and urbanisation in order to evade irreversible and costly environmental damage. Among the key approaches to climate-informed planning of cities would include the provision of sufficient engagement/ employment opportunities in all classes of urban centres as well as rural hinterland so as to check the out-migration to metropolitan cities and Class-1 cities in India.

It is imperative to anticipate and address the impacts of CC, such as the rise in recurrent storms, cyclones and floods etc, through effective urban planning and design. The sustainability strategies for India that is susceptible to CC will be specific to the prevailing sub-tropical/ micro-climatic (monsoon) conditions including temperature rise and its influence on locational decisions, retrofitting of urban areas to cope with heat, approach to reducing urban heat islands, and lowering emissions.

5.5. Costs of CC in India

The cost of global CC impacts for India can be estimated by accounting for the loss in agriculture productivity, impact of higher power generation requirements with increasing temperatures, and health impacts from temperature rise. It is concluded that CC results in significant economic losses for the country across sectors *[CEEW, 2015]*, namely: (1) Production losses in rice, wheat, and maize alone could be up to USD 208 billion and USD 366 billion in 2050 and 2100 respectively (all prices are in USD at 2010 prices); (2) Additional power generation could require an incremental capital investment of USD 33 billion and USD 123 billion in 2050 and 2100 respectively to meet the higher cooling energy needs of India; (3) Health impacts should be best measured in terms of deaths due to a higher incidence of diseases; (4) Diarrheal deaths will decrease with increasing incomes. Deaths due to the higher spread of Malaria will increase significantly to 5000 in 2050 and 19500 in 2100. Deaths related to Dengue will also rise; (5) If disease-related deaths are valued at lifetime earnings, the loss of economic output will be USD 2.5 billion and USD 21 billion in 2050 and 2100 respectively;

(6) A conservative range of 45% to 1.19% of India's GDP in 2050 and 59% to 1.17% of India's GDP in 2100 is estimated as the cost of global inaction on mitigating CC; and (7) Losses in rice, maize and wheat production (impact sensitivity) per 1°C increase would be 4-20%, 3250%, and 5-20% respectively.

6. Conclusion

Planning is a necessary measure for the sustainable development of cities but it can be the other way around if planning does not address the phenomenon and effects of CC. Actions to combat the CC in India call for intensive awareness, capacity building, research, innovation and knowledge sharing to leverage the available skills and resources toward meeting the CC goals.

Most of the malfunctions that occur in the urban settlements are a direct or indirect consequence of the urbanization processes, specifically, a consequence of urban sprawl. Future planning strategies therefore must consider coping with different types of land use conflicts in order to ensure the sustainability of cities and the improvement of the relationship between different stakeholders and actors.

The onset of the COVID-19 pandemic has resulted in disruptions and delays in the process and actions to address CC. The climate emergency though hasn't changed during this period; it continues to happen and affects the world with a constant intensity. There is required a partnership between the governments, city administration and the public to think and act together to save ourselves and future generations from the harsh and irreversible climatic changes.

References

1. United Nations Department of Economic and Social Affairs, 2018 (UNDESA, 2018). www.https://un.org/development/desa/en/news/population/2018-revision-of-world-urbanisation-prospects.
2. html. Accessed February 14, 2022.
3. Census of India. 2011. Provisional Population: Totals Urban Agglomerations and Cities. https://censusindia.gov.in/2011. Accessed February 21, 2022.
4. McKinsey & Company (McKinsey Global Institute), 2010. India's Urban Awakening: Building Inclusive Cities, Sustaining Economic Growth. https://www.mckinsey.com/MGI_Indias_urban_awakening_ executive_summary.pdf. Accessed December 2011.
5. Global Climate Risk Index (GCRI), 2019. Accessed February 14, 2022.
6. Atkins & UK Department for International Development, 2012. Future Proofing Risks and Opportunities: For inclusive urban growth in developing countries. https:// Future Proofing Cities_Exec Summary4092013.pdf (investis.com). Accessed July 15, 2017.
7. Economist Intelligence (Economic Intelligence Unit; EIU). http://eiu.com/. Accessed February 18, 2022.
8. CDP Worldwide: CDP [Disclosure Insight Action]. http://www.cdp.net/en/. Accessed February 19, 2022.
9. Business Standard (dated: January 21, 2022): What's triggering extreme weather events in India? Interview with Mrutyunjay Mohapatra, Director General of Meteorology, India Meteorological Department. https://www.business-standard.com/podcast/current-affairs/what-s-triggering-extreme-weather-events-inindia-122012100088_1.html. Accessed February 19, 2022.
10. The First Post (dated November 09, 2021). https://www.firstpost.com/. Accessed February 12, 2022.
11. Frontline: India's National Magazine (dated January 25, 2021). India among countries worst affected by climate change: Global Climate Risk Index 2021. Accessed February 21, 2022.
12. The Indian Express (dated July 15, 2021). www.indianexpress.com. Accessed February 19, 2022.
13. Down to Earth (dated 2021). https://www.downtoearth.org.in/. Accessed February 19, 2022.
14. Government of India (GOI), 2021, Ministry of Statistics & Programme Implementation, The Envi-Stats India 2021 report, Vol. 1. Accessed February 19, 2022.
15. The Third Pole (dated September 16, 2021), Droughts and late monsoon floods batter South Asia.
16. https://www.thethirdpole.net/en/climate/2021-monsoon-drought-floods-batter-south-asia/. Accessed February 20, 2022.
17. 2030 Agenda for Sustainable Development and the Sustainable Development Goals (SDG), United Nations, 2015. https://sustainabledevelopment.un.org/. Accessed November 01, 2017.
18. United Nations Framework Convention on Climate Change (UNFCCC), 2015. https://www.unfccc.org/. Accessed February 20, 2022.
19. The Conference of the Parties (COP, 2015) is the supreme decision-making body of the Convention. A key task for the COP is to review national communications and emissions.
20. Climate Action Tracker (dated September 15, 2021). India Country Summary. https://climateaction tracker.org/countries/india/. Accessed February 20, 2022.

21. Tomlinson, R, 2021, Smart Cities and Climate Change: The Evolution and Curation of Knowledge; Urban Sustainability Laboratory Working Paper Series. Wilson Centre. Washington, DC. Downloaded February 10, 2022.
22. Council on Energy, Environment and Water (CEEW) [Integrated, International, Independent], 2015. The Costs of Climate Change Impacts (CCI) for India: A Preliminary Analysis (March 2015). https://www.ceew.in/ publications/costs-climate-change-impacts-india. Accessed February 21, 2022.

The fall of Palestine and the rise of apartheid

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Abstract. The states of Palestine and Israel involve lands of conflict. The Israeli authorities have for long confiscated lands, expelled Palestinian people, and leveraged Jewish Israelis. The Jew-Arab conflict is historic and continues to devastate the civilians.

There have been wars and war-like situations between Palestine and Israel over the past several decades. As always, the latest war of 2021 has accounted in significant damage to civilian infrastructure and genocide of several hundred innocent lives including women and children on the Palestinian side.

The USA and its allies have been staunch supporters of Israel and the Jewish homeland – all at the cost of innocent Palestinian Arabs. The atrocities by the Israeli administration and forces against the poor, unarmed and helpless Palestinian civilians amount to human rights violations, genocide and apartheid.

The conflict has not been and cannot be resolved for the reason that Israel continues to unilaterally act on the ground, disobeying and disrespecting all treaties and accords set forth by the United Nations.

Keywords: conflict, intrusion, illegal occupation, unilateralism, partition, genocide, apartheid.

1. Introduction

Palestine and Israel are historically lands of conflict ($29^0$30'N – $33^0$15'N and $34^0$15'E – $35^0$45'E), and continue to devastate the civilians, mostly the Arabs. The Israeli authorities have for long confiscated Palestinian lands and leveraged Jewish Israelis. The atrocities by the Israeli administration and forces against the poor, unarmed and helpless Palestinian civilians amount to human rights violations, genocide and apartheid.

This paper talks about the invasion, illegal occupation and expansion of Israel into Palestinian territory and subjugation of its people amounting to apartheid. This work essentially relies on information available in the public domain and holds no accountability for errors, misinformation, and/ or misrepresentation with regard to the conflict and ground realities.

2. Approach & Methodology

The Palestine-Israel conflict has remained current for over seven decades. There is hence no dearth of information through a variety of sources, both published and reported in print and electronic media – news and articles from various media houses, government data and documents, historic and political maps, live reporting and documentaries etc.

This paper relies on extended long-term research into the conflict involving Palestine and Israel by the author. The methodology followed broadly includes three stages: (A) research intent/ formulation of the problem involving – (i) problem identification, (ii) understanding

and its evolution, (iii) defining the scope and objectives, and (iv) ascertaining limitations; (B) data/ information sources and interpretation involving – (i) published reports/ docs/ treaties in the public domain, (ii) information through print and electronic media, (iii) political analysis and assessment, and (iv) interpretation, assessment and cross-referencing; (C) structuring/ presentation of the research involving – (i) preparation of tables and figures, (ii) listing out issues and observations, (iii) synthesis and conclusions, and (iv) attention to sources/ references. Among the limitations of the research is its over-dependence on secondary data/ information and no primary visits.

3. The fall of Palestine

The fall of Palestine started with the idea of Israel – an exclusive territory for Jews, in the land where Palestinians peacefully lived for centuries.

3.1. The European indulgence

The British forces took control of Palestine after the fall of the Ottoman Empire in 1917 and ruled for nearly three decades between World War I and World War II. They maliciously and malevolently designed the fall of Palestine through its partition.

The British Government published a document/ statement of policy on 2nd November 1917, later on, issued as a letter (May 14, 1918) from Arthur James Balfour, the then Secretary of State for Foreign Affairs, to Lord Walter Rothschild, a British Zionist leader, to announce support for the creation of a 'national home for the Jewish people in Palestine which was then part of the Ottoman Empire and home to a minority Jewish population.

At the time of the British Mandate *[Mandate, 1920]*, Jews made up around 6% of the total population of Palestine, i.e. around 56000 people *[Palestine, 1946]* and they lived scattered in settlements, particularly in Jaffa and Haifa till 1917. By the year 1918, the Zionist organisations had started making land purchases throughout Palestine for Jewish settlements *[HRW, 2021]*.

The declaration contained in this letter read viz. – "His Majesty's Government view with favour the establishment in Palestine of a National Home for the Jewish people, and will use their best endeavours to facilitate the accomplishment of this object, it being clearly understood that nothing shall be done which may prejudice the civil and religious rights of existing non-Jewish communities in Palestine, or the rights and political status enjoyed by Jews in any other country".

The text of this declaration had been submitted to President Woodrow Wilson of the United States of America (US/ USA) and was approved by him before its publication and, the Governments of France and Italy publicly endorsed it respectively on the 14th of February and 9th May 1918, *[Palestine, 1946]*.

3.2. The bias of USA

On May 14, 1948, the head of the Jewish Agency proclaimed the creation of the independent state of Israel as the United Kingdom's colonial mandate over the territory ended. US President Harry Truman immediately recognised it thus becoming the first country to have given instant recognition as a new sovereign nation *[Truman Library]*.

All countries but the USA consider Israeli occupation and settlements in Palestine as illegal and a violation of international law *[Aljazeera, 2021]*. Israel's territorial conquest and unilateral annexation of East Jerusalem in 1980 and Golan Heights – belonging to Syria – in 1981, are illegal under international law. It is again only the USA that gives recognition to this *[Aljazeera, 2021]*.

US President Joe Biden, and several other Presidents in the past, have not only defended Israel on its military action against Palestine but also provided financial aid and equipped Israel with precision-guided weapons saying Israel has a right to defend itself is baffling *[Truman Library]*.

3.3. Financial aid by USA

The US has always backed and buoyed Israel with both funds and the latest technology to stay ahead of its neighbours and adversaries. The total US aid to Israel during the period 1946-2018 has been to the tune of USD 236 billion *[USAID Data Service, 2020]*. The US pledged to provide USD 38 billion in military aid to Israel from 2019 to 2028 in an arrangement between the two countries in 2016. It is perhaps in line with this agreement that the Biden administration has notified Congress of a proposed US weapons sale to Israel worth USD 735 million (May 2021) *[CNN Politics, 2021]*.

3.4. Military aid by USA

Israel has been the single largest recipient of US foreign assistance since World War II and this sale is one small part of overall US military support *[US Greenbook, 2020]*. The US military aid for Israel has been designed to maintain Israel's qualitative military edge (QME) over its neighbouring militaries and enemies. The rationale for QME is that Israel must rely on better equipment and training to compensate for being much smaller in land area and population than most of its potential adversaries *[QME (1), 1972 and QME (2), 1981]*.

The successive US administrations have, for decades, taken measures to maintain Israel's QME in several ways, and the US arms sales policy has traditionally allowed Israel first regional access to US defence technology *[Israel Policy Forum, 2016]*. Israel acquired the F-15 in 1976, six years before Saudi Arabia. It received the delivery of the F-16 fighter in 1980, three years before Egypt. In cases where both Israel and an Arab state operate the same US platform, Israel has first received either a more advanced version of the platform or the ability to customize the US system *[Israel Policy Forum, 2016.]*. In cases where Israel objected to a major defence article sale to an Arab military (e.g., the 1981 sale of Airborne Early Warning and Control System aircraft, AWACS to Saudi Arabia), the US Congress has, at times, advocated for and legislated conditions on the usage and transfer of such weapons before or after a sale. The US has compensated Israel with offsetting weapons packages or military aid when selling other major US defence articles to a Middle Eastern military rival.

4. The rise of apartheid

Apartheid refers to inhumane acts committed in the context of systematic oppression by one racial group over another and with the intent of dominating the marginalized group, and it is a crime *[HRW, 2021]*.

4.1. The intrusion by Jews

Jews had been planning a homeland in Palestine since 1897 *[The Tapestry, 2018]* while the first wave of Jewish arrival to Palestine began as early as 1881 *[The Tapestry, 2018]*. These settlements by Israel are illegal and violative of international law which prohibits settling its people into occupied areas *[Geneva convention, 1949]*.

The process of privatisation of land under British rule accelerated the sale and transfer of properties to Zionist organisations, and the displacement of Palestinian inhabitants *[HRW, 2021]*. An estimated 376,415 Jewish emigrants, mostly from Europe, arrived in Palestine between 1920 and 1946 *[Palestine, 1946]*.

The intrusion of Jews into Palestine during the initial years (1920-32) was on a low scale *[Palestine, 1946]*, which got amplified during the later years 1933-44, with 1935 accounting for the maximum number (60,000) ever, and it happened from all over the place – Asia (11

countries), Europe (27 countries), Americas (10 countries), Africa (7 countries), and Oceania (2 countries) *[Palestine, 1946]*. The Jewish population in Palestine, composed principally of immigrants, increased from less than 10 per cent in 1917 to over 30 per cent in 1947 *[UNISPAL (1)]*.

4.2. UN partition plan

It all started in 1916 when Britain and France clandestinely decided to split the Arab provinces of the Ottoman Empire between them *[The Tapestry, 2018]*. The British, however in 1947, referred the case of Palestine to the United Nations (UN). The special committee of the UN General Assembly (UNGA) on Palestine proposed its partition into three parts – (i) Palestinian Arab, and (ii) the other Jewish; and announced Jerusalem to remain under international control *[UNSCR, 1947]*.

Israel, already allocated a larger chunk of land (55%) by the UN, proclaimed independence and went to war with neighbouring Arab nations in 1948, thereby expanding to 77 per cent of the mandated Palestinian territory, and a larger part of Jerusalem which was to be under international control *[McCarthy, 1990; Haddad, 2020]*.

4.3. Unilaterism of Israel

Israel has waged several wars on Palestine and taken control of increasingly larger lands each time. The West Bank, the Palestinian territory, occupied by Israel was divided into three areas A, B and C in the Oslo Accords of 1993 and 1995. Despite these being part of Palestinian territory, there has been increasing interference and control by Israel in violation of the Oslo Accord *[Aljazeera 2021]*. Oslo Accord of 1995 seeks to implement the Oslo Agreement 1993 defining the security, electoral, public administration and economic arrangements until permanent settlement by UN Security Council (UNSC) Resolutions 242 and 338, and the release of Palestinian detainees *[UN, 1995]*.

Unilateralism is the attitude of Israel, and it reflects in their policy making. Israel has unilaterally and in violation of the Oslo Accords declared a majority area of the West Bank as the Jewish state *[The Hindu, 2018]*.

4.4. Rule of apartheid

All across and in every aspect of life, Israeli authorities systematically privilege Jewish Israelis and discriminate against Palestinians. All laws, policies, and statements by Israeli officials that the objective of upholding Jewish Israeli control over demographics, political power, and land has long guided government policy, are misplaced and blatant lies. In pursuit of this goal, authorities have evicted, restricted, forcibly disconnected, and subjugated Palestinians by their identity to varying degrees of intensity. These atrocities are so severe that they amount to the crimes against humanity of apartheid and persecution *[HRW, 2021]*.

There is a single authority, the Israeli government, that rules primarily over the area between the Jordan River and the Mediterranean Sea, inhabited by two groups of coarsely equal size, methodically providing privileges to Jewish Israelis while repressing Palestinians, most severely in Palestinian territory, made-up of the West Bank, including East Jerusalem, and Gaza *[HRW, 2021]*.

4.5. Obstacles & inhuman acts

Across Israel and the Palestinian territory, Israeli authorities have pursued an intent to maintain domination over Palestinians by controlling their lands and demographics for the benefit of Jewish Israelis. While Jewish Israelis are given guaranteed residency rights, Palestinians are denied residency permits, and barred from any construction in West Bank or entering the Israeli settlements.

A key strategy of Israel has been to integrate Jew communities by increasingly separating Palestinians. In areas of Palestinian control, the intent has been coupled with inhumane acts, including sweeping movement restrictions, mass land confiscation and the suspension of civil rights for millions of Palestinians, carried out amid systematic oppression *[HRW, 2021]*. Since 2002, Israel has been constructing a wall that stretches for 700 kilometres and more. This means that there are over 700 road obstacles including 140 checkpoints. The wall is 8 meters high and it cannot be breached. Israel explains that the wall is for security reasons. Rather than obeying the internationally-recognised 1967 boundary, known as the Green Line, 85 per cent of the wall has been illegitimately constructed by Israel in the Palestinian territory – the West Bank *[Aljazeera, 2021]*. This wall is criminal and severely restricts the freedom of movement of the Palestinian people.

5. Conclusion

An extensively large number of Palestinian Arabs have been forcefully displaced and exiled, and their properties confiscated ever since Israel occupied the West Bank and Gaza in 1967. Israel has taken control of a majority of Palestinian land (amounting to tens of thousands of hectares) and declared it a Jewish state for Jewish people. It continues to commit crimes of apartheid and persecution against the Palestinian Arabs. The USA goes unconstrained in providing financial and military support to Israel, thus partnering in its crimes against humanity.

The international community should convince and bring the USA on board to push Israel to maintain a permanent ceasefire and end brutality. It must be pushed to respect UN-administered borders to resolve the long-standing conflict and bring an end to apartheid and persecution of Palestinian Arabs.

References

1. Aljazeera, 2021, https://interactive.aljazeera.com/aje/2017/behind-balfour/index.html. Accessed May 19, 2021.
2. CNN Politics, 2021, https://edition.cnn.com/2021/05/17/politics/us-israel-weapons-sale/index.html. Accessed May 20, 2021
3. Haddad, M, 2020, Palestine and Israel: Mapping an annexation. https://www.aljazeera.com. Accessed May 19, 2021.
4. Human Rights Watch (HRW), 2021, A Threshold Crossed: Israeli Authorities and the Crimes of Apartheid and Persecution. https://www.hrw.org/. Accessed May 28, 2021.
5. Israel Policy Forum, 2016, The Double-Edged Sword of the Qualitative Military Edge. https://israel policyforum.org. Accessed December 05, 2021.
6. McCarthy, J, 1990, The Population of Palestine, The Institute for Palestine Studies Series. Columbia University Press, New York.
7. Palestine, 1946, A Survey of Palestine, Volume 1. Prepared in December 1945 and January 1946 for the information of the Anglo-American Committee of Inquiry. Printed by the Government Printer, Palestine; Tables 3-11; pp 187-203.
8. Qualitative Military Edge, 1972 (QME (1), 1972). The concept of QME (independent of its application to Israel) dates back to the Cold War. In assessing the balance of power in Europe, US war planners would often stress to lawmakers that, because countries of the Warsaw Pact had a numerical advantage over US and allied forces stationed in Europe, the US must maintain a “qualitative edge” in defence systems. For example, see, Written Statement of General William O. Gribble, Jr., Hearings on Research, Development, Test, and Evaluation Program for Fiscal Year 1973, Before Subcommittee No. 1 of Committee on Armed Services, House of Representatives,

Ninety-Second Congress, Second Session, February 2, 3, 7, 9, 22, 23, 24, March 6, 7, and 8, 1972.
9. Qualitative Military Edge, 1981 (QME (2), 1981). The concept of QME was subsequently applied to Israel about its Arab adversaries. In 1981, then-U.S. Secretary of State Alexander Haig testified before Congress, saying, "A central aspect of US policy since the October 1973 war has been to ensure that Israel maintains a qualitative military edge." Secretary of State Alexander Haig, Statement for the Record submitted in response to Question from Hon. Clarence Long, House Appropriations Subcommittee on Foreign Operations Appropriations, April 28, 1981.
10. The Hindu, 2021 (May 14, 2021), Explained: Israel's Iron Dome rocket defence system. https://www. the hindu.com/news/. Accessed July 21, 2021.
11. The Mandate for Palestine, 1920 (Mandate, 1920). League of Nations. https://en.wikipedia.org/wiki/ Mandate_for_Palestine. Accessed May 19, 2021.
12. The Palestinian History Tapestry (The Tapestry), 2018, https://www.palestinianhistorytapestry.org/. Accessed May 26, 2021.
13. The Harry S. Truman Library and Museum (Truman Library), National Archives and Records Administration. https://www.trumanlibrary.gov. Accessed May 19, 2021.
14. United Nations, 1949 (Geneva convention, 1949), Geneva Convention relative to the protection of civilian persons in time of war of 12 august 1949. https://www.un.org/en/genocideprevention/ documents/atrocity-crimes/Doc.33_GC-IV-EN.pdf. Accessed July 07, 2022.
15. The United Nations Information System on the Question of Palestine (UNISPAL) (1), History of the Question of Palestine. https://www.un.org/unispal/history/. Accessed July 06, 2022.
16. The United Nations Information System on the Question of Palestine (UNISPAL) (2), The Origins and Evolution of the Palestine Problem: Part II (1947-1977).
17. https://www.un.org/unispal/history2/origins-and-evolution-of-the-palestine-problem/part-ii-19471977/. Accessed July 06, 2022.
18. US Overseas Loans and Grants (Greenbook), 2020, The US State Department, and the Missile Defence Agency.
19. United Nations Security Council, 1947, UN Resolution 181(II) (UNSCR, 1947). http://unscr.com/en/ resolutions/181. Accessed July 12, 2022.
20. United Nations Security Council, 1967, UN Resolution 242 (UNSCR, 1967). https://peacemaker.
21. un.org/sites/ peacemaker.un.org/files/. Accessed July 12, 2022.
22. United Nations Security Council, 1973, UN Resolution 338 (UNSCR, 1973). https://peacemaker. un.org/middleeast-resolution338. Accessed July 12, 2022.
23. United Nations, 1995, Israeli-Palestinian Interim Agreement on the West Bank and the Gaza Strip (Oslo II). https://peacemaker.un.org. Accessed July 11, 2022.
24. USAID Data Service, March 2020. This is based on (inflation-adjusted) constant USD at 2018 prices.

Cricketscapes and the city: a case study of Purnea, Bihar

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Abstract. Cricket is a popular culture in India. The overwhelming presence of the sport marks a notable component in the cultural landscape of a city. The paper aims to explore the cricketing landscape in small town India by taking the case of Purnea in Bihar. It involves the geographical understanding of how cricket is imagined, performed and promoted in the non-metropolitan urban enters of India. Purnea has witnessed a rapid growth in urbanisation and a notable expansion in cricket both as a game and facilities associated. Using qualitative research methods, which include, semi-structured interviews, participant observation and walk along ethnography, the paper provides an insight into the cultural landscapes of cricket. It examines the relationship between space and cricket by taking into account the playgrounds, institutions, infrastructure, teams and formats. The paper contributes to the field of geography by extending the dialogue between urban landscapes and sporting culture through the lens of cricket. In doing so, it makes an attempt to overhaul the sporting aspirations in the region.

Keywords: Landscape, Place, Space, Cricket, Ethnography

1. Introduction

The overwhelming presence of cricket is a notable feature of Indian homes, streets, public spaces and the landscape of the city. The game is celebrated as a religion in India. It has crept into the everyday lives of people through tea-time discussions, advertisements on television and bill boards, news and nationalism. Indians have unparalleled zeal for the game, such that, cricket can be found in every nook and corner of the country. This paper looks at the micro-level occurrence of cricket and the way it establishes a cultural landscape in the Indian cities. Sports is a cultural phenomenon. They play an essential role in the making up of a city (Bale, 2003). Sportscapes (Appadurai, 1996) in the city have an impact much beyond the stadiums or arenas it is played (Bale and Moin, 1995). Cricket as a venerable sport in India, has a major role in shaping the Indian cities. While cultural landscapes are understood as structures, forms, patterns and human influence over the natural landscape, cricket produces a landscape which has a cultural content beyond the humanly created physical expressions (Wildren, 1997). This paper looks at these cricketscapes that are produced out of human imagination and cognition over space. The central argument of the paper is that cricket as a mass culture in India produces distinct cultural landscapes in the Indian cities, understood as cricketscapes in this paper, that exist beyond the material and physical aspects of landscapes. For this study, he city of Purnea is taken as a case study to elaborate on the understanding of sports, city and landscape in the Indian cities.

The city of Purnea lies in the North-East part of the state of Bihar. It is the district headquarter of the Purnia district and lies on the important transport route National Highway-31 (Ganga-Darjeeling Highway), which connects the North-East India to North India. The town has witnessed economic growth in the last decade and it has emerged as an important centre for education, medical and hospitality industry. The gradual urbanisation of the town has led to people from surrounding regions to come to the city in search of a better livelihood. As a result of which, people from different walks of life come together in public spaces. Cricket, as the most popular sport in town, binds these people together beyond the caste, class

and religious attributes. The game provides a medium of interaction between people and public spaces like grounds and promotes cultural integration.

This paper tries to understand the coming togetherness of people over a shared space which shapes the cultural landscape of the city. An ethnographic method of enquiry has been adopted to bring out the nuances of space-place interaction, cultural entity of sports and the making up of the cricketspaces produced in the process of playing the game.

The paper is divided into three parts. The first part, talks about the spatialisation of cricket in the city. The second part enquires into the way the game of cricket transforms the city landscapes. The last section explores the interconnections of cricket beyond the level of the city to state and national level. looks. The paper contributes to the field of geography by enquiring about the cultural landscapes that exist beyond physical forms and are a product of cognition of human. It also adds sports geography as an essential field of enquiry into the understanding of city by taking the case study of cricket in the city of Purnea, Bihar.

2. Methodology

A combination of qualitative research methods has been used in the study to bring out the nuances of space-place interaction, making up of the cultural landscape and lived experience of the people. The qualitative methods have been used to generate high quality information imbued with actual experience (Creswell, 1994). The research methods include semi-structured interviews, participant observation and walk along ethnography, each of which outline the cultural and social organisation of people, settings or ways of life (Calhoun, 2002). The interview subjects include a professional cricket player like Vijay Bharti, who happens to be the first player from the town to play the Ranji Cricket Tournament from divided Bihar, amateur cricket players from the town who play with different clubs in the city as well as people occupying public grounds to play the game. The observed site includes important public grounds of the town like Rangbhoomi Maidan, DSA Grounds etc. The city of Purnea has been selected as the study area as the region has seen recent upheavelment in the form of sporting culture in the last few years. The presence of a functioning District Cricket Association along with more than 50 cricket clubs makes the town as an essential locus for the development of cricket in the region. Scarce time and limited number of cricket matches due to the affect of the coronavirus were a few setbacks in data collection and survey.

3. Litrature review

Majority of literature on landscape are associated with forms, functions, processes, and context (Widgren 2002). These elements come together in different context to give rise to interfaces or 'readings' of the landscape, each valid in its specific social and historical context (Hannes Palang & Gary Fry, 2003)[3]. Landscapes studies in this regard are closely linked to cultural studies, interaction of space-time continuum and planning-management exercises. These approaches are skewed towards viewing landscape in the material form. The character of landscapes has been limited to visible elements present over space, that one can touch, smell, see or measure. The cultural turn in landscape studies brought in focus how different cultures perceive and interpret landscape, as well as the way cultures give symbolic meanings to landscape. It explores the ways in which landscape has modified by human activity, as opposed to the primeval natural landscape. At the same time, the way in which humans had changed the landscape through the clearing of the forests, the draining of the marshes, the cultivation of the heaths and the growth of towns was the principle thrust of teaching in

[3] Palang, H. & Fry, G. (2003), Institute of Geography, University of Tartu, Estonia, Institute of Landscape Planning, Norwegian Agricultural University, Norway

historical geography (Darby 1951). This approach brings together geographic, ethnic, socio-economic groups to explore the study of cultural heritage management.

Despite these varied means of studying landscapes, humanistic approaches that involve the study of landscape in our mind is scarce. Landscape studies have a bend towards the material aspects in space. Even within the ambit of sports geography the concept of landscape deals with the importance of stadiums for economists and spatial planners in the city landscape (Bale and Moin, 1995), stadium landscape as a blend of horticulture and architecture (Bale, 2003) and the impact of sporting events or sport stadiums on a certain area as "nuisance fields" (Bale, 1980b, 1993, 1994, 1999) or "Locally unwanted Land Use" (Van Dam, 1998).

There is scope of work in the field of humanistic approaches. Cosgrove (1985) sought to reformulate landscape as a concept whose subjective and artistic resonance are to be actively embraced. He says that the incorporation of individual, imaginative and creative human experience into studies of the geographical environment, aspects which geographical science is claimed to have devalued at best and at worst, ignored. Landscape analysis through humanistic methods have opened up new ways to understand everyday life, architecture, paintings and historical nuances of a place. The development in the field of landscape study through cultural and historical approaches provide crucial groundwork to study sports at the level of the city. A sport like cricket is a result of culture and human experience over spaces that is reflected within cities. The game of cricket imposes certain dynamics in the public spaces where it is played. These renewed dynamics last over spaces till the game is in action. The public turns neutral once again as the game gets completed. The study of a landscape in transition, when the game is in action is an interesting field of enquiry, an aspect of landscape studies rarely taken into academic consideration. This paper looks at the making of cognitive landscapes that occur over the public spaces of towns in India through the understanding of landscape under sports geography by taking the case of cricket in Purnea, Bihar.

4. Making up of cricketspaces

Cricketspaces are understood as the spaces in the city which are occupied by people involved in playing the game. These spaces constitute of public grounds, parks and stadiums and are transitory in nature. The growing population in the urban towns of India have rendered a contest for spaces for varied activities. The activity of cricket has to negotiate with the other activities to claim public spaces. The heightened competition and the lack of availability of spaces makes the cricketspaces a transitory affair, that is, they appear over spaces for short duration and disappear after the games get completed. The landscape of cricket is established in the Indian cities through the utmost zeal and compassion for the game that exists within people. The making up of cricketscapes takes root from the home spaces itself. It is the immediate surrounding of children that makes them take up the game. This is evident from a field interview of Vijay Bharti who narrates the reasons behind him playing the game.

My elder brother was a cricket fanatic. He inspired me to take up the sport. He was an excellent bowler which helped me improve my batting skills. I would play cricket at the terrace, garden and the street outside my residence. The whole family watched cricket on television and we would cheer for India. (Vijay Bharti, Professional Cricketer, 26)

The transition from home to public spaces comes naturally to children as they grow up. Pursuance for better skills and a space to showcase their talent, makes the children occupy public spaces of the town. The case of Purnea is no different. Public grounds are present as archipelagos in the city. The choice for selecting a particular public ground is dependent on social connection, distance from home and a lack of sporting infrastructure at schools. The public spaces are inclusive and give way to people from all backgrounds beyond race, caste, class and age. Vijay Bharti's narrative elaborates on this account of preference of a public ground.

The Rangbhoomi Maidan is nearest to my house. As a child I would visit the ground but there were not many people of my age. So, I had to play with elder people. These people were also the friends of my elder brother so I always got a chance to represent myself. Later I encouraged my friends from school and neighbourhood to join me at the ground. It was problematic for us in the beginning as elder people would push us out from the ground. We had no choice as our schools lacked sporting facility as well as other grounds were too far for everyone to reach. Hence we used to shift to corner areas of the ground to play the game. Slowly we made it to the centre part of the ground by developing contacts with elders and gathering more people. (Vijay Bharti, Professional Cricketer, 26)

Location and social connection emerge as the two most dominant factors in the selection of a particular ground. Similar evidences were reflected with people playing the game in other grounds in the city. This was seen with the young police recruits joining the police academy in Purnea, would play cricket in Police Lines ground, students from district government school occupying Zila School Ground after classes, people living outskirts of the town playing the game at Polytechnic Ground located in their vicinity. A map of popular public grounds often used for cricket are shown in the map below.

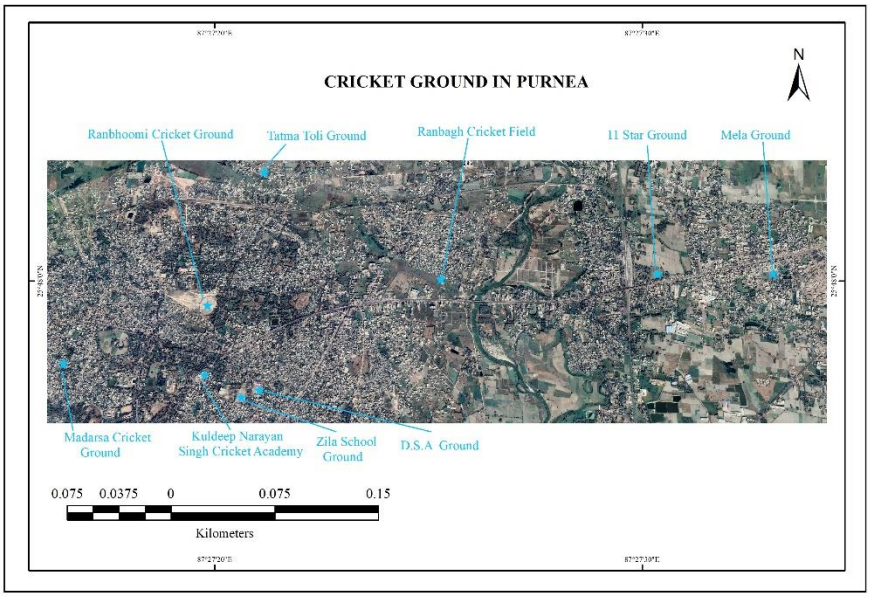

Fig 1: Popular Cricket Grounds in Purnea (Source – Google Earth)

The activity of cricket is widespread in the cities of India. They are borne out of the home spaces itself thorough television, advertisements, social infrastructure among friends and family. Further the activity of cricket is taken to the public ground where the game is developed through social ties. In this way, cricket becomes a dominating prospect of the landscape of the city.

5. Dynamics of the landscape

In the last section we looked at the way cricket landscapes come to be in the cities from the perspective of an individual. This section looks at the dynamics of the cricket landscapes at the scale of the ground. The incidence of organised cricket tournaments on the pubic grounds establish a microcosm of cricket landscape. These tournaments are amateur in nature but shape the functionality of public grounds. It provides a medium to people from different parts of the town to come together and share a competitive space. The process of organising a tournament involves issuing a prize money for the winning team and a participation fee. This is followed by teams registering for the event. Matches occur on the scheduled days which can last up to

a week. The tournaments are a crucial juncture where the city and the sport of cricket meet. It provides an opportunity for individual cricket players to show their skills on the scale of the city and an earn a name for themselves. This is evident from the interview of Aatish Anand, a popular cricketing figure in the town.

I have been playing cricket in the organized tournament for a long time. This gives me an opportunity to generate some money for my pocket expenses, also improves my image in the town. A lot of people, especially youngsters, know me. I love this game and I play all the matches with the intensity to win. It provides me an escape from my everyday life and provides me with a sense of belonging with the people and place I am playing. (Aatish Anand, 24)

Thus, the spaces of cricket are an important site for enragement of people in the town. At the same time, the tournaments attract enterprises and business from the town and provides them an opportunity to advertise their products. The sponsors are localised in their purview hence, the impact of cricket landscape can be seen beyond the space it is played. Observations from the field reflect these nuances of externalities effect induced by cricket matches.

The matches have begun and a large number of people have gathered to watch it. This is surprising considering the level at which the matches are taking place. The match is between the teams Purnea Super Kings and Team Aditya Vision. The first team is inspired from the Indian Premier League Franchise, Chennai Super Kings, and has players from all around the city. The second team has people working in the Aditya Vision shop which is the largest retailer for electronic goods in the town. Other sponsors include shops of mobile phones, clothing stores and automobiles located in different regions of the city. Bill boards, hoarding and pamphlets along with local hawker stalls have begun surrounding the playing area.

Hence, when the match is into play, the landscape is transformed into an entity that has a definite role in the city with regard to people-to-people contacts, economic functions and development in the cultural capital. It is important to note that even these transformations brought by tournaments are transient in nature. Once the tournament is over the landscape returns to its original function as a routine open public space. The picture below showcases post-match celebration of a cricket team

Fig 2: Winners of Amateur Tournaments organized at Rangbhoomi Maidan, Purnea
Source – Field Survey (28th August, 2020)

Cricket is itself a product of the Indian culture and is dominantly reflected onto spaces of everyday life in spaces of home and public at towns and cities of India. The next section looks into these interconnections in detail.

6. Scales

Cricket as a cultural activity in the smaller towns of India becomes a norm to replicate the sporting culture produced at the national level. Cricket finds its place in the Indian culture as a measure against the British colonial power, struggle for independence, economic reforms in the country and as an emergence of a global power. The progress of cricket and India runs parallel to each other and it has been extensively dealt through historical and sociological lenses. This paper looks at the geographical account of cricket in India in the context of changes it has brought to the landscape of the smaller towns in India. The major reason to justify the overwhelming presence of cricket in the public grounds of India emerge from the aspirations of people from smaller towns. While the issue of cricket nationalism inspires people to take up the sport others play the game as a means for entertainment. However, they do not find any other sport which attracts as much people as cricket. Hence, cricket becomes as one of the few means to develop social contacts and find a place in the society.

We have been fed cricket right from our childhood. Even in my childhood pictures I have posed with a bat in my hand. As far as I am concerned there is no other sport that attracts the level of enthusiasm as cricket does. The only reason we switch to other sports in due to the unavailability of cricket. For example, if it rains too much, we play football and if gets too dark we play badminton by switching the street lights on. Everyone has a bat or a ball at their homes, but you would rarely find football or badminton rackets with people. Cricket has dominated the sporting realm of India because of what we see on television, news and radio. It is because of these reasons we take cricket as the only sport and an aftereffect of this subconscious decision is reflected on the fields where the games are played. (Divyanshu Jha, 24)

The role of the District Cricket Association (DCA), Purnea also needs to be accounted for establishing cricketscapes in the town. DCA is the nodal agency responsible for the development of cricket in the district. The expenses of DCA are carried out by the Board of Cricket Control in India (BCCI). The responsibilities of DCA include, organising official tournaments for scouting talent, maintain infrastructure for sports and promoting a sports culture in the region. Rajeev Kumar, the elected president of DCA talks about the recent developments of sports infrastructure in the region with the help of increased funds from BCCI. His narrative mentions the developments in DSA grounds, Purnea which happens to the official ground for cricket in the town. Fig 2 gives insights on the working of DCA meetings headed by Rajeev Kumar.

Purnea has witnessed a drought for a long time when it comes to cricket players. We have not been able to produce cricket players from this region. But this situation is about to change in the upcoming years. With improved infrastructure qualities like green turf surface and coaching facilities, the aspirations of the players have increased. The selection criteria is purely based on talent and there is no discrimination when it comes to selection. There was a time when people from this region had to migrate to cities like Delhi and Mumbai to try their luck in cricket but nowadays, they can receive the same facitilities here. For many years the Bihar Ranji Team was defunct because of political reasons, now that Bihar Ranji has resurfaced, it is optimum time for development of cricket in this region. I am very optimistic about growth in near future. (Rajesh Kumar, DCA Persident).

The infrastructural development in the region is bound to strengthen the cricketscapes of the town with more people actively taking part in the game. the development of institutional cricket has induced a positive feedback on the mindset of people who are now willing to take the sport as a career option. This is evident from an interview with a young fast bowler who is also part of the district cricket team.

I have always wanted to play cricket and I like bowling a lot. There is plenty of

opportunity for me in Purnea. I get to ball with a new ball in every practice session which has improved my bowling style. I just need to perform consistently in order to get selected. (Harsh, 16)

Fig 3: DCA Meeting (23rd August, 2020)
Source – Field Survey

Hence, the institutional framework for cricket has changed the cricketscapes in a positive manner. Affirmative action by the government and increased awareness about sports in the household has furthered the scope of cricket as well as other sports in the region.

7. Discussion

The paper explores the various facets of the existence of cricketscapes over public grounds of India by taking the case study of Purnea. The evidences in the form of semi-structured interviews and observations put lights on the genesis of cricketscapes, their existence in the town and the interconnection with the national level sports policies. The first section talked about the way in which cricketscapes are established at the very first place. The narrative of a professional cricket player gives an idea of development of affinity towards cricket at the level of the household. Furthermore, location and social connection enables a child to access the level of a public ground where he becomes a part of the cricketscapes. At the level of the ground there are several people occupying the public space at the same time. Cricket is played through negotiations and contestations for space. It is the combined lived experience of all players in the ground that give rise to a cricketscapes at the level of the town. The second section talks about an interesting aspect of cricketscapes through the amateur tournaments that are held in the town. It is the amateur tournaments which make the cricketscapes visible in the city. the players participating in the tournament see it as an opportunity to thrust their image in the town as well as access a platform for his representation. The externalities effect created by the tournament is evident from the observations taken in the field. The site at which cricket tournaments are occurring attract enterprises and business. The field gets transformed into a microcosm of economic and social sphere with distinct functions in the town. The last section mentions the ties with the sporting culture and policies at the national level which help in bringing positive changes in the cricketscapes of the town. The narrative of a cricket follower gives insight into the reason for the domination of cricket over the public grounds. The comments by the DCA president and a cricket player gives account of the development of cricket infrastructure that has occurred in recent times. Both project an optimistic future for cricketscapes in the region. Thus, the development of cricket spaces begins right from the spaces of home which motivates a child to take up the sport. As

the child grows up tends to move to public grounds to improve skills and social connections. This is the first level at which cricketscpaes are visible with large number of games occurring at the same time. A special aspect of public grounds are the tournaments which act as nodes in the town to attract enterprises and make cricketspaces evident in the town. Further, connection with national ties established cricketscapes by strengthening the domination of cricket over public spaces through policies and affirmative actions.

8. Conclusion

The paper draws the concept of sportscapes as described by John Bale (2005) and applies it to the game of cricket. It comes up with the concept of cricketscapes and defines it as spaces in the city constituting of public grounds, parks and stadiums which are occupied by people involved in playing the game. An ethnographic field of enquiry consisting of semi-structured interviews and observation gave depth to the micro-level study of cricket. The explores the literature gap that exists in geography as well as the landscape studies. Within the subject matter of geography sports has rarely been addressed as a spatial phenomenon. Also, the studies related to cricket have an orientation towards historical and sociological consequences of the game. Looking at the game through the lens of geography helps us uncover the varied spatial phenomena in terms of third space, lived experience, everyday life and landscape study. Even in the ambit of landscape study material and physical items realm has been in prime focus. The creation of landscape through human assemblage and induced patters over space has rarely been studied. The paper brings forward the case study of cricket in Purnea to provide knowledge about the way public spaces are appropriated and landscapes are produced through human actions on space. Altogether, this paper brings forward how the cricketscapes are produced, appropriated and contested through the level of home, public grounds, the city and national structures of culture, politics and social infrastructure.

References

1. Appadurai, A. (1995). Playing the Modernity: The Decolonisation if Indian Cricket. University of Minnesota Press.
2. Bale, J. (1981). Geography, Sport and Geographical Education, Geographical Association.
3. Bale, J. (1989). Sports Geography, Taylor and Francis.
4. Bale, J. (1993). Sport, Space and the City, Routledge.
5. Bale, J. (1994). Landscape of Modern Sport, Leicester University Press.
6. Bale, J. (1996). Space, Place and Body Culture: Yi-Fu Tuan and a Geography of Sport, Taylor and Francis.
7. Bale, J. (1998). The Stadium and the City, Keele University Press.
8. Bale, J. (2003). Sites of Sport: Space, Place and Experience, Ebrary.
9. Bose, M. (1990). A History of Indian Cricket, Andre Deutsch.
10. Desia, A. and Maharaj, B (2020). South Africa's race to return to global sport: results and prospects on home-ground – the case of cricket, Sport in Society Cultures, Commerce, Media, Politics
11. Fletcher, T (2015) Cricket, migration and diasporic communities. Identities, 22 (2). 141 - 153. ISSN
12. Greenfield, and Osborn. (1997). Enough is Enough: Race, Cricket and Protest in the UK, Taylor and Francis.
13. Guha, R. (1998). Cricket and Politics in Colonial India, Oxford University Press.
14. James, C.L.R. (1963). Beyond the Boundary, Hutchinson.
15. Kaufman, and Patterson. (2005). Cross-National Cultural Diffusion: The Global Spread of Cricket, American Sociological Association.
16. Koch, N. (2017). Critical Geographies of Sport Space, Power and Sport in Global Perspective, Taylor and Francis Group

17. Maigaard, P. (1941). Battingball Games, Universita degli Studi di Roma.
18. Majumdar, B. (2002). The Vernacular in Sports History, Economic and Political Weekly.
19. Mannathukkaren, N (2001). Cricket and the 'Nation': The Silences of 'Lagaan'. Economic and Political Weekly.
20. McCarthy, C. (2009). The Future in the Present: The Status of Sport and Intellectual Labour. Peter Lang AG.
21. Morgan, R. (1976). Rain Starts Play, The Royal Geographical Society.
22. Palang, H. & Fry, G. (2003), Institute of Geography, University of Tartu, Estonia, Institute of Landscape Planning, Norwegian Agricultural University, Norway
23. Rinehart. R. (2010). "Performing" Sport: Re-visioning Sport Practices in an Age of Global Discord. University of California Press.
24. Rooney, J. (1992). Atlas of American Sport, Macmillan Publishing Country.
25. Roy, B. (2003). Cricket's Social Subtext, India International Centre.
26. Sandiford, K. (1982). Cricket and the Victorians: A Historiographical Essay, Berghahn Books.
27. Stoddard, B. (1988). Sport, Cultural Imperialism and Colonial Response in the British Empire, Cambridge University Press.
28. Storey, D. (2011). Sport and Geography, Geographical Association.
29. Tambe, and Tambe. (2010). Cheerleaders in the Indian Premier League. Economic and Political Weekly.
30. Waithe, C. (2015). Professional cricket migrants 'going Down Under': temporary, skilled, international migration?
31. Walvin, J. (1984). Sport, Social History and the Historian, British Journal of Sports History.
32. Williams, J. (2002). Equal Opportunity Cricket, Slate Group, LLC.
33. Wise, N & Kohe, G. (2020). Sports geography: new approaches, perspectives and directions, Sport in Society, 23:1, 1-10,

The Evolution of the Temporal and Spatial Pattern of Foreign Trade in Heilongjiang Province since the Reform and Opening Up

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Abstract. The approval of the China (Heilongjiang) Pilot Free Trade Zone has given Heilongjiang Province's international trade new life. As a border province, Heilongjiang Province performs the significant mission of China's opening up to the north in the "One Belt, One Road" strategy. The evolution of Heilongjiang Province's international trade patterns across time and space, as well as its trade structure characteristics, are investigated using H-P filtering. According to the study: (1) there is a gradual shortening of the foreign trade cycle's fluctuation interval and an increase in its amplitude, and (2) the growth of foreign trade since reform and opening up can be divided into four stages: high-speed development period, initial adjustment period, rapid development period, and adjustment and recovery period; (2) The main import trading partner is Europe, and the import concentration is gradually increasing. The scope of trade space is continuing to expand, and the trade direction is influenced by the "One Belt, One Road" strategy and global oil and gas trade relations; (3) The transition of major export trading partners from Asia to Europe, the concentration of exports showed a slow downward trend; (4) (3) Products with high labor and capital inputs make up the majority of export commerce; resource- and labor-intensive products make up the majority of import trade.

Key words：Foreign trade;Temporal and Spatial Pattern;Trade structure;Commodity structure;Heilongjiang Province

1. Introduction

China's economy has experienced decades of rapid growth since the reform and opening up, dependent on foreign trade, and has gradually developed a multi-level pattern of opening up from the coast to the riverbank, from the east to the central and western regions[1]. The scientific question of the overall pattern of international trade has been extensively studied by academics as China's level of opening up to the outside world keeps improving. The Heilongjiang Province, which guards China's northern border and is situated in the heart of Northeast Asia, is a crucial land route connecting Asia and the Pacific to Russia and the European continent. Due to its proximity, there is a high concentration of regional trade[2], and foreign trade benefits from this in particular. The Vision and Actions for *Jointly Building the Silk Road Economic Belt and the 21st Century Maritime Silk Road*, jointly released on March 28, 2015 by the National Development and Reform Commission, the Ministry of Foreign Affairs, and the Ministry of Commerce, served as a global strategy for China's further opening up in the new era. It promoted the transformation of China's regional structure of opening up to the outside world and made significant changes in China's foreign trade[3]. Heilongjiang Province has increased its regional strategic importance under the "One Belt, One Road" initiative as the window and boundary of China's opening up to the north. The China (Heilongjiang) Pilot Free Trade Zone was established on August 2, 2019, giving Heilongjiang's international trade new historical prospects and development space. Studying the spatiotemporal characteristics of Heilongjiang Province's foreign trade development since the reform and opening up, determining the province's foreign trade's development context, the structure of its import and export commodities, and identifying the key areas of its foreign

trade that are crucial for the creation of the Heilongjiang Free Trade Zone and the promotion of its exports are all important in this context.

To study the pattern of foreign trade, relevant research primarily employs the geographical concentration index of import and export trade, the trade intensity index, the dominant comparative advantage index, the trade combination index, the trade gravity model, social network analysis, and other techniques[4-10]. The influencing factors of foreign trade were investigated using the spatiotemporal geographical weighted regression model and multiple linear regression [6]. Regarding study topics, the majority of pertinent studies [4-25] concentrate on the phased characteristics of international trade volume, intraregional group structure, inter-regional variations, import and export commodity structure, and import and export country structure. According to study, the "One Belt, One Road" strategy, free trade zones, and other opening up strategies and policy areas [5,8,10,11,13-15] are the main foundations of the pertinent research, which also offers matching recommendations and preventative actions. When it comes to research subjects, scholars have studied issues on a variety of levels, including the national [4-7, 9-10, 16, 17], regional [18-21], and provincial [12-15]. Some researchers have also examined the foreign trade patterns of particular industries, such as the ITC, natural gas, marine energy, high-tech, etc. [22-25].

Although the size and structure of international commerce in Heilongjiang Province have generally been analyzed, there are certain gaps. In terms of research time scale, the majority of studies concentrate on short and medium time series [5,21-25] and a particular time node [18-20], omitting the evolution of foreign trade patterns with long-term sequences, and the research time is early, making it impossible to demonstrate changes in recent years. Regarding research content, it focuses on two areas: first, it examines the growth pattern of Heilongjiang Province's foreign trade volume and the evolution characteristics of trade structure, and assesses the comparative advantages, terms of trade, relative export performance, trade efficiency, etc. [26-28]; second, it examines the economic effects and impacts of foreign trade and looks at the connection between foreign trade[29-30] and economic growth[31] in Heilongjiang. One of them is the lack of a more thorough classification of commodities in the research of trade structure evolution in Heilongjiang Province, and the significance of the structural evolution features.

In this context, the multi-year evolution characteristics of Heilongjiang Province's foreign trade from 1978 to 2019, the distribution characteristics of trading partners, and the characteristics of trade commodity structure are analyzed. Based on the data of Heilongjiang Province's foreign trade volume, import and export countries, and import and export commodities, through H-P filtering and trade integration index.

2. Research methods and data sources

2.1. Research Methods

H-P filtering

P filtering is a technique for separating the long-term trend part and the cyclical fluctuation part from the macroeconomic data of the time series[32], while foreign trade, as an economic activity, alternates between the recovery stage and the recession stage in the time series[36], identifies the evolution trend and cyclical fluctuations of import and export trade volume since Heilongjiang Province's reform and opening up, and grasps the development law of the province. The future steady growth of Heilongjiang Province's international trade is critically important. The equation is:

$$Y_t = Y_t^c + Y_t^g \quad (1)$$

$$\{Y_t^g\}_{t=0}^{T+1} = \min \sum_{t=1}^{T} \left\{ \left(Y_t - Y_t^g\right)^2 + \lambda \left[\left(Y_{t+1}^g - Y_t^g\right) - \left(Y_t^g - Y_{t-1}^g\right) \right]^2 \right\} \quad (2)$$

where Y_t stands for a time series, Y_t^c for the periodic elements removed from the time series, Y_t^g for the growth factor removed from the time series, which is the answer to the $\{Y_t^g\}_{t=0}^{T+1}$ minimization problem, λ for the weight of long-term trends and cyclical fluctuations, and t = 1, 2, 3,..., n for the sample size. Chinese academics have studied λ values, and it is known that the value of λ=6.25 is best for analyzing the economic cycle of China's annual data [33]. Using the natural logarithm of Heilongjiang Province's total foreign trade since reform and opening up, the time series is smoothed.

2.2. Data Sources

The statistics come from the UN Comtrade database, *the Heilongjiang Statistical Yearbook*, and the China Statistical Yearbook. Among these, the Heilongjiang Statistical Yearbook was established in 1987, and statistics on the principal commodities in various nations (regions) as well as the total volume of items imported and exported have been published since 1986. The total import and export volume of goods by country (region) is used to explore the spatial pattern of Heilongjiang Province's foreign trade, the import and export volume of major commodities is used to analyze the structure of import and export commodities in Heilongjiang Province, and the foreign economic and trade data are used to analyze the multi-year evolution characteristics of Heilongjiang Province's total foreign trade from 1978 to 2020. It is statistically significant to use the data of major commodities in Heilongjiang Province to examine the structure of import and export commodities. The export (import) amount of major commodities accounted for 58.68 %, 79.94 % (78.19 %), 60.09 % (99.58 %), and 48.71 % (95.18 %) of the export (import) value of the main commodities in 1996, 2006, 2016 and 2019, respectively. The study [35] by Yang Rudai and Zhu Shi'e separates commodities into four product groups, of which technology-intensive items are categorized in accordance with the Classification of High-tech Industries (Manufacturing) (2017). (Table 1).

Tab.1 Classification of foreign trade import and export commodities in Heilongjiang Province

classify	Representative products	SITC Code
Resource-intensive products	Primary products such as logs, pulp, vegetables, grains and manufactured products based on raw materials	SITC0、SITC2（Not included SITC23、SITC26）、SITC3、SITC4、SITC6（Just Include SITC61、SITC64）
Labor-intensive products	Textiles, clothing, footwear products, simple metals, processed food products and plastic products	SITC1、SITC2（SITC26）、SITC6（Not included SITC61、SITC64）、SITC8（Not included SITC87、SITC881、SITC882、SITC883、SITC884）
Capital-intensive products	Automation products such as automobiles, processing industrial products such as steel, rubber, and chemicals, and engineering products such as machinery	SITC2（Just Include SITC23）、SITC5（Not included SITC54）、SITC7（Not included SITC72、SITC75、SITC76、SITC78、SITC79）

Technology-intensive products	Electronic and telecommunications products, as well as high-tech products such as medicine, medical equipment, and optical instruments	SITC5（Just Include SITC54）、SITC7（Just Include SITC72、SITC75、SITC76、SITC78、SITC79）、SITC8（Just Include SITC87、SITC87、SITC881、SITC882、SITC883、SITC884）

3. Features of Heilongjiang Province's spatiotemporal pattern of foreign trade scale

3.1. Features of the multi-year evolution of the amount of international trade

Using H-P filtering, the development trend of Heilongjiang Province's international trade is divided into long-term trend sequences and cyclical fluctuation sequences from 1978 to 2019. (Figure 1).

According to the cyclical fluctuations in Heilongjiang Province's foreign trade volume over time, using the "valley-valley" division method, which counts the time between one fluctuation's lowest point and the next lowest point as a cycle, the growth of foreign trade in Heilongjiang Province since the reform and opening up can be divided into five medium cycles: the first cycle from 1978 to 1989; the second from 1989 to 1998; the third from 1998 to 2009; and the fourth from 2000 to the present. It can be seen from the start and end times of the five major cycles obtained by using H-P filtering that the fluctuation characteristics of Heilongjiang Province's foreign trade are: the cycle fluctuation interval is gradually shortened, and the fluctuation amplitude is gradually expanded; Cyclical fluctuations are primarily affected by the foreign trade policies, economic conditions, and global financial crisis of major partners.

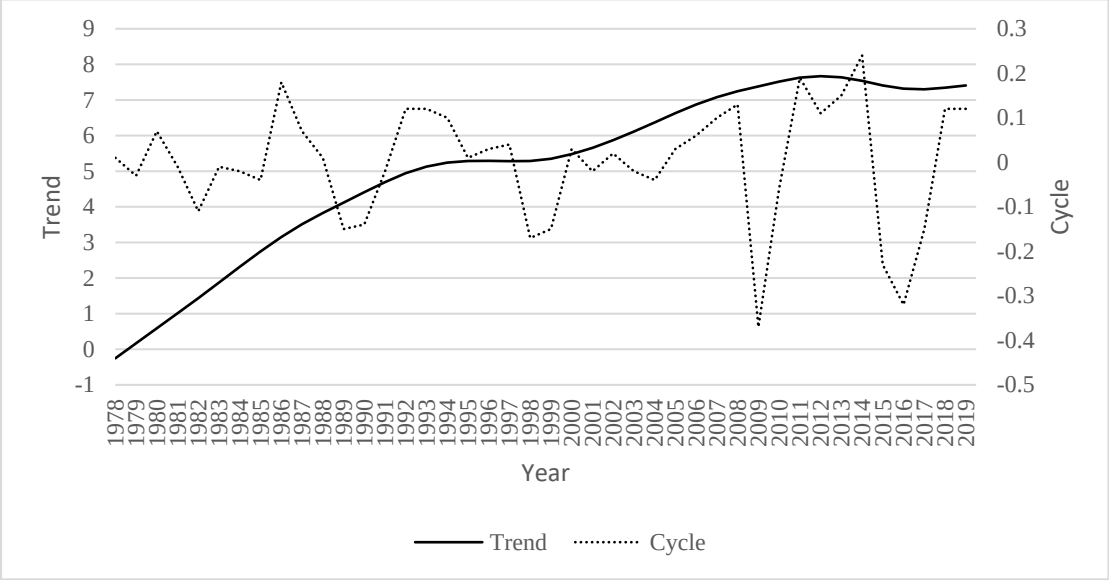

Fig.1 Multi-year trend and cyclical fluctuation of foreign trade volume in Heilongjiang Province

According to Figure 2, between 1978 and 2019, Heilongjiang Province's total import and export volume increased from US$0.5 billion to US$27.1 billion, with an average annual growth rate of 16.6%, exceeding the country's average annual growth rate (14.09%). The import volume eventually surpassed the export volume, and the proportion of the nation's total foreign trade showed a downward trend. Among them, the overall amount of imports and exports peaked in 2014, making up 0.74 % of all foreign trade conducted by the nation; Imports have grown from US$0.3 billion to US$22.03 billion, with an average annual growth rate of

17.46 %. While exports have climbed greatly but have fluctuated, they have lagged behind imports over time and have continued to fall after 2010.

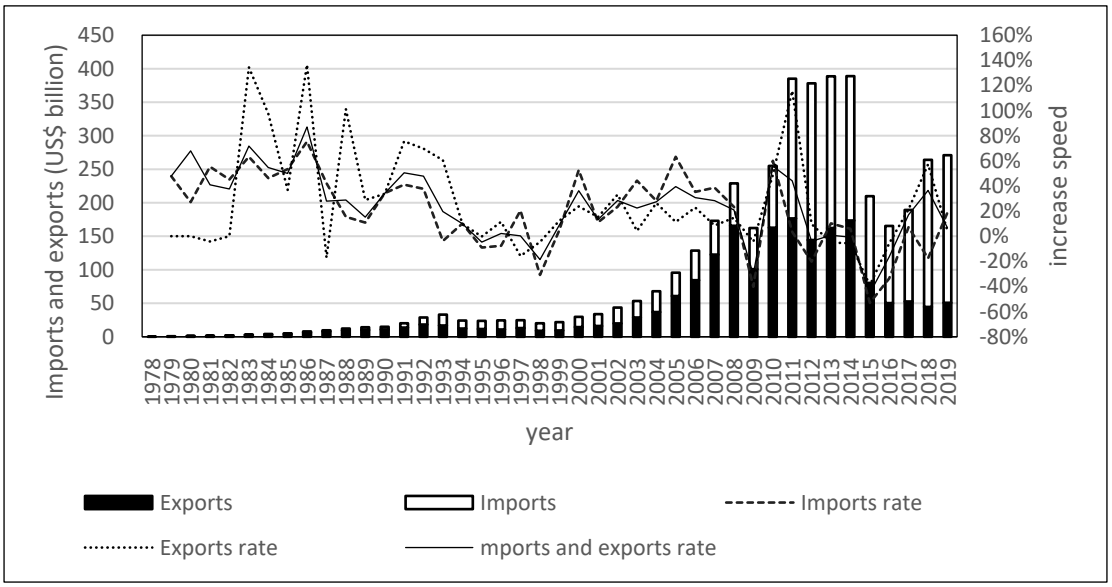

Fig.2 Export and import volume of Heilongjiang Province from 1978 to 2019

The development of international commerce in Heilongjiang Province has generally displayed a phased growth tendency from the perspective of long-term development trends. From 1978 to 1993, Heilongjiang Province experienced the first stage of rising foreign trade development, during which the volume of foreign trade increased significantly. From 1994 to 1999, the province experienced the first stage of steady development, during which the volume of foreign trade did not increase significantly. From 1999 to 2010 saw the second phase of ascent, and from 2011 to 2019 saw the second stage of stable development in Heilongjiang Province. The growth of Heilongjiang Province's foreign commerce since the reform and opening up may be split into four stages, according to the multi-year change pattern of the province's total foreign trade:

(1) Rapid development era (1978-1993). The average annual growth rate of foreign trade volume in Heilongjiang Province was 41.88 %, which was 15.95 %age points more than the national average (25.93 %). The development of China's foreign economic and trade has entered a period of prosperity during this time due to the fundamental national policy of opening up to the outside world and the formulation of a number of policies to promote foreign trade, and Heilongjiang Province achieved an average annual growth rate of 56.45 % from 1978 to 1986. The 1987 US stock market crash set off a global economic crisis that had a direct impact on the expansion of foreign trade in Heilongjiang Province, with import and export growth rates in 1987 and 1988 falling to 27.96% and 28.82%, respectively. Following the State Council's 1988 publication of the "Reply on the Question of Heilongjiang Province's Barter Trade and Economic and Technical Cooperation on the Soviet Border," which provided preferential policies for the development of border trade in Heilongjiang Province, the province's development of foreign trade gradually picked up, and the growth rate of import and export increased.

(2) Initial time of adjustment (1994-1999). The average annual growth rate of foreign commerce volume has dropped to -2.84 % in Heilongjiang Province, where the development of foreign trade is sluggish. This is because Heilongjiang Province's trade advantages with Russia weakened, the growth rate of imports and exports declined, and the total import and export volume decreased by 4.67 % in 1995. This is because in 1993, Heilongjiang Province's main trading partner Russia started implementing the foreign trade export commodity quota

and licensing system, which caused the cost of import and export commodities to increase. The entire import and export volume of Heilongjiang Province decreased by 18.48 % in 1998 compared to the previous year as a result of the Asian economic crisis that began in 1997.

(3) Rapid growth phase (2000-2010). With an average annual growth rate of 21.46 %, Heilongjiang's foreign commerce has expanded quickly, outpacing the national average annual growth rate (48.10 %) in the same time period by 26.64 %age points. Following China's WTO membership, the province of Heilongjiang's total foreign trade increased from 0.70 % in 2002 to 0.89 % in 2008, with exports rising from 0.61 % to 1.16 % and imports falling from 0.8 % to 0.56 %. The trade surplus grew over time, and the level of dependence on foreign nations was relatively high.

(4) Modification of the recuperation time (2011-2019). The growth rate of foreign commerce in Heilongjiang Province has drastically slowed down, and the trade imbalance has persisted. The annual growth rate of foreign trade volume has dropped to -3.38 %. Among these, the amount of foreign commerce remained at a high level of more than 35 billion US dollars from 2011 to 2014. However, following the Republic of Crimea's secession from Ukraine and admission to the Russian Federation in 2014, European and American nations slapped economic sanctions on Russia[4], which had an immediate impact on Russia's commerce with China. Due to this, Heilongjiang's total international commerce has significantly decreased, falling to US$16.54 billion in 2016, down 57.58 % from 2014, and the share of national foreign trade has decreased to 0.45%. Meanwhile, international trade remained sluggish as trade protectionism and unilateralism increased[5]. As a result, the growth of foreign trade in Heilongjiang Province was hindered. In 2018, Heilongjiang Province's total import and export volume recovered to 26.41 billion US dollars, but the recovery pace was slow in 2019 as the total import and export volume only climbed by 6.76 %.

3.2 Characteristics of the spatiotemporal pattern of foreign trade partners

Intercontinentally speaking, since reform and opening up, Europe has replaced Asia as Heilongjiang Province's primary export trading partner, with the export concentration showing a slow downward trend; Europe has replaced Asia as the province's primary import trading partner, with the import concentration rising year after year (Table 2). During the period from 1986 to 2019, Heilongjiang Province changed from exports to Asia to Exports to Europe, and the proportion of exports to Asia and Europe fell from 95.87% to 85.93%, and the export concentration declined; The pattern of import trade in Heilongjiang Province dominated by Europe has been strengthened, the gap between the proportion of Europe and Asia has increased, and the concentration of imports has increased significantly. Specifically, in 1986, The main export trading partners of Heilongjiang Province were Asia (64.44%), followed by Europe (31.43%). From 1986 to 1996, the intercontinental pattern of foreign trade in Heilongjiang Province did not change much, and Asia was still the main export market, but the proportion of exports to Asia fell to 55.43%, exports to North America rose to 9.73%, and trade concentration weakened; Europe (60.51%) became the main import market. Exports from Heilongjiang Province climbed to 60.92 % of total exports to Europe between 1996 and 2006, while exports to Asia decreased to 27.09 %. The primary export market shifted from Asia to Europe, and it eventually became clear which features of the import trade pattern dominated by Europe. The difference in exports from Heilongjiang Province to Europe and Asia steadily closed between 2006 and 2019, and the export concentration fell; Europe was

[4] [Xinhua net [EB/OL]]. Rupee exchange rates fell [source: http://www.xinhuanet.com/world/2014-07/17/c 1111665578.htm, 2014-07-17.]
[5] [Ministry of Commerce of the People's Republic of China [EB/OL].http://trb.mofcom.gov.cn/article/zuixindt/201803/20180302723654.shtml, 2018-03-26.]

the largest trade partner for imports (81.41%), and the features were improved, and the import concentration was high.

Tab.2 Intercontinental characteristics of import and export volume in Heilong-jiang Province

continent	1986	1996		2006		2016		2019	
	Exports	Exports	Exports	Imports	Exports	Imports	Exports	Imports	Exports
Asia	64.44%	55.43%	31.25%	27.09%	25.69%	36.23%	10.82%	39.53%	8.82%
Africa	0.09%	0.75%	0.11%	4.36%	0.21%	3.42%	1.27%	2.46%	0.74%
Europe	31.43%	33.12%	60.51%	60.92%	60.65%	43.90%	72.63%	46.40%	81.41%
Latin America	0.70%	0.59%	1.72%	1.78%	2.13%	5.46%	8.05%	3.28%	4.16%
North America	3.00%	9.73%	6.41%	5.33%	10.90%	7.69%	6.75%	6.48%	1.64%
Oceania and the Pacific Islands	0.34%	0.38%	0.00%	0.52%	0.42%	3.30%	0.48%	1.85%	3.23%

Note:The table contains facts and statistics from the Heilongjiang Statistical Yearbook of 1987. This yearbook lacks statistics on foreign commerce importing nations and areas, making it impossible to calculate intercontinental data.

Tab.3 The top 20 trading partners of import and export volume in Heilongjiang Province

ranking	1986		1996		2006		2016		2019	
	Exports	Imports	Exports	Imports	Exports	Imports	Exports	Imports	Exports	Imports
1	Hong Kong	Japan	Japan	Russia	Russia	Russia	Russia	Russia	Russia	Russia
2	the Soviet Union	Hong Kong	Russia	Korea	Hong Kong	Saudi Arabia	America	Brazil	Hong Kong	Saudi Arabia
3	Japan	Federal Republic of Germany	Korea	Japan	America	America	Turkey	America	America	Brazil
4	North Korea	America	Hong Kong	Canada	Korea	Japan	Pakistan	Saudi Arabia	Korea	New Zealand
5	Indonesia	-	America	Germany	Japan	Germany	Japan	France	The United Arab Emirates	Australia
6	Poland	-	Vietnam	Uzbekistan	Sudan	Korea	Australia	Japan	Germany	America
7	America	-	Germany	Taiwan	Malaysia	France	Korea	Iraq	India	Iraq
8	Malaysia	-	Holland	Hong Kong	North Korea	Malaysia	India	Germany	Japan	Japan
9	Czechoslovakia	-	Britain	France	Taiwan	Italy	Hong Kong	The United	Spain	Germany

								Arab Emirates		
10	Federal Germany	-	Taiwan	Italy	The United Arab Emirates	Brazil	Singapore	Italy	Britain	France
11	Singapore	-	North Korea	Kazakhstan	Vietnam	Singapore	Germany	Canada	Holland	The United Arab Emirates
12	the Philippines	-	Singapore	Baxi	Germany	Argentina	The People's Republic of Bangladesh	Angola	Australia	Sweden
13	Britain	-	Thailand	Belgium	Holland	Canada	Ecuador	Columbia	Indonesia	Angola
14	Thailand	-	Malaysia	Singapore	Romania	Britain	Indonesia	Britain	Vietnam	Chile
15	Romania	-	Indonesia	Indonesia	Indonesia	Thailand	The United Arab Emirates	Spain	Turkmenistan	Korea
16	Pakistan	-	Italy	Venezuela	South Africa	Switzerland	Uzbekistan	Korea	Singapore	the Philippines
17	Australia	-	Spain	CZ	Britain	Austria	Sudan	Kuwait	Schadt Helfrich effect	Spain
18	Hungary	-	South Africa	Malaysia	India	Taiwan	the Philippines	Ireland	Canada	Israel
19	Cuba	-	Pakistan	Holland	Ukraine	Belgium	Holland	Mongolia	Belgium	Canada
20	Mongolia	-	France	Britain	Syria	Holland	Britain	Congo	Mexico	South Africa
					The sum of the top five					
	73.29%	79.70%	44.53%	59.46%	73.95%	80.93%	51.92%	83.60%	47.75%	87.70%
					The sum of the top ten					
	84.66%	-	50.04%	69.72%	80.12%	90.29%	65.49%	90.74%	62.70%	93.06%
					The sum of the top 20 %ages					
	99.03%	-	54.34%	74.93%	87.23%	96.33%	81.01%	96.19%	77.44%	96.41%

Note: *Heilongjiang Statistical Yearbook 1987* lacks statistics on foreign trade importing countries and regions, and the data comes from *Heilongjiang Yearbook 1978*。

Since the reform and opening up, the spatial and temporal distribution of Heilongjiang's foreign trading partners has demonstrated the following characteristics:

(1) Russia is the primary importer and exporter, and the trade volume of export trading partners exhibits the "dispersion-concentration-dispersion" development trend, with a notable trend toward diversification; the trade volume of imported trading partners is concentrated.

The trade volume of export trading partners exhibits a "dispersion-concentration-dispersion" development trend in terms of export trade. The former Soviet Union (19.66%), Japan (19.18%), and North Korea (6.66%) were just a few of the East European and East Asian nations (regions) that Heilongjiang Province relied on geographical advantages to establish relatively stable trade exchanges with in 1986. Hong Kong (21.13%) of China served as a special economy and the primary gateway for the mainland to connect with the global market, wh In 1996, Heilongjiang Province's exports to Russia decreased to 11.59 %, and its exports to Japan increased to 13.42 % of the total export value, taking the top spot. From 1996 to 2006, the proportion of Heilongjiang's exports to Russia rose to 53.79%, and the proportion of exports from the top 20 countries and regions increased from 54.34% to 87.23%. Additionally, the concentration of export trading partners increased, with a particular focus on Eastern Europe. Eastern Europe continued to hold the top export position between 2006 and 2019, but the export trade volume in West Asia, Oceania, and the Americas increased significantly, strengthening the degree of export dispersion. The proportion of the top ten countries and regions among export trading partners fell from 80.12 % to 62.7 %, and the top 20 countries and regions fell to 77.44 %.

Russia, the United States, and Saudi Arabia are the top import trading partners, along with the more recent additions of New Zealand, Australia, and Pakistan. The first spot belongs to Russia, whose dominance is steadily increasing, and import trading partners account for a disproportionate share of its trade volume. The %age of the top ten nations and regions climbed from 69.72 % to 93.6 % between 1996 and 2019, and the amount of import commerce became more concentrated. Noteworthy developments from 2011 include the official start-up of the Sino-Russian crude oil pipeline, improved trade ties between Heilongjiang Province and Russia, and an increase in the share of Russian imports in global imports from 70.24 % to 77.20 % from 70.24 % to 2019—all of which strengthened Russia's dominant position.

(2) Both the geographic reach of import and export commerce and the trade distance have increased.

In terms of export trade, there are now more export trading partners and stronger export trade ties with Asian nations and regions. Heilongjiang Province had 56 export trading partners in 1986, including 10 of the top 20 Asian nations and regions. Exports to Hong Kong, the former Soviet Union, Japan, North Korea, and Indonesia accounted for 66.63 % of total exports. From 1996 to 2006, there were 200 export trading partners, and Sudan and South Africa placed sixth and sixteenth in terms of the volume of export commerce, respectively. There were 169 export trade partners in 2016, and among the top 20 nations and regions, Uzbekistan, Turkey, and the United Arab Emirates were trading partners of Asian nations and regions, as were Pakistan, Bangladesh, and India in South Asia. Australia, an Oceania nation, climbed to sixth place. The number of export trading partners increased to 171 in 2019, the volume of export commerce grew, and the proportion of exports to Europe (46.40 %) surpassed that of Asia (39.53 %). Export trade to Europe is primarily for Russia, the United Kingdom, and Germany, and export trade to Asia has established some level of export trade links with other regions of Asia, including the United Arab Emirates (3.85 %), Turkmenistan (1.48 %), and Saudi Arabia, in addition to East and South-East Asian countries (1.33 %).

The number of import trading partners has grown, and the countries involved in secondary import commerce have changed often. Heilongjiang Province had 46 import trading

partners in 1996, with Russia accounting for 33.75 % of those partners and South Korea for 12.81 %. The number of import trading partners rose to 68 in 2006, with Saudi Arabia (10.23%) and the United States (10.16%) joining the list of less significant import trading partners. The number of import trading partners climbed to 94 in 2016, with Brazil (6.62 %) and the United States being the two smallest importers (5.97 %). There were 91 import trading partners in 2019, with Saudi Arabia (3.97 %) and Brazil being the next-largest import trade partners (3.30 %). The number of secondary import trading partners has fluctuated, ranging from East Asia to West Asia to North America and Latin America, and the trade distance has increased. As a result, the growth of import commerce has slowed.

(3) The "Belt and Road" strategy has an impact on export trade, while global oil and gas trade linkages have an impact on import commerce.

In terms of export commerce, the number of transactions with "Belt and Road" nations has grown, as has the amount of transactions, and the relationship between export trade and other trade has progressively gotten closer. A total of 36.47 % of exports were made in 1986 to the top 10 export trading partners along the route. Due to the shift in the foreign trade policy of Russia, a significant export trading partner of Heilongjiang Province, and the drop in export volume, 7 of the top 20 export trading partners along the route accounted for 15.66 % of the total exports in 1996. 8 of the top 20 areas and countries with export trading partners along the route climbed to 43.64 % of exports from 1996 to 2019.

The "Belt and Road" plan has a minor impact on import commerce, which is mostly impacted by global oil and gas trade links. Six nations were located along the route in 1996, and two of them were among the top ten, accounting for 36.77 % of all imports. Five of the top 20 countries and regions with import trading partners are now along the route, up from four in 1996. In addition to Russia, the top 20 nations and regions now include Saudi Arabia, Brazil, Iraq, Angola, and South Africa. Heilongjiang Province requires a lot of energy power to advance the "Ten Major Projects," the "Eight Major Economic Zones," and projects like the modern agricultural construction of the Songnen Plain and the Sanjiang Plain. As a result, the import demand for crude oil and other energy and mineral raw materials is rising, and crude oil imports made up 70.44 % of all imports in 2019.

4 Characteristics of foreign trade structure of Heilongjiang Province

4.1 Characteristics of export trade structure

Grain, oil, and food commodities are no longer Heilongjiang Province's primary exports; instead, the province now exports "miscellaneous products," "machinery and transportation equipment," and "manufactured products classified by raw materials," all of which fall under the SITC one-digit designation. In 1996, 2006, 2016, and 2019, it represented more than 60% of the primary export commodities. Grain, oil, and food have been replaced as the primary commodity kinds by (SITC two-digit code) "clothing and apparel accessories," "textile yarns, fabrics, and goods," followed by "road vehicles (including air-cushion vehicles)" and "Electrical Machinery, Instruments, and Utensils." Exports' share of labor-intensive goods fell, capital-intensive goods steadily overtook them, technology-intensive goods gradually increased, and the composition of export commodities was optimized (Table 5).

Tab.5 Top 10 main commodity types in of export value in Heilongjiang Province (SITC two-digit code)

Ranking	1986	1996	2006	2016	2019
1	Grain, oil and food	65	84	84	78
2	Textile class	84	85	33	77

3	Soil and livestock products	22	65	85	05
4	Coal class	05	83	65	65
5	Petrochemical class	54	75	05	67
6	Hardware mineral class	85	82	77	84
7	Light industrial products	04	05	82	85
8	Crafts class	67	58	67	82
9	Mechanical equipment	32	01	78	56
10	Medical and health care	69	04	56	89

Note: The caliber of statistical commodities in *heilongjiang statistical yearbook 1987* is different.

Resource-intensive and labor-intensive products made up the majority of Heilongjiang Province's export commodity structure during the early stages of reform and opening up. Grain, oil, and food goods made up 50.90% of Heilongjiang Province's export commodities in 1986, while textiles made up 12.000% of the total. In 1996, 33.04 % of the top ten largest export commodities were labor-intensive goods. It is important to note that although the industrial manufacturing sector in Heilongjiang Province has a strong foundation and the equipment manufacturing industry is a key construction project during the "First Five-Year Plan" and "Second Five-Year Plan" periods, the equipment manufacturing products are not the main import and export commodities.

The structure of Heilongjiang Province's exports, which primarily consist of light industrial goods like apparel, clothing accessories, and footwear, has changed since China's membership to the WTO due to fluctuations in the proportion of resource-based exports like vegetables and fruits. This is because, despite Heilongjiang Province having a great agricultural base, there is little processing done on "big but not strong" agricultural products, there is little added value to the products, and there is little international competitiveness[37]. The export situation for agricultural products has improved thanks to the promotion of modern green agriculture and agricultural industry clusters in Heilongjiang Province. The proportion of agricultural exports in exports increased from 6.04 % to 17.66 % in 2006–2019, and vegetables and fruits moved up from seventh to third in the ranking of major export commodities.

Since the Northeast Revitalization Strategy was put into place, Heilongjiang Province has focused on changing the industrial structure, fully using the benefits of the equipment manufacturing sector, and increasing the proportion of capital-intensive products in export commodities. Among them, apparel and clothing accessories, which accounted for 80.11 % of the primary export items in 2006, led Heilongjiang Province; In 2016, the proportion of labor-intensive products (52.87%) in export commodities declined, and the proportion of capital-intensive products (16.25%) increased slightly; Road vehicles, including air-cushioned vehicles, rose to the top spot in terms of capital-intensive products in 2019, and overall, the proportion of capital-intensive products in major export commodities (32.22 %) increased significantly. Labor-intensive products (38.99 %) remained at the same level as major export products, while resource-intensive products (20.76 %) were ranked second.

Technology-intensive products account for a far smaller %age of exports than other products, and growth is moderate. In 2006, 2016, and 2019, significant export commodities made up 7.29 %, 4.73 %, and 8.03 % of technology-intensive products, respectively.

4.2. Structural characteristics of import trade

Non-edible raw materials (except fuels), manufactured products classified by raw materials, and finished chemical products and related products were the main categories of imported goods in Heilongjiang Province (SITC single-digit code), and they were replaced by "animal and vegetable oils, oils and fats, waxes," "non-edible raw materials (except fuels)," "food and live animals," which accounted for 52.84 %, 91.92 %, and 92.63 % of Specifically, "fixed oils, crude oils, finished products or fractionation," "cork and wood," and "cereals and cereal products" are the three main commodity categories (SITC double digit code). In Heilongjiang Province, the categories of imported goods are progressively blending together, and it is amazing to see how the international trade import structure is dominated by resource-intensive goods (Table 6).

Tab.6 Top 10 main commodity types in Heilongjiang Province in terms of import value (SITC two-digit code)

Ranking	1999	2006	2016	2019
1	25	24	42	42
2	24	42	04	24
3	42	56	24	04
4	57	67	22	22
5	51	25	25	32
6	75	71	56	28
7	67	74	67	78
8	87	22	87	25
9	56	23	28	87
10	74	73	73	56

Note:The 1999 data from the *Heilongjiang Statistical Yearbook 2000* are utilized because the *Heilongjiang Statistical Yearbooks 1987* and *Heilongjiang Statistical Yearbooks 1997* do not have statistics on foreign trade importing nations and areas.

The import commodity structure of Heilongjiang Province is stable, with a focus on goods that need a lot of resources. Resource-intensive goods made up 42.78 % of imported goods in 1999 and capital-intensive goods made up 38.36 %. Resource-intensive products made up 56.19 % of imported goods in 2006, while the shift in capital-intensive products was negligible (36.82 %). From 2016 to 2019, the proportion of resource-intensive products rose to 96.04%, capital-intensive products fell to 2.93%, and technology-intensive products rose to 1.03%.The proportion of crude oil imports in Heilongjiang Province's total imports increased significantly in 2011, following the official start of the China-Russia crude oil pipeline, accounting for 68.21 %. Since then, the proportion of crude oil imports has continued to maintain a high share, accounting for 56.07 % and 70.44 % respectively in 2016 and 2019.

5. Conclusions and discussions

5.1. Conclusion

1) From the standpoint of international trade volume, heilongjiang province's foreign trade volume has generally fluctuated cyclically since the reform and opening up, with the

time interval of cyclical fluctuation gradually getting shorter and the fluctuation amplitude gradually getting larger. It can be broken down into four stages of development, according to the long-term trend, including the high-speed development phase, the first adjustment phase, the rapid development phase, and the adjustment and recovery phase. Overall, the volume of foreign trade in Heilongjiang Province has increased quickly but has experienced significant fluctuations. The import volume has gradually overtaken the export volume, the trade deficit has grown, and the province's share of the nation's total foreign trade has decreased to a low level.

2) In terms of trading partners, the primary export trading partners of Heilongjiang Province have shifted from Asia to Europe at the intercontinental level, and the export concentration has shown a moderate declining trend; Europe is the primary trading partner for imports, and import concentration is rising annually. Russia is the primary import and export trading partner at the national (regional) level, and the volume of export trading partners' trade exhibits a development trend of "dispersion-concentration-dispersion," with the tendency toward diversification being important; concentration of import trading partners' amount of trade; The area covered by import and export trade has grown, as has the trading distance; The "Belt and Road" strategy has an impact on export commerce, while global oil and gas trade relations have an impact on import trade.

3) From the standpoint of import and export commodity structure, Heilongjiang Province's export commodity structure is optimized, capital-intensive products have gradually become the main export products, and technology-intensive products have gradually increased; The types of imported commodities are gradually singled out, and the structure of foreign trade imports is remarkable, with resource-intensive commodities occupying a significant portion of the market.

5.2 Conversation

Since the reform and opening up of the H-P filter, Heilongjiang Province's foreign trade has experienced cyclical fluctuations that have grown more severe, especially in the wake of the effects of the economic downturn in Russia, its main trading partner. The foreign trade volume has also always grown slowly, and the trade deficit has widened. In response to external economic shocks, Heilongjiang Province should actively participate in the national development strategy, seize opportunities for the transformation and upgrading of foreign trade under the new normal, and transform to high-quality development; In light of the current state of the weak export market, Heilongjiang Province should strengthen its export competitiveness, actively engage in a higher level of international labor division, optimize the export industry structure, and support the transformation and upgrading of Heilongjiang Province's industrial structure by promoting the export added value [38].

In terms of the organization of import and export commodities, Heilongjiang Province should further increase the level of deep processing of export agricultural products, convert the province's agricultural products' advantages into export advantages, and improve the province's global competitiveness; further play up the advantages of the old industrial base, boost investment in innovation in the industrial manufacturing industry, and improve the province's global competitiveness.

References

1. LIU W, S-ONG Z, LIU H, et al. Regional development report of China, 2015. Beijing: The CommercialPress, 2016.
2. QI F, HE C, Zhang W, Evolution of geographical patterns of export trade and the expansion of Trade Network at the Provincial Level , Economic Geography, 2021,41(02):35-46.

3. LIU H,LIU W. Study on relationship between the belt and road initiative andregional development strategies of China. Bulletin of Chinese Academy of Sciences,2017, 32(4):340-347.
4. [4]YIN W，WU F. Evolut-ion of geographic concentration of Chinese export trade [J]. World Regional Studies, 2017,26(6):40-48.
5. [5]ZOU J, LIU W. Trade network of China and countries along Belt a-nd Road Initiative areas from 2001 to 2013. Scientia Geographica Sinica, 2016, 36(11): 1629-1636.
6. [6]LI E, LU Y, CHEN Y. Geogr-aphic pattern evolution of China's merchandise export and its influencing factors: Based on the analysis of merchandise export distance and the GTWR model-based on the em-pirical analysis of Chinese export data from 1984 to 2013, Geographical Research, 2019,38(11):2624-2638.
7. [7]Fan H,Wang Z,Su B. Spatial pattern of commodity export of China to its surrou-nding countries. Scientia Geographica Sinica, 2013,33(12):1428-1433.
8. [8]Song Z, Che S, Yang Y. Topological relationship between trade ne-twork in the Belt and Road Initiative area and global trade network. Progress in Geogr-aphy,2017,36(11):1340-1348.
9. [9]GONG P, SONG Zg, LIU W. A Study on trade pattern of China with Ru-ssia and Central Asia. Geographical Research, 2015, 34(5):812-824.
10. [10]ZHANG H，LIU W，LIU Z. Trade pattern and its influencing factors between China and important node regions under “the Belt and Road” initiative:A Case Study of Transcaucasia Countri-es. Geography and Geo-Information Science, 2021,37(01):135-142.
11. [11]REN M, CHEN J, SONG Y. An analysis of trade structure a-nd potential between China and Iran under the background of the "Belt and Road" Init-iative. World Regional Studies, 2019,28(05):54-64.
12. [12]YANG X, PENG F, ZHANG Q, HU W. The rank-size distribution and influencing factors of foreign trade in China's border from 2000 to 2017. World Regional Studies, 2020,29(06):1102-1112.
13. [13]JIANG X, YANG Y, WANG S. Analysis of export trade's spatial pattern evolution and influencing factors of Gansu Province with " the Belt and Road" areas. World Regional Studies, 2020,29(05):1029-1039.
14. [14]DU Y, ZONG H. The evolution and influencing factors of spatial pattern of trade between Chongqing and ASEAN countries under the bac-kground of "The Belt and Road Initiative". World Regional Studies, 2020,29(04):697-707.
15. [15]LIANG Y，LIU L，LIU L，CHEN W． Spatial a-nd Temporal Changes in the Pattern of Export Trade between Guangdong Province and the Countries along “One Belt and One Road”. Tropical Geography, 2015,35(05):664-670.
16. [16]Lu Q, Zhang C, Yang C, et al. The development of foreign trade in China's seven economic regions and its regional pattern changes, 1965-2004. Acta Geog-oraphica Sinica, 2007(08):799-808.
17. [17]ZHAO Y, LIU X, GE Y. Analysis of Trade and Commodity Patterns between Chi-na and Central Asia. Economic Geography, 2020,40(07):93-103.
18. [18]SONG Z, CHE S, LIU W. Analysis of spatial pattern and trade structure of f-oreign trade in Central China. Geographical Research, 2017,36(12):2291-2304.
19. [19]LIU Z，ZHANG W，LIU W. Spatial pattern of foreign trade in Northeast China. Scientia. Geographica Sinica, 2016,36(09):1349-1358.
20. [20]ZHENG L, SONG Z , LIU W, LIU Y. Spatial pattern and trade structure of foreign trade in western China. Geographical Research, 2015,34(10):1933-1942.
21. [21]WANG M. E-mpirical analysis of foreign trade of six provinces in Central China from 2007 to 2012.China Economist,2014(1):65-66.

22. [22]LI G, JIN Y, GUO X. The temporal and spatial pattern of China's I-CT foreign trade and its evolution characteristics. World Regional Studies, 2022,31(01):29-40.
23. [23]LIU J. Evolution of world natural gas trade pattern based on social network analysis. Ec-onomic Geography, 2016,36(12):89-95.
24. [24]HAN M，LI S. Network characteristics and community structure of Marine Energy Products trade among the countries along the Belt and Road. Econo-mic Geography, 2020,40(10):108-117.
25. [25]QU R, LI J. International High-Tech Products trade pattern and China's tra-de status. Economic Geography, 2020,40(03):102-109+140.
26. [26]DING X, HAN Q. Comparative Advantage & Comparative Advant-age Trap: An Empirical Analysis Based on Foreign Trade of Heilongjiang Province. Jou-rnal of International Trade, 2015(02):84-93.
27. [27]LIU C, XU Y. The trade efficiency of Heilongjiang with Russia under the background of "The Belt and Road Initiative". Enterprise Economy, 2019,38(11):48-54.
28. [28]KANG C. Research on Heilongjiang province's foreign trade and trade with Russia optimization strategy based on REP Index. Commercial Research, 2016(06):109-115.
29. [29]YANG Z, LI C. Research on the relationship between fore-ign trade and economic growth in Heilongjiang province-An empirical study based on VAR Model. Foreign Economic Relations & Trade, 2020(07):72-76.
30. [30]ZHANG M, LI Y, GAO C. Analysis on co-integration and causality relationship between foreign trade and economic growth of Heilongjiang province. Science-Technology and Management, 2007(06):7-10.
31. [31]Yang Z, Wang R. Research on the Relationship between Commodity Structure of Foreign Trade and Industrial Structure in Heilongjiang Province. Foreign Economic R-elations&Trade, 2022(03):50-54.
32. Hodrick R J, Prescott E C. Postwar U.S. Business Cycles: An empirical investigation. Journal of Money, Credit and Banking,1997,29(01),1-16.
33. [33]YANG D. Three Frequency Selective Filters and Their Applications in China. The Journal of Quantitative & Technical Economics, 2007(09):144-156
34. [34]Finger J M, Kreinin M E.A measure of export similarity and its possible uses. Econo-mic Journal, 1979,89(356):905-912.
35. [35]YANG R, ZHU S. International comparison of Zhu-jiang Delta's foreign trade develop-ment. Journal of International Trade, 2007(12):60-67.
36. [36]WU L. The coincidence of foreign trade cycle and economic cycle: empirical evidence from China. Journal of Commercial Economics, 2019(03):182-185
37. [37]PAN L, XU Y, CUI L, GAO P. Evaluation and influencing fa-ctors of international competitiveness of agricultural products in Heilongjiang province. agricultural economics and management, 2021(05):109-115.
38. [38]Li F, Liu Sa, Cheng Y, et al. Effect of value-added in China's exports on regional industrial structure advancement. Scientia Geographica Sinica, 2017, 37(1): 37-45.

Balancing Globalisation And Localization: The Way Ahead For Africa

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Abstract. The borderless world created due to globalization brings diverse products, technology, finance, trends and not each of these preclude the other but are somewhere complementary. On one side Africa began opening its borders in efforts to become globally competitive in the international markets and on the other side had less attention towards its local responsibilities. It is impertinent to say that going completely local will not be possible for African nations since they aren't self-reliant in all aspects and focussing more on the globalization will further impede its economy in terms of loss of competitive advantage and economic stability. What is needed to follow as a course by the African countries is a hybrid model where in they could optimally balance globalization and localization with several policies for industries in their countries to consider the localization aspect of certain industries. The purpose of this article is to provide a lens view of the interactions taking place between localization and globalization and how creating a balance between the two will lead to development in the long run for Africa. To dwell deeper into the aspects of how an optimum balance between the two will create an environment that could foster growth for African nations, a literature review of relevant theoretical contributions has been conducted followed with a discussion on their main insights. We posit that the theoretical perspectives and scenarios associated are capturing the broad contours of the debate on globalization and localization and the hybridization of the two in Africa.

Key words: globalization, localization, Africa, balance, economic, stability.

1. Introduction

The multidimensional phenomenon of globalization encompasses not just economic component but also political, ideological, cultural and other facets. Conventionally international trade has been regarded as a driver of growth but whether all the countries get benefitted from international trade is still a doubt. The unequal economic relations between the developed and the developing nations is yet to be reduced and with that gap widening, globalization will not be able to help the developing or less developed nation like Africa as much as it would to the developed nations. The economic disparity has widened between Africa and developed countries in the recent years with the ratio of income falling from 12% in 1980 to 8% today in comparison to the richer nations. With pressures from WTO and peer nations competing, Africa like many other countries failed to plan in advance the measures to protect its industries. But today, many countries with strong industrial base have started to think on the lines of promoting localization with terms like America First, Buy Uganda Build Uganda (BUBU), Buy British, Make in India etc. African nations too like other countries have resorted already or are in the process to indicate a strong national desire to go local. Much of the credit for realizing the importance of localization to the world at large and African nations in particular can be accorded to the Covid-19 pandemic, where they had to encourage domestic manufacture of essential and critical goods with international trade coming to a halt. There are several case studies of African countries that provide insightful demonstration of creative, sustainable and indigenous models of entrepreneurship contributing to economic independence at the grassroot level.

2. Globalization and Africa:

Globalization can be referred to as the system or policy that promotes global interdependence, interaction and interconnection among various nations to facilitate trade through advanced technologies, price mechanism and competition in free markets. The beginning of the late 20th century witnessed African nations opening their borders to be globally competitive in the international markets. As a result, multinational and global companies began to grow in record numbers. Many African leaders criticised globalization with only a few who opposed its implementation. A survey by Pew Research Centre in 2003 showed that only 41% of South Africans, 44% of Ugandans, 46% of Kenyans and 58% of Nigerians viewed globalization positively. Globalization has been of key importance in promoting economic growth and diversification in many developed and developing nations leading to cultural development, gender equality and fostering political stability. But that's not how it went for African nations. Globalization failed to make an impact in Africa because of several factors like political unrest, poor infrastructure, and eroding human capital. It is also for a fact that globalization has failed in making a world village where all the countries could be at the same level. Globalization did not succeed in eliminating the disparities in the standards of living between poor and rich countries. It naturally led to a wave of international conflicts and backlashes over the value distribution caused due to globalization. One of the reasons of failure of African companies in the world is accorded to the theory which stresses that the world is not experiencing globalization rather Americanization with the latter having a dominance in the world through drastic penetration of American companies in other countries. It is also important to mention that Globalization has been beneficial for certain countries like Mauritius and Rwanda as it attracted international investors due to its congenial business environment. MNCs have played a pivotal role in countries like Ghana, Morocco, Egypt, South Africa, Tunisia, Nigeria etc. by providing employment to its local population and helping raise their standard of living.

3. Localization and Africa:

Localization refers to the adjustment of companies to fit its product with specific local resources or cultures to fulfil the needs and demands of local people and government. Localization aims at increasing the use of local resources and regional economic growth. To target the local audience and nation, global companies need to accommodate local contents like employing the local people, adding some local raw material to their main product, adapting the product to the suitability of local culture and environment etc. The leaders of African countries may need to shorten supply chains and develop ecosystems to enable localization by engaging with the stakeholders to frame structures and policies that encourage resilience. To say the least, localization currently is disrupting the equilibrium that has been enjoyed by global companies for years. Although the equilibrium will again be challenged in the long run and localization may stay only for a short period as countries would likely return to globalization for promoting economic growth as a path to prosperity. But for the time being, localization is the new reality. Uganda for instance is religiously promoting the use of local people and locally manufactured products under the policy named "Buy Uganda Build Uganda". Certain laws have been introduced for the same with a desire to protect national content. Similar is the approach of countries like South Africa, Namibia, Senegal and others who are insisting on buying locally manufactured goods not just to the public but also to the MNCs operating there.

4. Africa's Dismal Performance:

The benefits of globalization were oversold to the developed nations and its costs to the least developing nations were undercounted. Africa is projected to account for more than 25 per cent of the world population by 2050 and yet the effects of globalization on the continent and its population has received far less attention. With globalization, advanced economies succeeded in producing goods more cheaply whereas African countries were struggling to

develop local industries that could create some jobs, it therefore resulted in premature deindustrialization in the continent. The trade marginalization of African countries has been largely due to the economic stagnation and specific barriers limiting export performance like droughts and desertification, high transportation costs, inadequate and expensive telecommunications, high incidence of AIDS/HIV, impact of increase in oil prices, administrative constraints and poor institutions etc. Moreover, countries like Zimbabwe, Mozambique, Malawi had to bear the wrath of climate change due to the recent cyclones that hit them even though Africa has very limited contribution in the problem of climate change that's happening due to globalization.

5. The Grand Bargain:

The low per capita income of several African countries makes Africa as the least developed continent of the world. To our utter dismay, most of the African nations have still been playing too weak role even at the stake of their own critical development within the international institutions. This self-marginalization weakens them further in the international market. The data of world trade and finance clearly shows that the developed nations have been the beneficiaries of the globalization at the expense of the developing nations, African countries in particular. Monocultural export, indebtedness and inability to attract foreign investments are the major factors responsible for Africa missing the opportunity to bank the benefits of globalization. To overcome such issues planned debt reduction and expansion of cooperation with other countries for development along with diversification of exports is needed. Africa being rich in natural resources, agricultural products and other raw materials that are requisites in manufacturing key products can bargain its stake at the global platform and can enrich itself by exporting these products to other nations in exchange for foreign direct investments. Moreover, Africa has not been able to benefit from globalization and international trade due to its natural resources being spread unevenly throughout the continent. The leaders of the continent need to collaborate through strategic pooling of physical, human and natural resources to gain momentum for trade at the first place. They also need to work on improving trade infrastructure like poor road and telecommunication that form fundamental aspects of logistics.

6. Impact of Covid on Localization:

During the pandemic, almost all the countries had build national stockpiles and encouraged domestic production of critical and essential goods to relive themselves from the dependency on international trade to fulfil their requirements. While African countries had been importing 99% of their vaccines, with only a few vaccine manufacturers who would not engage in manufacturing vaccine's active ingredients rather fill and finish products those were imported; no wonder the Covid vaccination rate stands to as low as 11%. It took them a pandemic to come with new developments that could change the narrative of finding the African countries at the back of vaccine queue. In the first quarter of this year, a South African company completed the process if reproducing Moderna's vaccine against Covid. Such important and necessary moves, not just by African countries but by others as well will have an impact on reshaping existing supply chains and trade links, not just for healthcare but also food and energy and likewise. Also, the recent outbreak of war between Russia and Ukraine has resulted in deglobalization of trade in by declining trade integration between several countries. Such situations of pandemic followed by war has further reduced the expectations of reliance on global supply chains by nations and they have started looking for an inward and inhouse supply chain that is stable and steady.

7. Glocalization:

It is a combination of globalization and localization. It emphasises on global companies to strategize their products and markets based on the local environment to accommodate both local and global standard. African nations need to walk out of insularity into rationalization with the help of glocalization. It is not a simple dichotomy method rather globalization and localization are considered as two ends with a link in between where the global companies can have the choice of a combination between the two to make a strategy for survival and growth. African firms with global supply chains can have access to technology, capital and better inputs that could help upgrade products and make it more competitive, so glocalization is the way forward to succeed and sustain. Several factors are responsible for disrupting the equilibrium enjoyed by multinationals for many decades. It is time for them to respond by adapting glocalization both strategically and tactfully. Even with huge potentials Africa has faced formidable challenges and the continent by 2030 will bear close to 90% of the world's poorest people. To share the prosperity of globalization with other developed nations, it has to adapt the way ahead for glocalization that could help correct its current account deficits and increase international competitiveness. The impediments that restricted its growth like low productivity, high transaction costs, undercapitalization, inadequate market infrastructure, support services and poor macroeconomic policies need to be eliminated to make its local industries competitive and sustainable. Africa also needs to strengthen their service sector instead of focusing only on the extractive sector. Education and training programs should be organized for developing digital know-how, soft skills, cognitive and critical thinking among its population. Relying on low skill and low-cost labour is no more an option for Africa. It also needs to improve digital infrastructure and skills with measures focused at penetrating internet to its population in cognizance to the world average rate of 57%.

8. Conclusion:

The history of Africa indicates to some growth retarding policies which creates a link between the region's policy regimes and its structural characteristics hinting at the African poverty trap. At the same time, Globalization is an inevitable process and no country can escape it. International trade is not just about exchange of goods and services but building external economic relations, bilateral and multilateral negotiations, exploring opportunities and generating consensus aiming at fostering economic growth and development. Such economic exchanges also help in promoting security, peace and reducing tension among nations. For instance, Africa can greatly benefit from the current trade war between China and America if acted on right time and in right momentum. It is rather important for the African nations to embrace it so save themselves from marginalization. The leaders of Africa need to be prepared to negotiate with the global players on account of local considerations, conflicts and barriers alongside the global economy still expanding to newer heights. They also need to examine in detail various new models of economic development that can be implemented in different countries of Africa to enhance self-sufficiency, economic growth and sustainable development. The degree of globalization and localization in the African nations need to be figured out and maintained. The policymakers should focus on bridging the gaps in digital infrastructure and accelerating regional integration. African leaders also need to commit to industrialization as no economic growth and development is possible without a robust industrial base. A structured industrial revolution is necessary in the continent for sustainable, collective and comprehensive growth of Africa. At the end of the day, to be a successful nation prioritizing overall scale and footprint is important by increasing local penetration and greater global expansion. Maintaining this balance will not be an easy feat by the nations but several tools and solutions can help achieve the same.

References

1. Bora, S., Bouët, A., & Roy, D. (2007). The marginalization of Africa in world trade (Research Brief, No. 7). Washington, DC: International Food Policy Research Institute (IFPRI). Retrieved from
2. Agarwal, J. P., Dippl, M., & Langhammer, R. J. (1985). EC trade policies towards associated developing countries: Barriers to success (Kieler Studien, No. 193).
3. Collier, P. (1995). The marginalization of Africa. International Labour Review, 134, 541–557.
4. Davies, G. (2013). Why world trade growth has lost its mojo. Financial Times Blog of September 29, 2013.
5. Ndikumana, L. (2015). Integrated Yet Marginalized: Implications of Globalization for African Development. African Studies Review, 58(2), 7-28. doi:10.1017/asr.2015.35
6. Yankuzo, K. I. (2014). Impact of Globalization on the Traditional African Cultures. International Letters of Social and Humanistic Sciences, 15, 1-8
7. Hagen, R. J. (2002). Marginalisation in the context of globalisation: Why is Africa so poor? Nordic Journal of Political Economy, 28, 147–179.
8. Iyoha, M. A. (2005). Enhancing Africa's trade: From marginalization to an export-led approach to development (Economic Research Working Paper Series, No. 77). Tunis, Tunisia: African Development Bank.
9. Low, P., Olarreaga, M., & Suarez, J. (1998). Does globalization cause a higher concentration of international trade and investment flows? (Staff Working Paper, ERAD-98-08). Geneva, Switzerland: World Trade Organization, Economic Research and Analysis Division (ERAD).
10. McMillan, M., & Rodrik, D. (2011). Globalization, structural change and productivity growth. In M. Bacchetta, & M. Jansen (Eds.), Making globalization socially sustainable (pp. 49–84). Geneva, Switzerland: International Labour Organization and World Trade Organization.
11. Milanovic, B. (2016). Global inequality: A new approach for the age of globalization. Cambridge, MA: The Belknap Press of Harvard University Press.
12. Murshed, S. M. (2000). Globalization, marginalization and development (Working Papers, No. 175). Helsinki, Finland: United Nations University, World Institute for Development Economic Research (UNU/WIDER), February.
13. Ng, F., & Yeats, A. (1996). Open economies work better! Did Africa's protectionist policies cause its marginalization in world trade? (World Bank Policy Research Working Paper, No. 1636). Washington, DC: The World Bank.
14. Stiglitz, J. E. (2002). Globalization and its discontents. New York, NY: W.W. Norton.
15. Kavina, A. (2020). Positive and Negative Aspects of Globalization in Nation Building in Africa. Journal of the Institute for African Studies.
16. Makinde, T.M. (2013). Globalization as a Constraint to Development in Africa: The Nigerian Experience. Public Administration Research, 2, 191.
17. Wenjing, W., Rongchengsup, W., Ayenagbosup, K., Nguhi, S., Kimatu, J.N., & Patrick, J.M. (2012). The impact of globalization on African countries economic development. African Journal of Business Management, 6, 11057-11076.
18. Shittu, W.O., Yusuf, H.A., El Moctar El Houssein, A. and Hassan, S. (2020), "The impacts of foreign direct investment and globalisation on economic growth in West Africa: examining the role of political governance", Journal of Economic Studies, Vol. 47 No. 7, pp. 1733-1755.
19. Manda, D.K. and Sen, K. (2004), The labour market effects of globalization in Kenya. J. Int. Dev., 16: 29-43.

20. Jacobsen, M., & Lawson, S. (1999). Between Globalization and Localization: A Case Study of Human Rights Versus State Sovereignty. *Global Governance, 5*(2), 203–219. http://www.jstor.org/stable/27800228

Assessment of visitor satisfaction for Ba Ra – Thac Mo tourist site, Binh Phuoc province

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Abstract. The assessment of visitor satisfaction is an important basis for setting out development strategies at the tourist destination. This study was conducted to determine the influencing factors and the degree of influence of these factors on visitor satisfaction, thereby offering solutions to develop the Ba Ra-Thac Mo tourist area in Binh Phuoc province. Then, by looking up the method using a questionnaire, the authors conducted a survey with 170 visitors. The model was tested through regression analysis. The findings indicate that there are six variables that affect visitor satisfaction for the Ba Ra-Thac Mo tourist area, listed in decreasing order as follows: cultural tourism resources, security, safety, natural tourism resources, tourism technical facilities, service workers and local communities, service price.

Key words: Factors affect, satisfaction, visitor.

1. Introduction

Visitor satisfaction as a marketing technique to draw public attention, thereby establishing tourism development plans and increasing the quality of tourist services at the destination. Due to its significance, there have been several research on variables impacting tourist satisfaction, which have led to solutions being proposed to enhance visitor satisfaction at a site. Typically, the study of Parasuraman et al. (1985 - 1988) assesses service quality based on customers' perceptions and expectations; Cronin & Taylor (1992) claim that the perceived level reflects satisfaction; Tribe & Snaith (1998) assessed visitor satisfaction based on perceived value and expectations of both positive and negative attributes. The authors of this study provide a theoretical framework to quantify visitor satisfaction based on Cronin & Taylor's (1992) theory and examine visitor satisfaction at the Ba Ra-Thac Mo tourism region (1992). on value perception.

Binh Phuoc is a boundary region lining Cambodia, situated around 121 km from Ho Chi Minh City. The territory has a moderately rich and various the travel industry potential with a primitive woods environment, an arrangement of streams and cascades, verifiable relics, and so forth. As indicated by the Vietnam Statistical Yearbook 2020, the area's travel industry income arrived at VND 390 trillion, representing 2.18% and the quantity of vacationers to Binh Phuoc was 784.4 thousand turns, representing just 1.31% of the entire country (General Statistics Office of Vietnam, Binh Phuoc Provincial Statistics Office, 2021). Ba Ra - Thac Mo traveler region is situated in Phuoc Long town; is the most popular vacationer location of Binh Phuoc, yet it likewise has a typical number of guests of around 6000 visitors/day on siestas and Tet (Management Board of Ba Ra – Thac Mo traveler region, 2020). The explanation is because of the absence of help administrations (catering establishments, accommodation facilities, entertainment services, etc). In order to improve service quality as well as build a suitable development orientation to attract tourists, the assessment of visitor satisfaction is essential. Therefore, in this article, the authors will focus on assessing the level of satisfaction and the impact of factors on visitor satisfaction at Ba Ra - Thac Mo tourist site; from which to make effective and timely policies and recommendations with the situation of the tourist area.

2. Materials and Methods

Field method: The authors conducted fieldwork at Ba Ra - Thac Mo tourist site before constructing the survey questionnaire. Collect data by photos, documents, notes and practical observations for the purpose of understanding the actual situation, the study area as well as verifying the actual information with the theory. From there, there is an objective, multi-dimensional view as well as a basis for the author's team to build a scientific questionnaire that is consistent with reality. The author conducted field research for 5 days from April 30 to May 4, 2021.

Questionnaire survey method: The authors based on documents and survey activities to design the questionnaire. The survey questionnaire consists of two parts: Part 1 is about demographic questions, the author uses an identifier scale; Part 2 is questions about tourism activities and visitors' evaluation, the author uses nominal scale and interval scale. For the interval scale, the authors uses a 5-point Likert scale; built 7 independent scales, 1 dependent scale with 34 observed variables to assess visitor satisfaction for Ba Ra - Thac Mo tourist site. The authors use non-probability sampling method because the tourist site is not open to sell tickets. According to Hair et al. (2006), each variable in the exploratory factor analysis must have at least 5 observations, scale 1:5. The study builds 34 variables, so the corresponding minimum number of samples is 34 x 5 = 170. The author collects 170 survey questionnaires to ensure the minimum sample, the time of collection is from January 2022 to March 2022.

Descriptive statistics method: The authors test the scale through Cronbach's Alpha coefficient, exploratory factor analysis (EFA), multivariate regression analysis to determine the factors and the degree of impact of each factor on visitor satisfaction. at Ba Ra - Thac Mo tourist site, Binh Phuoc province.

3. Results

3.1. Research models

According to Corin & Taylor (1992), service quality is equal to perceived level instead of having to measure both perceived and expected value as the Servqual model of Parasuraman et al. (1985). The author also agrees that tourist's perception at tourist destination can measure satisfaction level. Therefore, the author chooses the Servperf models (Corin & Taylor, 1992) and adjusts it to suit the study area to build a model to assess visitor satisfaction in Ba Ra - Thac Mo tourist site. Along with studying the theoretical models of satisfaction, the authors conducted a field study in Ba Ra - Thac Mo tourist area with the aim of building a theoretical framework for assessing visitor satisfaction in Ba Ra – Thac Mo. The author builds a theoretical framework to assess visitor satisfaction in Ba Ra - Thac Mo, including 7 influencing factors: (1) natural tourism resources; (2) cultural tourism resources; (3) infrastructure; (4) tourism technical facilities; (5) security, safety; (6) service price; (7) service workers and local communities.

Natural tourism resources: Natural tourism resources of Ba Ra - Thac Mo include unspoiled Ba Ra Mountain landscape, attractive Thac Mo Lake, attracting tourists to visit and have fun. Besides, there are also many studies showing that natural resources are a factor affecting visitor satisfaction such as Holsat model; theoretical framework of authors Hoang & Le (2015), Nguyen & Van (2020), Nguyen & Hoang (2020), Nguyen (2020); Phuong (2020);… Therefore, the author chooses “natural tourism resources” as one of the factors affecting the satisfaction of tourists in Ba Ra - Thac Mo.

Cultural tourism resources: Ba Ra Mountain was recognized as a historical relic in 1995 with many historical vestiges such as Bang Lang hill, Ba Bay Tuyet cave (Bat cave), Ba Ra prison, Ba temple at the base of the irvingia malayana tree with great historical value. In addition, the tourist site is also a famous cultural and spiritual destination in the Southeast region, attracting a large number of tourists to visit on holidays and Tet. There are also many

studies showing that the elements of cultural tourism resources affect visitor satisfaction such as: Le et al. (2014), Nguyen (2020),... So, the selection of "cultural tourism resources" as one of the factors affecting the satisfaction of tourists in Ba Ra - Thac Mo is reasonable.

Infrastructure: Tourism infrastructure includes: network, means of transport; communications; Electricity and water supply works also play an important role in tourism development. In which, the traffic network is composed of the traffic network to the tourist site and the traffic network in the tourist site. There have been many studies that show that infrastructure is a factor affecting visitor satisfaction such as: Nguyen & Van (2020); Hoang & Le (2015) when assessing visitor satisfaction at Suoi Luong tourist site. Therefore, the author chooses "infrastructure" as a criterion to build a theoretical framework.

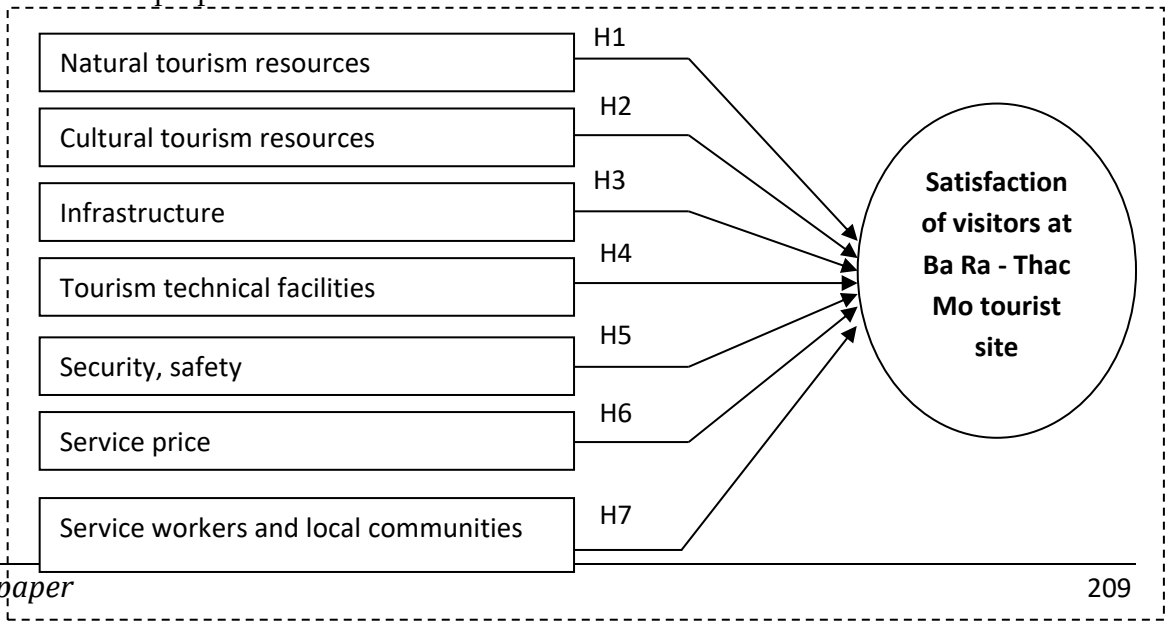
Tourism technical facilities: Components of tourism facilities include: accommodation; amusement parks; restaurants; shopping stores; souvenir shops; transport, travel agency. Tribe & Snaith (1998) also suggested that physical conditions affect visitor satisfaction. Some other studies by Le et al. (2014), Hoang (2015) also selected technical facilities to affect the satisfaction of tourists. Therefore, the selection of factors of "tourism technical facilities" to build a framework for assessing visitor satisfaction in Ba Ra - Thac Mo is necessary.

Security, safety: Security and safety is a factor that many tourists care about when choosing a tourist destination. Parasuraman et al. (1985) built "safety" as one of the 10 components affecting customer satisfaction with service quality. Authors Dinh et al. (2011), Nguyen & Tran (2013), Hoang (2015), Hoang & Le (2015), etc. also chose security and safety affect visitor satisfaction. Therefore, the author will build "security, safety" is one of the factors that create satisfaction.

Service price: Service price is the amount of money that visitors have to pay to experience the services at a tourist destination (Needham, 1996). The studies of Zeithaml et al. (2000), Dang (2015), Vo (2019), ... also build a theoretical framework that has price factors affecting visitor satisfaction. Therefore, the author decided to choose "service price" as a criterion to build a theoretical framework.

Service workers and local communities: Service workers and local communities are the creators of intangible service values such as responsiveness, empathy and service capacity, which affect visitors' perception of service quality. The theoretical framework of the authors Vo (2019), Nguyen & Vong (2020), Trinh & Phan (2020) also includes the service staff element. Therefore, the selection of "service workers and the local community" is one of the factors constituting the framework for assessing visitor satisfaction in Ba Ra - Thac Mo.

Based on studies on factors affecting visitor satisfaction at Ba Ra - Thac Mo tourist site, the authors have proposed a research model as follows:



Source. *Authors, 2022*

Figure 1. Theoretical model to study visitor satisfaction in Ba Ra - Thac Mo tourist site

3.2. Building a research scale

After building the theoretical framework, the authors form a scale with 31 observed variables, of which 03 are dependent variables on satisfaction and are rated by Likert scale from 1 to 5, corresponding to the rating levels from Strongly disagree, disagree, neutral/ no opinion, agree and strongly agree.

Table 1. Observable scales and variables to assess visitor satisfaction in Ba Ra - Thac Mo tourist site

No.	Scales and observed variables	Sign
1	**Natural tourism resources**	H1
	Unspoiled, attractive ecological landscape	TN1
	Fresh air, open space	TN2
	Landscape suitable for camping	TN3
	The water of lake and streams is clear and clean	TN4
2	**Cultural tourism resources**	H2
	Attractions of faith and religion	VH1
	Valuable historical sites	VH2
	Majestic Mieu Ba Festival	VH3
	Attractive local specialties	VH4
	The temple space is clean and dignified	VH5
3	**Infrastructure**	H3
	The roads in the tourist area are of good quality	HT1
	There is a full means of transporting guests up the mountain	HT2
	Many rest stops and benches to rest	HT3
	Convenient parking	HT4
	Full toilet	HT5
	Full, convenient trash cans	HT6
4	**Tourism technical facilities**	H4
	Comfortable accommodation	KT1
	Full catering facility	KT2
	There are many entertainment facilities	KT3
	Convenient shopping facility	KT4
5	**Security, safety**	H5
	Safe way to hike up the mountain	AN1
	Danger warning signs are easy to see	AN2
	Fence the dangerous areas	AN3
	Superstitions are strictly controlled	AN4
	There is a security force to ensure safety	AN5
6	**Service price**	H6
	Selling price of temple worship items is reasonable	CP1
	Reasonable food prices	CP2
	Reasonable prices for souvenirs	CP3
	Reasonable accommodation service price	CP4
7	**Service workers and local communities**	H7
	Happy salesman	NV1
	The shopkeeper has neat clothes	NV2
	Local people are enthusiastic and hospitable	NV3
8	**Satisfaction**	Y
	Are you really satisfied with Ba Ra - Thac Mo tourist site?	HL1
	You will continue to come back to visit Ba Ra - Thac Mo tourist site	HL2
	Will you introduce to everyone about Ba Ra - Thac Mo tourist site?	HL3

Source. Authors, 2022

3.3. Demographic characteristics of tourists at Ba Ra - Thac Mo tourist site

Through a survey of 170 visitors in 2022 at Ba Ra - Thac Mo tourist site, the demographic characteristics of visitors here are as follows:

The proportion of female tourists accounted for 54.7% with 93 visitors, the proportion of male tourists is 45.3% with 77 tourists. Thus, there is not too much difference between the percentage of male visitors and the rate of female visitors to the site. This proves that the site is attractive to both male and female tourists.

Visitors to the resort are mostly between the ages of 25 and 48. In which, the highest is from 25 to 34 years old with 44.7%; visitors from 35 to 48 years old accounted for 24,1%; from 18-24 years old also accounted for a high proportion with 16.5%; from 49 to 60 years old account for 10.6% and the lowest is customers over 60 years old, only 4.1%. It can be seen that the tourist area is attractive to both young and middle-aged tourists due to both its attractive natural landscape and attractive and sacred spiritual tourist attractions.

The academic level of visitors in Ba Ra - Thac Mo tourist site is mainly from high school to higher education. The highest percentage are tourists with higher education for 36.5%; ranked second is tourists with high school education with 31.8%. Tourists with lower middle school accounted for 11.8%; intermediate level accounted for 8.2%; primary education 5.8%; have not finished primary school 3.5% and 1.8% of postgraduate. Thus, visitors to the resort are distributed at many different levels, proving that the resort is suitable for all types of visitors. However, tourists with high qualifications account for a large proportion because these subjects have a higher demand for tourism to learn, explore and relax.

Visitors to the tourist area have quite a variety of occupations. Specifically, the businessman has the highest rate, accounting for 19.5%; employees have a rate of 17.6%; public servants have the rate of 17.1%; students 15.9%; workers 10%; farmers 8.8%; army, police 4.1%; retired officers 2.9% and other (housewives, self-employed) is 4.1%. This result shows that business professions, civil servants, employees and students have a higher demand for tourism than workers, farmers and soldiers and police.

Table 2. *Demographic characteristics of tourists at Ba Ra - Thac Mo tourist site*

Classify	Quantity (person)	Rate (%)	Classify	Quantity (person)	Rate (%)
Sex			**Job**		
Male	77	45.3	Student	27	15.9
Female	93	54.7	Farmers	15	8.8
Age			Workers	17	10.0
18-24 years old	28	16.5	Army, police	7	4.1
25 – 34 years old	76	44.7	Public servants	29	17.1
35 – 48 years old	41	24.1	Businessman	33	19.4
49 – 60 years old	18	10.6	Retired officers	5	2.9
Over age 60	7	4.1	Employee	30	17.6
Academic level			Others	7	4.1
Haven't finished elementary school	6	3.5	**Income**		
Primary school	10	5.9	Less than 3 million dong	23	13.5
Middle school	20	11.8	3 – 6 million dong	33	19.4
High school	54	31.8	6 – 9 million dong	60	35.3
Intermediate	14	8.2	9 – 12 million dong	27	15.9
Higher education	62	36.5	12 – 15 million dong	17	10.0

Postgraduate	3	1.8	Over 15 million dong	10	5.9
Others	1	0,6	**Type of residence**		
Marital status			Rural	96	56.5
Single	47	27.6	Urban	74	43.5
Get married	122	71.8	**Transport**		
Others	1	0.6	Motorbike	109	64.1
Destination			Car	52	30.6
Inside the district	27	15.9	Bus	2	1.2
Inside the province	120	70.6	Others	7	4.1
Outside the province	23	13.5			

Source. *Author, 2022*

The main income of tourists is good, from 6 to 9 million dong with the rate of 35.3%, mainly concentrated in workers, officials, employees, workers and farmers. Income from 3 to 6 million dong, accounting for 19.4%, mainly focuses on young workers, officials and employees. Income from 9 to 12 million dongs accounts for 15.9%; from 12 to 15 million dongs account for 10%; over 15 million dong, accounting for 5.9%, mainly concentrated in business people, employees, etc. Incomes below 3 million, accounting for 13.5%, mainly focus on students.

Tourists coming here are mainly married guests with 71.8% because most of them are domestic tourists with relatively early marriage age. The proportion of unmarried guests accounted for 27.6%, concentrated among students and 0.6% of other.

Visitors to Ba Ra - Thac Mo are more concentrated in rural areas with 56.5% coming from districts in the province; There is not much difference in urban areas with 43.5% coming from Phuoc Long town, Binh Long town, Dong Xoai city and Ho Chi Minh city.

Tourists coming here account for 100% of domestic tourists due to the great influence of the Covid-19 pandemic. In which, guests in Phuoc Long town accounted for 16.5%; Intra-provincial visitors accounted for the highest proportion with 70.6% mainly from neighboring districts such as Phu Rieng, Bu Dang, Bu Gia Map and Dong Xoai city. Visitors from outside the province also accounted for a relatively low rate with 13.5%, mainly from Ho Chi Minh City, Binh Duong, Dong Nai, Dak Nong, some provinces in the Mekong Delta and the Central region.

Through statistics, visitors to Ba Ra - Thac Mo mainly travel by motorbike with the rate of 64.1%, mainly focusing on visitors in Phuoc Long town and neighboring districts such as Phu Rieng, Bu Gia Map, Bu Dang. Passengers traveling by car accounted for 30.6%, mainly in urban and suburban areas. Traveling by passenger coach accounts for 1.2% due to the inconvenience because there is no system to transport passengers to the mountain, so very few people choose this vehicle. Other means of transportation accounted for 4.1%, mainly tourist car rental.

3.4. Analyze the reliability of the scale

Through table 3, we see that all 7 factors have Cronbach's Alpha coefficient greater than 0.6; This shows that the measurement scale used for the study is good and has high reliability (Hoang & Chu, 2005). However, during the scale reliability analysis, there was one variable CP1 that was removed because of the correlation coefficient less than 0.3. Thus, after evaluating the reliability of the scale, the study has 7 scales of independent factors with 30 observed variables and 1 dependent scale that are eligible to conduct exploratory factor analysis and multivariate regression.

Table 3. Result of Cronbach's Alpha coefficient of factors

Sign	Factors	Cronbach's Alpha
H1	Natural tourism resources	0.747
H2	Cultural tourism resources	0.709
H3	Infrastructure	0.765
H4	Tourism technical facilities	0.770
H5	Security, safety	0.827
H6	Service price	0.785
H7	Service workers and local communities	0.834
Y	Satisfaction	0.728

Source. *Authors, 2022*

3.5. Exploratory factor analysis (EFA)

The results of exploratory factor analysis showed that KMO = 0,777; Sig = 0,000; cumulative variance is 64,2% (>50%). However, the rotation matrix table has some bad variables that need to be eliminated: variables with factor loading less than standard load factor (less than 0,5), it's variable NV5. Remove the NV5 variable and rotate the matrix 2 times. After conducting the 2nd rotation of the matrix, the results of data testing with KMO = 0,770; Sig = 0,000; cumulative coefficient of variance increased to 66,1%, all variables have loading coefficients greater than 0.5, satisfying the conditions for exploratory factor analysis.

Table 4. The 2nd factor rotation matrix in exploratory factor analysis EFA

Sign	Observed variables	Factors						
		1	2	3	4	5	6	7
AN1	Safe way to hike up the mountain	0.805						
AN2	Danger warning signs are easy to see	0.764						
AN3	Fence the dangerous areas	0.740						
AN5	There is a security force to ensure safety	0.716						
AN4	Superstitions are strictly controlled	0.670						
HT4	Convenient parking		0.762					
HT1	The roads in the tourist area are of good quality		0.719					
HT2	There is a full means of transporting guests up the mountain		0.650					
HT3	Many rest stops and benches to rest		0.648					
HT6	Full, convenient trash cans		0.634					
HT5	Full toilet		0.579					
TN2	Fresh air, open space			0.755				
TN3	Landscape suitable for camping			0.721				
TN4	The water of lake and streams is clear and clean			0.717				
TN 1	Unspoiled, attractive ecological landscape			0.686				
KT4	Convenient shopping facility				0.765			

KT3	There are many entertainment facilities	0.712			
KT2	Full catering facility	0.694			
KT1	Comfortable accommodation	0.667			
CP2	Reasonable food prices		0.835		
CP4	Reasonable accommodation service price		0.792		
CP3	Reasonable prices for souvenirs		0.723		
NV2	The shopkeeper has neat clothes			0.899	
NV1	Happy salesman			0.873	
NV3	Local people are enthusiastic and hospitable			0.685	
VH4	Attractive local specialties				0.732
VH3	Majestic Mieu Ba Festival				0.669
VH2	Valuable historical sites				0.647
VH1	Attractions of faith and religion				0.641

Source. *Authors, 2022*

3.6. Regression analysis

Through regression analysis, the adjusted R^2 value is 31.6%, which means that 31.6% variation in visitor satisfaction at Ba Ra - Thac Mo tourist area is explained by the following factors: factors are included in the model; Other factors have not been studied yet (Table 5).

Table 5. *Assessing the appropriateness of the visitor satisfaction research model at Ba Ra - Thac Mo tourist site*

R	R Square	Adjusted R Square	Std. Error of the Estimate
0.657[a]	0.334	0.316	0.45151

Source. *Authors, 2022*

In addition, the Sig. value of the F-test in the table ANOVA = 0.000 (≤ 0,05), that means independent variables have influence on dependent variables (Table 6). Variance inflation factor (VIF) of all factors is ≤ 2 which means that polylinearity does not occur (Table 7).

Table 6. ANOVA testing of the research model of visitor satisfaction at Ba Ra - Thac Mo tourist site

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	13.917	7	1.988	9.753	0.000[b]
Residual	33.025	162	0.204		
Total	46.942	169			

Source. *Authors, 2022*

The analysis results in Tables 7 and 8 show that there are 6/7 factors affecting visitor satisfaction at Ba Ra - Thac Mo tourist site in decreasing order as follows: H2 “Cultural tourism resources”, H5 “Security, safety”, H1 “Natural tourism resources”, H4 “Tourism

technical facilities", H7 "Service workers and local communities" and finally H6 "Service price". Only H3 "Infrastructure" due to the value Sig. of the test T = 0.651 means that the factor "infrastructure" has no impact on visitor satisfaction in Ba Ra – Thac Mo. rom here, we have the following multiple linear regression equation:

$$Y = 0.473 + 0.300*H2 + 0.200*H5 + 0.145*H1 + 0.125*H4 + 0.110*H7 + 0.097*H6$$

Table 7. Results of regression analysis of visitor satisfaction research model at Ba Ra - Thac Mo tourist site

Model	Unstandardized Coeficients		Standardized Coeficients			
	B	Std.Error	β	t	Sig.	VIF
(Constant)	0.473	0.491		1.000	0.000	
H1	0.145	0.75	0.145	1.920	0.000	1.000
H2	0.300	0.77	0.300	3.887	0.000	1.000
H3	0.041	0.92	0.031	0.454	0.651	1.091
H4	0.125	0.58	0.125	1.540	0.009	1.000
H5	0.200	0.60	0.200	2.516	0.003	1.000
H6	0.097	0.65	0.097	1.278	0.000	1.000
H7	0.110	0.89	0.110	1.227	0.000	1.000

Source. *Authors, 2022*

Table 8. The degree of influence of factors on visitor satisfaction at Ba Ra - Thac Mo tourist site

Factor	β	% contribution/impact
H2	0.300	30.70
H5	0.200	20.47
H1	0.145	14.84
H4	0.125	12.79
H7	0.110	11.25
H6	0.097	9.95
Total	**0,977**	**100**

Source. *Authors, 2022*

Factor H2 has a coefficient of 0.300 and has a positive relationship with the scale of tourist satisfaction about Ba Ra - Thac Mo tourist site. This means that, when tourists assess their satisfaction about cultural tourism resources by 1 point, the satisfaction level of tourists increases by 0.300 points, corresponding to the unnormalized correlation coefficient is 0.300. In addition, the factor of cultural tourism resources also contributes 30.7% to the satisfaction of visitors at Ba Ra - Thac Mo tourist site.

Factor H5 has a coefficient of 0.200 and has a positive relationship with the scale of tourist satisfaction about Ba Ra - Thac Mo tourist site. This means that, when visitors rate the satisfaction of Security, safety by 1 point, the satisfaction level of tourists increases by 0.200 points, corresponding to the unnormalized correlation coefficient is 0.200. Besides, the factor of security, safety also contributed 20.47% to the satisfaction of visitors at Ba Ra - Thac Mo tourist site.

Factor H1 has a coefficient of 0.145 and has a positive relationship with the scale of tourist satisfaction about Ba Ra - Thac Mo tourist site. This means that, when visitors rate the satisfaction of natural tourism resources by 1 point, the satisfaction level of tourists increases

by 0.145 points, corresponding to an unnormalized correlation coefficient of 0.145. Moreover, the factor of natural tourism resources also contributes 14.84% to the satisfaction of visitors at Ba Ra - Thac Mo tourist site.

Factor H4 has a coefficient of 0.125 and has a positive relationship with the scale of tourist satisfaction about Ba Ra - Thac Mo tourist site. This means that, when visitors rate the satisfaction of tourism technical facilities by 1 point, the satisfaction level of tourists increases by 0.125 points, corresponding to an unnormalized correlation coefficient of 0.125. In addition, the factor of tourism technical facilities also contributed 12.79% to the satisfaction of visitors at Ba Ra - Thac Mo tourist site.

Factor H7 has a coefficient of 0.110 and has a positive relationship with the scale of tourist satisfaction about Ba Ra - Thac Mo tourist site. This means that, when visitors rate the satisfaction of service workers and local communities by 1 point, the satisfaction level of tourists increases by 0.110 points, corresponding to an unnormalized correlation coefficient of 0.110. Moreover, the factor of service workers and local communities also contributes 11.25% to the satisfaction of visitors at Ba Ra - Thac Mo tourist site.

Factor H6 has a coefficient of 0.097 and has a positive relationship with the scale of tourist satisfaction about Ba Ra - Thac Mo tourist site. This means that, when visitors rate the satisfaction of service price by 1 point, the satisfaction level of tourists increases by 0.097 points, corresponding to an unnormalized correlation coefficient of 0.097. Besides, the factor of service price also contributes 9.95% to the satisfaction of visitors at Ba Ra - Thac Mo tourist site.

Thus, through the regression equation, there are all 6 factors affecting the satisfaction of tourists at Ba Ra - Thac Mo tourist site. The factors H1, H2, H4, H5, H6, H7 have a positive relationship with visitor satisfaction. It means that if you improve natural tourism resources, cultural tourism resources, Tourism technical facilities, security - safety, service prices, and service workers and local communities, It will certainly improve the satisfaction of visitors to Ba Ra - Thac Mo tourist site.

4. Conclusion and solution

4.1. Conclusin

The article has constructed an exploration model and decided the variables and the level of impact of these elements on visitor satisfaction. From 7 factors of the original research model, after performing regression analysis, only 6 factors have an impact on visitor satisfaction for Ba Ra – Thac Mo site in decreasing order as follows: resources for culture and tourism; safety; natural tourist resources; physical and technological infrastructure; labor in the service industry; local neighborhoods; and service costs . In which, humanistic the travel industry assets strongestly affect visitor satisfaction. This outcome shows the high common sense of social the travel industry when it is one of the conclusive elements when sightseers decide to visit the Ba Ra – Thac Mo site.

4.2. Solution

Based on the research results on visitor satisfaction at Ba Ra – Thac Mo site, the authors propose the following recommendations:

Exploiting the advantages of cultural tourism resources: In tourism development, tourism resources are the most important. They are the foundation for tourism development and the construction of accompanying services. Any place with great tourist resources will attract a large number of tourists. Therefore, cultural tourism resources are one of the important bases for tourism development in the Ba Ra – Thac Mo site. However, many works to develop cultural tourism in the tourist area are currently seriously degraded, and many of

these works are unknown to tourists. Therefore, the author proposes some solutions to exploit the advantages of cultural tourism as follows: Foster an arrangement to reestablish, protect, and take advantage of social assets, for example, Ba Temple, jail, Bat Cave, Martyrs' Temple, and the pagoda framework.

Since the festival isn't known to numerous tourists, it is important to grow the scale and advance the "Via Ba" festival to attract a large number of visitors from all over the world.

Create linkages between cultural tourist attractions in the tourist area and cultural tourist sites inside and outside the province in order to associate cultural values to create unique tourism products.

Focus on promoting investment and promoting the image of the cultural tourist attractions of the Ba Ra-Thac Mo site.

Exploiting the advantages of natural tourism resources: Along with cultural tourism resources, natural tourism resources are also one of the tourist attractions of the resort. Therefore, it is necessary to have appropriate solutions to maximize the potential of natural tourism:

Intensifying exploitation in depth, combined with environmental protection, avoids excessive impacts that damage the wild beauty of nature.

The rapid increase in the number of tourists has greatly affected the natural environment. Therefore, agencies and sectors need to strengthen patrols, control, and propaganda for people and tourists to protect the environment; do not litter indiscriminately; do not smoke when going up the mountain; and do not encroach on land, forest, etc

Calling for help from associations, specialists, and researchers to research and save the biodiversity and geography of the Ba Ra-Tac Mo tourist area consequently filling in as a reason for future research activities.

Building a separate campsite both develops tourism and does not affect the natural environment.

Building physical and technical infrastructure: Besides the role of tourism resources, infrastructure is one of the most important and indispensable factors if you want to develop tourism. However, at present, the system of technical facilities of the tourist area is rated by tourists as unsatisfactory due to the limited number of accommodation facilities and the number of dining, entertainment, and shopping establishments does not meet the needs of tourists. Therefore, it is necessary to offer solutions to upgrade the system of technical facilities, such as:

Creating conditions, attracting capital, and socializing investment to build accommodation, dining, and entertainment establishments from businesses Agencies need to pay attention and create conditions for local people to invest in guest rooms.

Constructing more latrines: Currently there is no latrine in the Ba Ra Mountain region for sightseers, causing dissatisfaction for vacationers while visiting here.

The parking garage must be extended. There is no confidential leaving for vehicles, so it needs to spread to the tourist campus.

Most tourists coming to Ba Ra Mountain comment that the resort needs to have a cable car system or at least a service car to take guests to the mountain. The lack of cable cars and service cars has greatly reduced the satisfaction of visitors to the resort. Therefore, the resort needs to quickly complete the cable car system to meet the needs of sightseers.

Ensuring security, order and safety: The management board of the tourist area needs to ensure and improve the safety level for tourists when traveling. The survey shows that the scale of "safe way to the mountain" and "with visible warning signs" are rated at an average level, lower than the average satisfaction level of the factor of security, order, and safety. Therefore, it is necessary to build railings so that tourists can hold on when climbing; clean the terraced area so as not to let moss cling to it in the rainy season, causing it to be slippery; and install new warning signs that are old or out of sight due to tree cover.

Build a speaker system to remind visitors not to smoke, ensure safety when climbing, pay attention to protect property instead of guarding, and rangers have to remind each tourist group like that before.

The control of superstition is being done very well by the tourist area. There is almost no situation of people selling gods, begging, beggars, pickpockets, or enticing guests at tourist destinations. However, when tourism is becoming more and more developed, the resort needs to add more forces to ensure security, order, and safety for visitors.

Developing human resources for tourism and local communities: From the survey results on tourism human resources and local communities, the satisfaction of tourists with this factor is very high, reaching a very satisfied level. heart. This factor plays an important role in creating service quality. However, at present, there are not many types of services in the tourist area, so it cannot be fully evaluated.

The current tourism human resources of Binh Phuoc in general and the Ba Ra-Thac Mo site in particular are lacking in quantity and quality. Almost all tourist attractions do not have guides or narrators to meet the understanding needs of visitors. Human resources in accommodation and dining establishments are also almost untrained in professionalism, so they are not really professional in serving tourists. Therefore, it is necessary to create conditions for managers to learn to improve their management skills and then to improve the professional skills of staff working in the field of tourism services through training courses and professional training.

References

1. A. Parasuraman, Valarie A. Zeithaml. & Leonard L. Berry. (1985). A Coneeptual Model of Service Quality and Its Implications for Future Research. Journal of Marketing. 49, 41 – 50. doi: 10.1177/002224298504900403
2. A. Parasuraman, Valarie A. Zeithaml. & Leonard L. Berry. (1988). SERVQUAL: A Multiple – Item Scale for Measuring Consumer Perceptions of Service Quality. Journal of Marketing. 64, 12 – 40.
3. Cronin, J.J. & Taylor, S.A. (1992). Measuring service quality – a reexamination and extension. Journal of Marketing. 56 (3), p.55 – 68.
4. Binh Phuoc Provincial Statistics Office. (2021). Binh Phuoc Provincial Statistical Yearbook 2020. Binh Phuoc.
5. David Needham. (1996). Business for Higher Award. Oxford, England: Heinemann.
6. Dow, D., & Karunaratna, A. (2006). Developing a multidimensional instrument to measure psychic distance stimuli. Journal of International Business Studies. 37, 578-602.
7. Dinh, C. T., Pham, L. H. N., & Truong, Q. D. (2011). Examining domestic tourists' satisfaction with tourism in Soc Trang province. Can Tho University Journal of Science, 20a, 199 – 209.
8. Dang, T. T. L. (2015). Factors affecting satisfaction of tourists towards the destination Binh. Journal of Asian Business and Economic Studies, 26(9), 101 – 119.
9. General Statistics Office of Vietnam. (2021). Statistical Yearbook 2020. Vietnam.

10. Hair J.F, Anderson, R.E., Tatham, R.L., and Black, W.C. (2006). Multivariate data analysis. Prentice-Hall, International, Inc.
11. Hoang, T., Chu, N.M.N. (2008). Analyze research data with SPSS. Hong Duc Publishing House.
12. Hoang, T. T. H., & Le, T. T. X. (2015). Assess the satisfaction level of domestic tourists in Suoi Luong eco-tourism site, Da Nang city. Central Vietnamese Review of Social Sciences, 5(37), 11 – 19.
13. Hoang, T. T. (2015). The factors affecting tourists' satisfaction at tourist attractions in Ho Chi Minh City. Ho Chi Minh City University of Education Journal of Science. 10(76), 87– 97.doi: 10.54607/hcmue.js.0.10(76).708(2015)
14. John Tribe, Tim Snaith. (1998). From SERVQUAL to HOLSAT: Holiday satisfaction in Varadero, Cuba. Tourism Management, 19, 25 – 34.
15. Le, T. T., Nguyen, A. T., Vu, T. H. N., Tran, T. T., & Tran, H. C. (2014). Study on Domestic Tourists' Satisfaction with tourism services Quality at Duong Lam Ancient Village. Journal Science and Technology Development, 12(4), 620 – 634.
16. Nguyen, T. N., Tran, T. H. A., & Nguyen, T. D. M. (2015). Visitors' opinions about fruit farm tourism in the Mekong Delta of Vietnam. Can Tho University Journal of Science, 36 (2015), 84 – 91.
17. Nguyen, M. T., & Hoang, M. D. (2020). Service quality factors that impact the domestic tourists' satisfaction at Vung Tau Back Beach. Industry and Trade Magazine, 1, 236 – 242.
18. Nguyen, V. K., & Vong, T. N. (2020). Factors affecting the satisfaction of tourists with the quality of tourism services in La Gi town, Binh Thuan province. Industry and Trade Magazine, 29, 30, 286 – 293.
19. Nguyen, T. T. N. (2020). Analyzing factors affecting the satisfaction of domestic tourists visiting Kien Giang province. Industry and Trade Magazine, 29, 30, 253 – 258.
20. Nguyen, T. V., & Van, T. V. (2020). The impact of destination image on the satisfaction of tourists when they visit My Tho city, Tien Giang province. Industry and Trade Magazine, 25, 306 – 313.
21. Phuong, T. N. M. (2020). Factors affecting the satisfaction of tourists with eco-tourism sites in Ben Tre province. Economy & Forecast Review, 96 – 100.
22. Trinh, T. H., & Phan, T. B. H. (2020). Measuring perceived value, expected value and satisfaction level of domestic tourists for agro-tourism in Da Lat city. Asia – Pacific Economic Review, 76 – 78.
23. Vo, K. N. (2019). Some factors affect service quality attourist destinations in Tien Giang province. Can Tho University Journal of Science, 55, 67 – 77; doi: 10.22144/ctu.jsi.2019.082.

Emergence of buddhism as a global religion

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Buddhism as a religion has successfully impacted lives of millions of people across the world. It originated in India in 563 BCE and due to this factor it is predominantly centered around east and Southeast Asia. Lord Buddha explained his doctrines an a simple way. It has played important role in the day to day life of people. Beliefs in traditional customs and practices of societies in Asian countries are deeply rooted. There are many rituals followed from a long time which are unknowingly associated with Buddhist practiced but people are unaware of it. A data published in an article of Pew Research Centre in 2019 confirmed that 506 million people in the world practice Buddhism as a religion, it represents 6.6% of the world's population[6].

GOVERNMENT DATA OF COUNTRIES WITH HIGHEST PERCENTAGE OF BUDDHIST POPULATION

1. Cambodia- approx. 95% (Theravada Buddhism)[7]
2. Thailand – 85-95% (Theravada Buddhism)[8]
3. Myanmar- 90.1% [9] Section 361 0f the constitution states that "The Union recognizes the special position of Buddhism as the faith professes by the great majority of the citizens of the union."[5]
4. Bhutan – 84.3% [10]
5. Sri Lanka – 70.2 % [11]
6. Laos – 66%[12]
7. Mongolia- 51.7 % [13]
8. Japan – 66.6 % [14]
9. Singapore – 31.1%[11]
10. South Korea – 15.5%[15]
11. Vietnam – 14.91%[13]

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[6] Data taken from Pew Research Centre

[7] US department of state, Ministry of cult and religion (MCR) 2020 Report on International Religious Freedom: Cambodia.

[8] ibid

[9] Department of Population Ministry of Labour , Immigration and Population Myanmar (July 2016).The 2014 Myanmar Population and Housing Census Report Volume 2-C. pp. 12-15 [5] "Myanmar's Constitution of 2008". Constituteproject.org.

[10] "Bhutan, Religion and Social Profile".

[11] "South Asia: SRI LANKA". CIA The World Factbook. 24 May 2022

[12] " Religious Composition by Country" , Pew Research Center 2015

[13] "2020 Population and Housing Census" (PDF). National Statistical office of Mongolia.

[14] Population figures from the Agency for Cultural Affairs Religious Yearbook 2021, as of the end of 2020. [11] "Census of Population 2020: Religion" Department of Statistics Singapore. 16 June 2021.

[15] Population by Gender, Age and Religion – City/Country. Korean Statistical Information Service (in Korean). 2015 [13] U.S. Committee for Religions Affairs (C.R.A.), 2018.

THE MAKING OF BUDDHISM AS A GLOBAL RELIGION

From the time of inception of Buddhism various kings patronage and helped in the flourishment of religion, there are many examples of it in the ancient Indian history like the Kings Bimbisara, Suddhodana, and Prasenajita .The spread of Buddhist values beyond the borders of India was first started during the reign of Ashoka who sent missionaries to different regions of the world. Ashoka was fond of the ethical values and humanitarian approaches of Buddhism. The values of Buddhism emphasized on the peaceful coexistence of different societies. Ashoka influenced by the inclusive values of Buddhism and in order to promote those values he sent scholars to promote these values in different regions of the world. Yona Dhammarakshit to Aparantaka (Kathiawad region of Gujarat , Kachchh and Sindh) , Maharakkhita to Yona(Present day Greece) ,Sona and Uttara to Suvarnabhumi (Myanmar and Thailand) , Mahinda and Sanghamitra to Lakshadweep and Srilanka etc are some of the important names sent to different regions of the Indian Subcontinent. Apart from these countries it spread different part of the word (Europe, America, Africa etc.) after the Mahaparinivarma (death) of Buddha (near about 2800 years ago). At present at least 6% of the population of the world have follows the Buddhism as a religion.

GLOBAL IMPACT:

- Lifestyle
- Idea of State
- Idea of Environment

LIFESTYLE

Buddhism helped people across the globe to cultivate good human values. The value system enshrined in the knowledge system of Buddhism enabled people to practice good things which lead to happy life. The idea of freeing the mind from all kind of concerns and taking a path of nirvana is popular amongst the people. It is an all encompassing condition that includes an continuing sense of accomplishment and joy , and permeates every aspect of our lives, enabling us to live in the most valuable , contributive and constructive way of life. Through the practices of Buddhist values, mentally it makes us strong from the core determination point. Our belief in the moral and ethical values takes us to the path of satisfaction. In our day to day life through practicing noble thoughts we create a value based environment, which takes us to the path to achieve wisdom to excel at our workplace or at home. This contributes to the wellbeing of society as a whole. Societies in Japan strongly believe in the idea of compassion and gratitude which Buddhism stressed upon.

IDEA OF STATE

The Buddhist idea of state has its origin in the Digha Nikaya, which is an important text of Tripitaka. Idea of state comes under the domain of political theory and to establish a social order it is required. It is a common consensus among group of people to choose a person as an authority above them. The constitution of Bhutan was planned in a way to enshrine Buddhist values it its core. The current constitution of Bhutan is based on the Buddhist philosophy[16]. In the royal command of Government of Bhutan king stressed that the constitution must promote and protect the people work for their well being. He stated that the country must have a stable political system which can ensure peace and justice to its people[17]. Buddhist philosophy has parted itself from materialistic achievements and stressed and focused on the path of

[16] "Background". Government of Bhutan. Archived from the original.

[17] "Royal Command". Government of Bhutan. Archived from the original.

happiness. The government of Bhutan emphasized on this particular idea and instead of calculating Gross Domestic Product (GDP) Bhutanese law and provisions is based to promote Gross National Happiness (GNH) a fundamental principle of the constitution of Bhutan[18].

IDEA OF ENVIORNMENT

Buddhist populations across the globe have developed an environmental consciousness and there are enough resources in Buddhist literature for constructing environmental ethics. Various terms has been used by different scholars amongst them "Green Buddhism" has been found expression in several researches [19] . A systematic ethical concern regarding environmental consciousness has began taking shape and which can be viewed in many subheadings like – the nature of human being , the nature of ultimate reality or the metaphysics , ecological consciousness , living and non-living beings and values associated with them . Bhutan is very much committed towards its environment and as stated earlier that the country is very much committed towards Buddhist values. Bhutan preserves 60% of its land under strict forest cover; the best thing in this commitment is that Bhutan has succeeded in doing so.

CONCLUSION

We can say that Buddhism originated in Ancient India in specific time and circumstances and after a long span of time it spread all over the world rapidly. This religion has established theories and concept to resolve the problem of mankind. Conflict resolution, teaching of moral values, ethics etc. are the key factors which attract people towards the Buddhism. Abolition of desire is the key to free from all kind of problems, it advocates too. The time of king Ashoka (third Buddhist Council) it crossed the boundary of Indian Subcontinent and spread all over the world by leaps and bound. Today it is fast growing religion in the world because of its simplikcity and adaptability.

BIBLIOGRAPHY

- Kaza, Stephanie and Kenneth Kraft (eds). Dharma Rain: Sources of Buddhist Environmentalism. Boston: Shambhala, 2000.
- Hunt-Badiner, Alan (ed.). Dharma Gaia: A Harvest of Essays in Buddhism and Ecology. Berkeley: Parallax Press, 1990.
- Tucker, Mary Evelyn and Duncan Ryuken Williams (eds). Buddhism and Ecology. The Interconnection of Dharma and Deeds. Cambridge, MA: Harvard University Press, 1997.

[18] "Constitution of the kingdom of Bhutan" (PDF). Government of Bhutan.

[19] See Tucker and Williams; Kaza ; Kaza and Kraft ; Hunt – Badiner Dharma Gaia and Mindfulness in the Marketplace.

Estimating the Decoupling between Net Carbon Emissions and Construction Land and Its Driving Factors: Evidence from Shandong Province, China

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Abstract. Human activities and land transformation are important factors in the growth of carbon emissions. In recent years, construction land for urban use in China has expanded rapidly. At the same time, carbon emissions in China are among the highest in the world. However, little is known about the relationship between the two factors. This study seeks to estimate the carbon emissions and carbon sequestrations of various types of land based on the land cover data of 137 county-level administrative regions in Shandong Province, China, from 2000 to 2020. The study has estimated the carbon emissions for energy consumption using energy consumption data and night-time light images hence net carbon emissions. The Tapio decoupling coefficient was used to analyze the decoupling between the net carbon emissions and construction land, and where the model for the decoupling effort was constructed to explore the driving factors of decoupling. The results showed that the relationship between net carbon emissions and construction land evolved from an expansive negative decoupling type to a strong negative decoupling type. Spatially, most areas in the province featured an expansive negative decoupling, but the areas with a strong negative decoupling have gradually increased. The intensive rate of land use and efficiencies in technological innovation have restrained carbon emissions, and they have contributed to an ideal decoupling situation. Although the intensity of carbon emission and the size of the population have restrained carbon emissions, efforts for decoupling have faded. The degree of land use has facilitated carbon emissions, and in recent years, efforts have been made to achieve an ideal decoupling. The method for estimation of net carbon emissions devised in this research can lend itself to studies on other regions, and the conclusions provide a reference for China, going forward, to balance urbanization and carbon emissions.

Keywords: net carbon emissions; construction land; decoupling; driving factor; Shandong Province; China

1. Introduction

Climate warming in the 21st century is one of the major challenges facing society and addressing climate change has become a global concern. It is unequivocal that human activities cause climate change, and carbon dioxide emissions are the main factor in this process [1]. According to the "Special Report on Climate Change and Land" released by the Intergovernmental Panel on Climate Change (IPCC) in 2019, agriculture, forestry, and other land types account for 23% of greenhouse gas emissions, and the carbon dioxide absorbed by

natural land processes is almost equivalent to 1/3 of the carbon emissions released by fossil fuels and industry [2]. The use of land, it's structure, and the intensity of use are closely related to socioeconomic development and this profoundly impacts the ecological environment and the well-being of humans in a region [3, 4]. Therefore, rational regulation of land use to achieve carbon reduction goals becomes an important measure for sustainable development in countries around the world. With rapid urbanization worldwide, the expansion of construction land is inevitably accompanied by high carbon emissions due to energy consumption, and there is a contradiction between the two processes. Hence, exploring the relationship between carbon emissions and construction land is of great significance for green and low-carbon development and efficient land use; moreover, coordinating the relationship between the two processes is crucial for achieving sustainable human development [5].

The total carbon emissions for China in 2020 were 9.899 billion tons, accounting for 30.70% of global carbon emissions [6]. In September 2020, President Xi Jinping pointed out: "China is committed to ensuring carbon emissions peak by 2030 and achieving carbon neutrality by 2060" [7]. The "14th Five-Year Plan" of China proposes that the country`s ecological civil construction will focus on carbon reduction, thereby promoting a comprehensive green transformation of economic and social development [8]. At present, in China, the task for reducing carbon emissions is facing both domestic and international pressures. With the acceleration of urbanization in China, the scale of urban construction land has expanded, and some areas have even experienced disorderly expansion [9, 10]. Construction land has crowded out a large amount of ecological land covered with vegetation, thus weakening the carbon sink capacity of the earth's surface. The contradictions between construction land and non-construction land have become increasingly prominent. Therefore, does the expansion or reduction of construction land have an impact on carbon emissions, and to what extent? What other factors affect carbon emissions? To what extent do these factors contribute to the decoupling between carbon emissions and construction land? China, as a big carbon emitter [11], has only 30 years from carbon peaking to carbon neutrality. Based on the above questions and objectives, it is particularly important and urgent to conduct in-depth research on the relationship between carbon emissions and construction land.

Land is an important vehicle for terrestrial ecosystems, and various land use types are interdependent and inter-constrained. The expansion or reduction of construction land will cause changes in other land use types, and carbon emissions and carbon sequestrations will also change accordingly [12, 13]. Based on this, in terms of the acquisition of a carbon emissions dataset, this study has estimated the net carbon emissions from the perspective of carbon sinks and sources of land use, using the carbon emissions (sequestrations) of each land type and the carbon emissions for energy consumption associated with construction land. Thus, the net carbon emissions can be estimated more accurately and have a scientific basis.

In China, a country endowed with a vast territory and natural resources, economic development varies from one region to another, and carbon emissions also vary in space [14]. The country needs to take differentiated and refined carbon reduction measures according to local conditions. The administrative units at a county level constitute the third-level administrative region of China, and they are the basis for the delivery and distribution of power at a local level. Therefore, in terms of the scale of research, the smallest rank for the county-level administrative region was selected as the research unit. At the same time, the decoupling relationship between net carbon emissions and construction land was analyzed with the aid of the Tapio decoupling coefficient. Combined with the Kaya identity and the Log-Mean Divisia Index (LMDI), a decoupling effort model was constructed to explore further the factors influencing net carbon emissions and the driving effects of various factors on the decoupling of net carbon emissions and construction land. The findings of the study provide insights into the sustainable development of urbanization and carbon emissions in the county areas of the

country. Furthermore, the findings will help guide local governments in formulating targeted carbon emission reduction measures and provide a scientific reference for China to achieve "carbon peaking and carbon neutrality" as soon as possible.

2. Literature Review

Carbon emissions from land use refer to the carbon emissions and carbon absorption due to the transformation or maintenance of the land type, which are usually measured by the carbon emissions (sequestrations) linked to land use [15, 16]. Carbon emissions from energy consumption refer to those caused by the large amount of energy consumed by human activities on construction land [17, 18], and which have been estimated by input-output and the IPCC's emission factors [19-22]. Nevertheless, these methods fail to capture carbon emissions at a fine scale. Therefore, many studies have tried to estimate the carbon emissions from energy consumption using night-time light images. In 2000, Doll et al. were the first to confirm that there was a significant correlation between night-time light brightness and carbon emissions [23]. Then, Elvidge et al. investigated the relationship between night-time light brightness and the energy associated with carbon emissions in 200 countries around the world, this providing an empirical reference for simulating carbon emissions with night-time light data [24]. Ambreen et al. found that the carbon dioxide concentration and night-time light brightness of cities in India were both high, while those of villages were both low, showing that night-time light images can be used as a basis for estimating carbon emissions [25]. In recent years, studies in China have begun to use energy consumption data and night-time light images to estimate carbon emissions. For example, Su et al. were the first to estimate the carbon emissions of construction land for cities at a prefecture level in China based on the Defense Meteorological Satellite Program/Operational Linescan System (DMSP/OLS) night-time light images, this study made up for the incomplete statistics on national carbon emissions [26]. Xiao et al. used the DMSP/OLS global stable night-time light data to simulate the energy consumption at the provincial level in China, and provided a useful reference in monitoring and assessing provincial energy consumption [27]. Du et al. estimated the carbon emissions of 289 cities in China using DMSP/OLS, National Polar-orbiting Operational Environmental Satellite System Preparatory Project /Visible Infrared Imaging Radiometer Suite (NPP/VIIRS) night-time light images, and carbon emissions from energy consumption [28].

As a prelude to reducing carbon emissions, researchers have explored the relationship between carbon emissions and land use. An early study showed that frequent changes in land use were an important cause of increased carbon emissions [29]. Land use and land cover change (LUCC) are significantly associated with deforestation, the loss of farmland, and the expansion of built-up land [30]. The conversion of land from pasture or forest to arable land will lead to a large increase in carbon emissions [31]. With the development of urbanization, the further occupation of arable land for construction will also lead to a large amount of carbon emissions [32]. Studies have confirmed that there was a significant correlation between urban non-agricultural land and carbon emissions [33]. Controlling the expansion of construction land and reducing the area of arable land occupied by construction land could effectively control the increase in carbon emissions [34]. With acceleration of urbanization of land, China's structure, intensity, and efficiency of land use have changed. Feng and Guo et al. studied LUCC and carbon emissions of cities and showed that the increase in construction land and the decrease in vegetation cover led to a significant decline in carbon storage [35, 36]. Zhang et al. confirmed that there was a two-way causal relationship between the quality of land urbanization and carbon emissions, and the former had a negative impact on carbon emissions in various provinces [37]. Tang et al. believed that low-level industrial development and land use management promote the increase of carbon emissions at the extensive land use stage, however, high-quality industrial development and land use optimization lower carbon emissions at the intensive land use stage [38]. A study has also demonstrated that intensive

land use could reduce carbon emissions more effectively than extensive land use [39]. For example, Stone, using data from 45 major U.S. cities, found that disorderly expanding cities generated more air pollutants than that of compact cities [40]. Makido et al. used the Landscape Pattern Index to measure the compactness of land use in 15 Japanese cities, revealing that the carbon emissions of compact cities were lower than cities that had undergone disorderly expansion [41].

The land is the carrier of terrestrial ecosystems. Extensive attention has been paid to the impact of land use/cover on carbon emissions. Research has demonstrated that there were significant differences in the carbon sink and carbon source capabilities between different land types, and the conversion from one type to another inevitably led to changes in carbon emissions [42]. Land use has become an important factor affecting the distribution of surface carbon dioxide concentrations [43]. The land is also the spatial carrier of human activities. Some researchers believe that carbon emissions are affected by factors other than changes in land use. In particular, the carbon emissions associated with construction land are the result of multiple factors [44]. Methods such as the Stochastic Impacts by Regression on Population, Affluence, and the STochastic Impacts by Regression on Population, Affluence, and Technology (STIRPAT) model, the multiple regression model, and grey correlation analysis have been used to analyze the factors influencing regional carbon emissions [45-47]. In 2004, Ang pointed out that the LMDI decomposition approach, which does not produce residual errors, is more suitable for factor analysis of time series than other methods [48]. Since then, this method has been used widely to explore the factors influencing carbon emissions [49, 50]. The factors influencing carbon emissions, such as economic development, industrial structure, carbon emission intensity, intensive rate of land use, the rate of urbanization, energy structure, and the size of the population, have been selected for decomposition research [51-53].

To sum up, detailed theoretical and empirical studies have been conducted on carbon emissions and land use. However, there are still some problems that need to be addressed at the outset. First, existing studies on carbon emissions should give more attention to energy-related carbon emissions and ignore the carbon sequestration effect of land cover. Second, existing studies on carbon emissions and land use are mostly limited to national, provincial, or the municipal scale, and little attention is paid to the county level emissions, which makes it difficult to accurately formulate carbon reduction measures. Third, among the studies on decoupling, the existing studies mostly analyzed the relationships between carbon emissions and economic growth[54-57], the decoupling relationship between China's net carbon emissions and construction land remains unclear. Little is known about the impact of the expansion or reduction of construction land on carbon emissions and the driving factors of the decoupling between the two factors. The major contributions of this study are as follows. First, we factor in the carbon source and carbon sink capacities of different land types and conduct empirical research using net carbon emissions. Second, the research scale is expanded to account for the decoupling between net carbon emissions and construction land at the fine county scale. Finally, we combine the Tapio decoupling coefficient, the Kaya identity, and the LMDI model to build a systematic framework, which is used to analyze the factors influencing net carbon emissions and the driving effects of each factor on the decoupling between the two.

3. Materials and Methods

3.1. Study Area

The research used the county level administrative units, the smallest administrative level in China as the study area and selected specifically all county-level administrative regions in Shandong Province. The province, located on the eastern coast of China and in the lower reaches of the Yellow River, is an important transportation hub along the "Belt and Road" [58]. The province plays a leading role in ecological protection and high-quality development

of the Yellow River Basin and has obvious advantages in its location for this research [59]. At present, Shandong Province is in the process of rapid urbanization including an expansion of urban construction land. Data from the sixth and seventh national censuses show that Shandong province has the second largest population in the country after Guangdong province for the period 2000-2020. In 2020, Shandong Province ranked third in the country in terms of total economic output, and the growth rate for the total value of imports and exports of goods was generally among the highest in the country, making the region one of the most promising and dynamic regions for economic development in the country. However, the economic structure of Shandong Province is dominated by industry including heavy chemical industries. According to the "China Energy Statistical Yearbook" and the “China Emission Accounts and Datasets (CEADs)” [60], from 2000 to 2012, Shandong Province was ranked first in China in terms of carbon emissions from an energy consumption standpoint. From 2013 to 2020, it was second in the country below Shanxi Province, a major coal producer. As a province with a large economy, a large population, and large carbon emissions, the relationship between Shandong's development and carbon emissions is very typical in China, and the task of realizing low-carbon development is clearly more challenging than that of other provinces.

County level administrative units in China include municipal districts, county-level cities, counties, etc. As of 2020, Shandong province has 137 county-level administrative units, including 57 municipal districts, 27 county-level cities, and 53 counties. Considering that the administrative division of Shandong Province was adjusted during the study period to ensure the uniformity and accessibility of the study data, the study area was defined uniformly according to the administrative division of Shandong Province in 2020.

3.2. Data Sources

The remote sensing data on land use were obtained from the Landsat TM images of 2000, 2005, 2010, 2015, and 2020 provided by the Resource and Environment Science and Data Center, Chinese Academy of Sciences at a resolution of 30 m. The night-time light data were sourced from the National Geophysical Data Center of the National Oceanic and Atmospheric Administration. The energy consumption data and the standard coal coefficient were from the China Energy Statistical Yearbook (2001-2021). Other data came from the Shandong Statistical Yearbook (2001-20201), the Shandong Urbanization Development Report (2001-2021), and the China National Intellectual Property Administration (CNIPA).

3.3. Methodology

This study estimated net carbon emissions from the perspective of carbon sinks and sources of land use, using the carbon emissions (sequestrations) of each land type and the carbon emissions associated with energy consumption on construction land. The net carbon emissions were determined by the difference between the carbon sink and the carbon source of land use. Carbon sinks refer to the storage and absorption of carbon, and forest land, grassland, water bodies, and unused land are carbon sinks. Carbon sources refer to the intensity of carbon emissions, and arable land and construction land are carbon sources [61]. Among them, the land type in this work refers mainly to the Status and Classification of Land Use (GB/T21010-2007), in combination with six first-level land categories, including arable land, forest land, grassland, water bodies, construction land, and unused land based on analysis of the Landsat TM images. Carbon emissions from land use refer to carbon emissions and carbon sequestration caused by soil and vegetation of arable land, forest land, grassland, water bodies, and unused land, which, in this study, were measured using the carbon emission (sequestration) coefficient. Carbon emissions from energy consumption are the carbon emissions caused by energy consumption from human activities undertaken on construction land [62]. We fitted Shandong Province’s carbon emissions from energy consumption with the night-time light data to obtain five regression equations. A double-precision test was

performed on the carbon emissions measured by each equation, and the most suitable equation was selected to estimate the carbon emissions from energy consumption at the county level in Shandong Province from 2000 to 2020. Then, the Tapio decoupling coefficient was used to analyze the relationship between the net carbon emissions and construction land. A decoupling efforts model was constructed based on the Tapio decoupling coefficient, the Kaya identity, and the LMDI model to explore the driving factors for the decoupling between net carbon emissions and construction land. The methodology used is outlined in Figure 1.

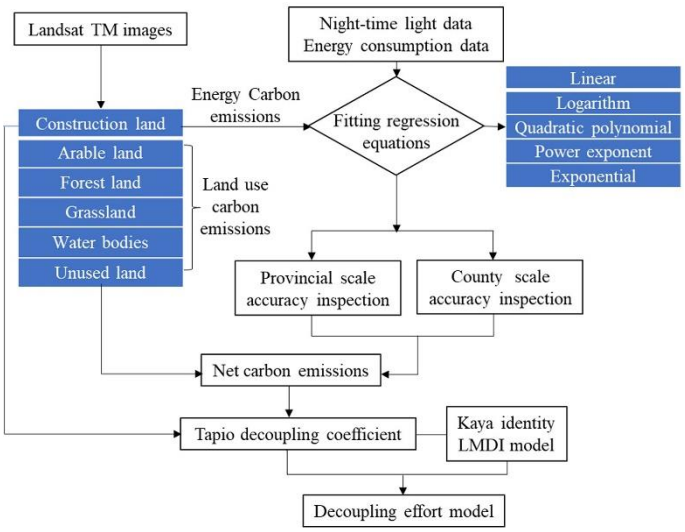

Figure 1. Flowchart of the methodology.

3.3.1. Estimation of Net Carbon Emissions

(1) Estimation of carbon emissions from land use

As previously described [63, 64], the carbon emission (sequestration) coefficients for arable land, forest land, grassland, water bodies, and unused land were obtained according to the latitude, longitude, and geographical location of Shandong Province, which were 0.422 t/(hm2·a) for arable land, -0.644 t/(hm2·a) for forest land, -0.021 t/(hm2·a) for grassland, 0.248 t/(hm2·a) for water bodies, and -0.005 t/(hm2·a) for unused land using the following equation:

$$E_x = \sum L_i \times \delta_i \quad (1)$$

where *Ex* represents the carbon emissions from land use, *i* is the land type. *Li* refers to the area of each land type. *δi* means the carbon emission (sequestration) coefficient of each land type.

(2) Estimation of carbon emissions from energy consumption

Previous studies have revealed a significant correlation between the intensity of night-time light and energy consumption due to fossil fuel emissions, and economic activity; further, night-time light images could effectively reflect the intensity of human activities [65, 66]. Therefore, as previously described [67, 68], the carbon emissions from energy consumption at the county level were estimated by the carbon emissions from energy consumption and night-time light data in Shandong Province. The process was as follows, namely, the preprocessing and fitting correction of night-time light images. First, the DMSP/OLS night-time light images from 2000 to 2013 were reprojected, resampled, and cropped to obtain the light data of China's administrative boundaries. Jixi City, with a relatively stable socioeconomic development, was selected as the invariant target area, and the satellite data of F162007 were used as a reference dataset to construct a regression model with other years.

Intra-year fusion and inter-year continuous correction were performed. Second, the annual synthesis, reprojection, resampling, and cropping of the NPP/VIIRS night-time light images from 2012 to 2020 were carried out to make them match the spatial resolution of the DMSP/OLS data. Outliers in the invariant area were removed, and the intra-year fusion and inter-year continuous correction were performed. Finally, DMSP/OLS and NPP/VIIRS night-time light data at the county scale for Shandong Province in 2012 and 2013 were counted, respectively. The regression relationship between DMSP/OLS and NPP/VIIRS data at the county scale for 2012 and 2013 was constructed using the county as the calibration unit, with the DMSP/OLS data as the reference and the NPP/VIIRS data as the calibration object. Considering the accuracy at the county scale, a linear regression without an intercept was chosen. As can be seen from Figure 2, the regression equation was Y = 0.880X where Y is the DMSP/OLS night-time light data for 2012 and 2013 and X is the NPP/VIIRS night-time light data for 2012 and 2013. The R_2 value was 0.886, which passes the 1% significance test, and the fit is good. The inter-year continuous correction was performed on the DMSP/OLS data from 2000 to 2013 and the NPP/VIIRS data from 2014 to 2020 was based on this regression equation. Based on the above calculations, the night-time light data at the county level scale in Shandong Province were obtained for 2000-2020.

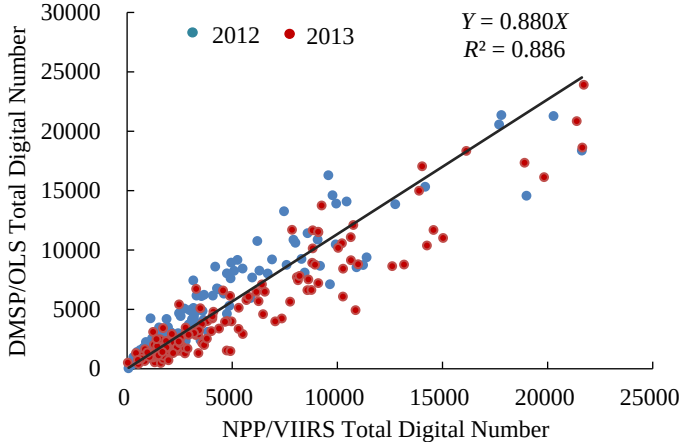

Figure 2. Fitting relationship between the DMSP/OLS and the NPP/VIIRS between 2012 and 2013.

Measurement of carbon emissions from energy consumption. Based on the carbon emission coefficient for energy consumption provided in the 2006 IPCC National Greenhouse Gas Inventory Guidelines [69], the carbon emissions from energy consumption in Shandong Province from 2000 to 2020 was calculated using the following equation:

$$E_y = \frac{44}{12} \times \sum E_i \times \theta_i \times \mu_i \quad (2)$$

where *Ey* represents the carbon emissions from energy consumption. *Ei* is the consumption due to various energy sources. *θi* refers to the standard coal coefficient of various energy sources. *μi* means the carbon emission coefficient for various energy sources. The standard coal coefficient and carbon emission coefficient for various energy sources are shown in Table 1.

Table 1. Carbon emission coefficients for energy consumption.

Types of energy	Standard coal coefficient	Carbon emission coefficient	Types of energy	Standard coal coefficient	Carbon emission coefficient
Raw coal	0.714	0.756	Natural gas	1.330	0.448

Coke	0.971	0.855	Heating power	0.034	0.670
Crude oil	1.429	0.586	Electricity	0.345	0.272
Petrol	1.471	0.554	Finished coal	0.900	0.756
Paraffin	1.471	0.571	Coke oven gas	0.614	0.355
Diesel	1.457	0.592	Liquefied petroleum gas	1.714	0.504
Fuel oil	1.429	0.619	Refinery gas	1.571	0.460

[1] The unit of heat converted into standard coal is kg standard coal/million J. The unit of electricity conversion is kg/kWh.

Estimation of carbon emissions and accuracy test. The total night-time light and carbon emissions for energy consumption in Shandong Province were fitted to build linear, logarithmic, quadratic polynomial, power exponential, and exponential fitting equations. To ensure the reliability of the fitted carbon emission values, the Mean Relative Error (MRE) of the carbon emissions in Shandong Province fitted by each equation and the carbon emissions from energy consumption calculated from the statistical data were calculated, that is, the MRE at the provincial scale. The night-time light values for the various regions were substituted into the regression equation. Considering the accuracy at the county scale, the regression equation without intercept was used for calculation. The weighted summation of the fitted carbon emissions in each region was used to obtain the fitted value of carbon emissions in Shandong Province, which was then tested for accuracy with reference to the carbon emissions from energy consumption, that is, the MRE at the county level scale, as shown in Table 2.

Table 2. Fitting equation for carbon emissions from energy consumption.

Model categories	**Fitting equation**	***p***	***R^2***	**Provincial scale MRE (%)**	**County scale MRE (%)**
Linear	Y=0.058x+16846.745	0.000	0.764	20.075	26.726
Logarithm	Y=35034.163lnx-413160.777	0.000	0.865	14.362	/
Quadratic polynomial	$Y=0.152x-6.618E-8x^2-13347.298$	0.000	0.877	12.788	55.265
Power exponent	$Y=0.428x^{0.875}$	0.000	0.856	15.190	76.165
Exponential	$Y=20611.685e^{X1.287E-6}$	0.000	0.691	23.190	/

[1] Y is carbon emissions from energy consumption and X is the total digital number of night-time light date.

Table 2 indicates that the regression coefficients of the five fitting equations were all significant at the 1% level, where R^2 was greater than 0.65, indicating a good degree of fit. The accuracy test at the county level indicated that the MRE for carbon emissions fitted by the quadratic polynomial and the power exponential equations and that calculated by the statistical data were too large, while the carbon emissions for some areas fitted by logarithmic and exponential equations already exceeded the carbon emissions calculated by the province's statistical data, which clearly was not possible and thus was excluded. The MRE for the carbon emissions fitted by the linear regression equation and the carbon emissions calculated by the statistical data were smaller, showing better stability. Thus, it is concluded that the nonlinear regression equation was not suitable for estimating carbon emissions at the county level.

Therefore, a linear regression equation was used to estimate carbon emissions from energy consumption.

3.3.2. Tapio Decoupling Coefficient

In 2005, when exploring the relationship between greenhouse gas emissions and economic growth in Europe, Tapio proposed the use of an alternative decoupling coefficient [70]. Compared with the Organization for Economic Co-operation and Development (OECD) decoupling coefficient, the Tapio decoupling coefficient overcomes the problem of base period selection and measures the decoupling relationship more accurately. In recent years, it has been widely used to explore the relationship between socioeconomic development and the environment [71, 72]. Therefore, the Tapio decoupling coefficient was used to analyze the relationship between net carbon emissions and construction land using the following equation:

$$T=\frac{\Delta CE}{\Delta LC}=\frac{(CE_n-CE_0)/CE_0}{(LC_n-LC_0)/LC_0} \quad (3)$$

where T represents the decoupling coefficient. ΔLC refers to the rate of change in construction land. ΔCE means the rate of change in net carbon emissions. CE_n and LC_n represent the net carbon emissions and the area of construction land at the end of the study. CE_O and LC_O stand for the net carbon emissions and area of construction land for the base period of the study.

Tapio has classified decoupling relationships into eight categories according to the decoupling coefficient, as shown in Figure 3. Strong decoupling means that *CE* is declining while the *LC* is growing. Recessive decoupling means that both the *LC* and *CE* are declining, and the rate of decline for *LC* is slower than that for *CE*. Weak decoupling means that both the *LC* and *CE* are growing, and the rate of growth for *LC* is faster than that for *CE*. Strong negative decoupling means that *CE* is growing while *LC* is declining. Expansive negative decoupling means that both the *LC* and *CE* are growing, and the growth rate for *LC* is slower than that for *CE*. Weak negative decoupling means that both the *CE* and *LC* are declining, and the rate of decline of *LC* is faster than that for *CE*. Expansive coupling means that *LC* and *CE* are growing at similar rates. Recessive coupling means that *LC* and *CE* are falling at a similar rate.

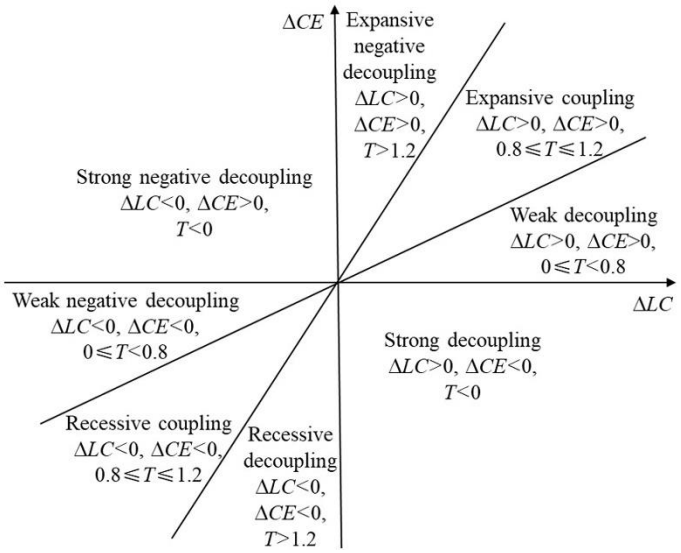

Figure 3. Classification criteria for decoupling relationships.

3.3.3. Decoupling Effort Model

In 1989, Yoichi Kaya proposed the Kaya identity at the IPCC International Symposium, which established an identity relationship between carbon dioxide produced by human activities and factors such as the economy and population [73]. Human activities are the main source of carbon emissions. Based on the Kaya identity and the LMDI model [74], a correlation between net carbon emissions and eight factors, including the intensity of carbon emissions, economic scale, the rate of intensive land use, industrial structure, the efficiency of technological innovation, the intensity of technological innovation, the size of the population, and the degree of land was used to explore the impact of each factor on net carbon emissions. Carbon emission intensity (β_1) refers to the carbon emissions released per unit of economic output and is an important indicator of the relationship between economic development and the environment, characterizing the impact of each region's level of economic development on net carbon emissions. The economic scale (β_2) was a measure of the economic output generated per unit of built-up land and measures the impact of economic concentration and development on net carbon emissions. The rate of intensive land use (β_3) is expressed as the area of land used for construction per unit of non-agricultural output and measures the impact of the economy and the intensive use of the resources of construction land on net carbon emissions. Industrial structure (β_4) is the basis for the orderly operation of regional production and life. Secondary and tertiary industries are important sources of carbon emissions. Based on the impact of industrial structure on net carbon emissions and was measured using the share of the value of non-agricultural industrial output. This study relied on the number of patents granted to indirectly characterize the financial investment in science and technology innovation, the investment in research personnel, and other related inputs [75]. Among them, the technological innovation efficiency (β_5) gives a measure of the impact of the investment benefit of scientific and technological innovation on net carbon emissions using the economic output representation of the unit of patent authorization. The technological innovation intensity (β_6) was characterized by the per capita patent authorization amount to characterize the impact of the level of scientific and technological innovation on net carbon emissions. The size of the population (β_7) was used to characterize the impact of population density on net carbon emissions by measuring the number of people living on a unit of construction land and the regional differences in the population distribution. The intensity of land use (β_L) was a measure of the direct impact on net carbon emissions of the expansion or reduction of construction land during rapid urbanization, using the built-up area as a proxy as follows. The equation for the Kaya identity is:

$$C=\sum_i(\beta_1\times\beta_2\times\beta_3\times\beta_4\times\beta_5\times\beta_6\times\beta_7\times\beta_L)=\sum_i\frac{C_i}{GDP_i}\times\frac{GDP_i}{L_i}\times\frac{L_i}{GDP_i^*}\times\frac{GDP_i^*}{GDP_i}\times\frac{GDP_i}{I_i}\times\frac{I_i}{P_i}\times\frac{P_i}{L_i}\times L_i \qquad (4)$$

where C is the net carbon emissions for Shandong Province. C_i refers to the net carbon emissions for the region i. GDP_i means the gross domestic product of the region i. L_i is the area of construction land for the region i. GDP_i* is the value of the non-agricultural output for region i. I_i is the number of patents granted for the region i. P_i is the number of people resident in the region i.

To further explore the driving effect of various factors on the decoupling relationship, the decoupling effort model was constructed in combination with the Tapio decoupling coefficient and the LMDI model [76], as indicated in Figure 4.

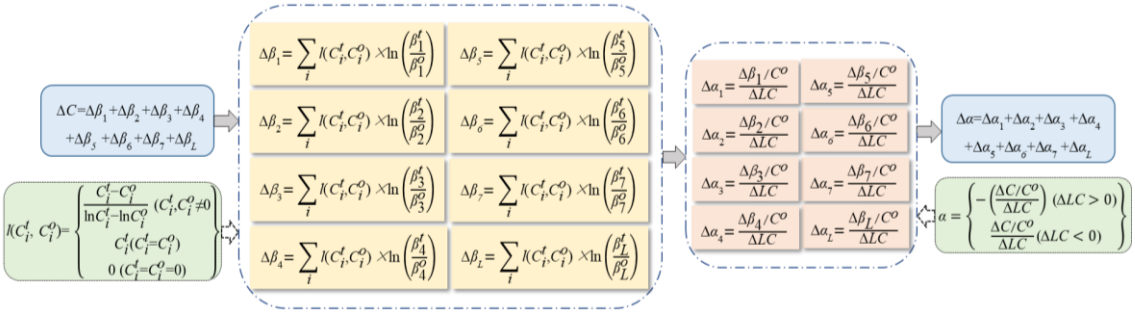

Figure 4. *The flowchart for the decoupling effort model.*

Where $\Delta\beta_1$, $\Delta\beta_2$, $\Delta\beta_3$, $\Delta\beta_4$, $\Delta\beta_5$, $\Delta\beta_6$, $\Delta\beta_7$, and $\Delta\beta_L$ refer to changes in the carbon emissions due to changes in the intensity of carbon emissions, the economic scale, the rate of intensive land use, industrial structure, the efficiency of technological innovation, the intensity of technological innovation, the size of the population, and the degree of land use, respectively. ΔC stands for changes in carbon emissions due to the total effects. T and o represent the corresponding variables at the end of the study and the base period, respectively. A is the decoupling effort index. $\Delta\alpha_1$, $\Delta\alpha_2$, $\Delta\alpha_3$, $\Delta\alpha_4$, $\Delta\alpha_5$, $\Delta\alpha_6$, $\Delta\alpha_7$ and $\Delta\alpha_L$ represent the decoupling effort index for the intensity of carbon emissions, the economic scale, the rate of intensive land use, industrial structure, the efficiency of technological innovation, the intensity of technological innovation, the size of the population, and degree of land use, respectively. $\Delta\alpha$ refers to the total decoupling effort index. If $\alpha \leq 0$, it means no decoupling efforts; in other words, the driving factor does not promote decoupling, but it does increase carbon emissions. If $\alpha \geq 1$, this means strong decoupling efforts are in play, and the driving factor promotes ideal decoupling. If $0<\alpha<1$, this means weak decoupling efforts, and the driving factors promote decoupling, but facilitation is weaker than that of the changes in construction land.

4. Results

4.1. Spatiotemporal Evolution of Land Types

The spatial evolution pattern for the different land types in Shandong Province from 2000 to 2020 was obtained based on analysis of the Landsat TM images. As shown in Figure 5, the area of construction land was second only to arable land, and its proportion increased by 4.772% from 2000 to 2020. Spatially, this expansion happened mainly along the Qingdao-Jinan Railway, the Yellow River Delta, and the coastal areas of the Shandong Peninsula. The most remarkable expansion was observed from 2015 to 2020; the area of construction land was reduced in the Yellow River Delta and the coastal areas of Binzhou, indicating that the wetland restoration project concerning aquaculture in these areas was an immediate success. Arable land is the main land type in Shandong Province. Its share decreased by 1.984% from 2000 to 2020, and arable land became fragmented spatially. Forest land and grassland were distributed mostly in the mountainous and hilly areas of central, southern, and eastern Shandong, from 2005 to 2015, and both forest land and grassland were degraded, especially the grassland in the Yellow River Delta. In recent years, affected by the policy of "returning farmland to forest land and grassland", forest land and grassland expanded slightly from 2015 to 2020. From 2000 to 2020, the proportion of water bodies increased by 1.914%, mainly in Laizhou Bay, the Yellow River Delta, and the coastal areas of Binzhou. The unused land was distributed mainly in the Yellow River Delta, whose proportion decreased by 0.807% from 2000 to 2020.

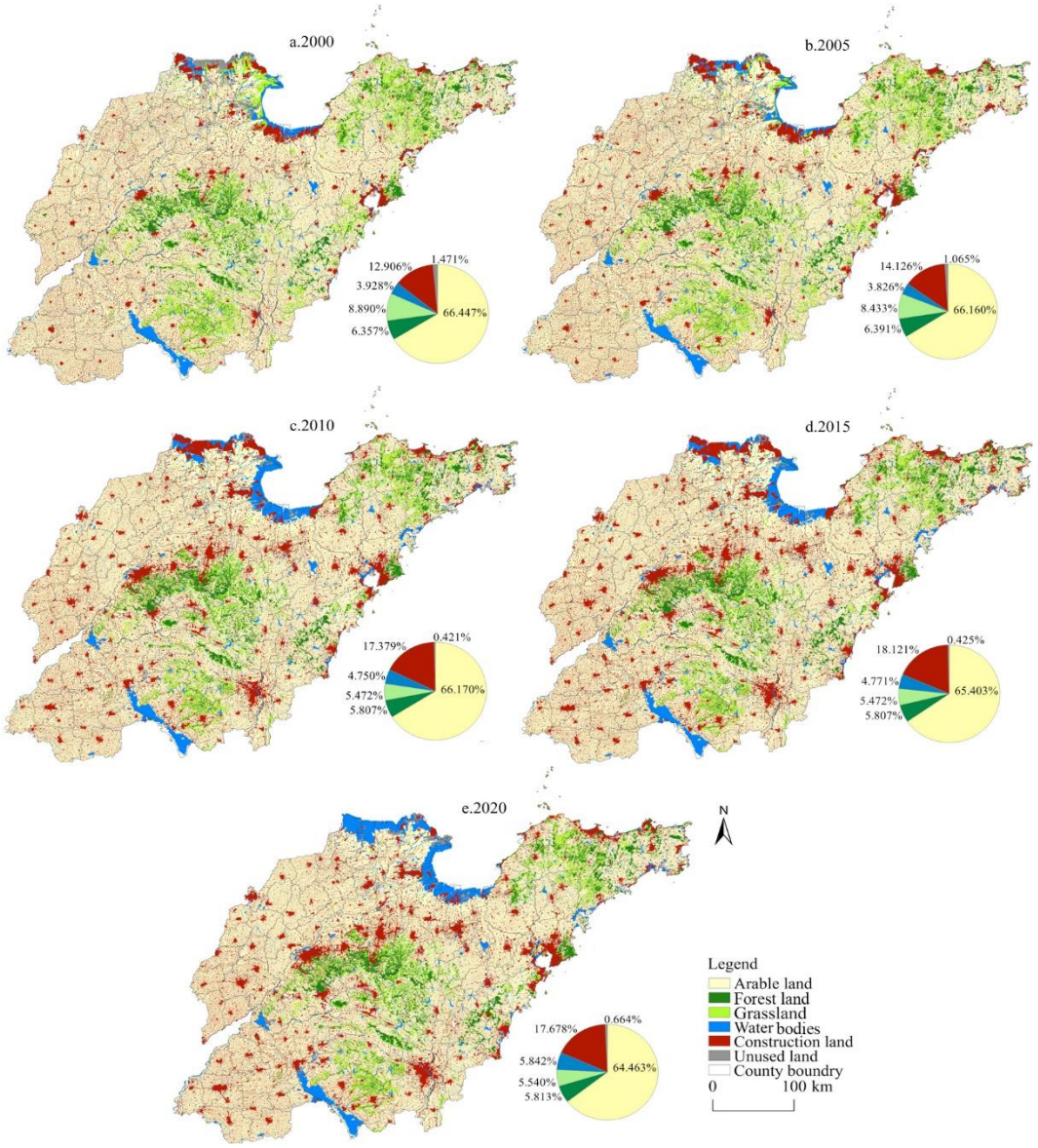

Figure 5. Spatial distribution patterns of land types in Shandong Province.

4.2. Spatiotemporal Evolution of Net Carbon Emissions

The net carbon emissions for Shandong Province were obtained by estimating the carbon emissions from land use and energy consumption. As shown in Table 3, the net carbon emissions increased gradually from 2000 to 2020, and where the carbon sinks of forest land accounted for more than 70% of the total, indicating that the carbon sink capacity was strong; the grassland, water bodies, and unused land had less carbon sinks; the carbon emissions released by construction land accounted for more than 95% of the total carbon emissions, and represented the main source of carbon emissions, whereas the carbon emissions of arable land declined but with some fluctuation. From 2000 to 2020, the proportion of the total carbon sources that could be offset by carbon sinks fluctuated between 0.1% and 0.5%, and the total carbon sources far exceeded the carbon sinks.

Table 3. Carbon emissions of different land types in Shandong Province (10000 t).

Carbon emissions	2000	2005	2010	2015	2020
Construction land	17320.64	42125.053	57167.141	61531.094	79969.061
Arable land	436.832	432.556	432.635	427.608	422.824
Forest land	-63.781	-63.761	-57.94	-57.944	-58.182

Grassland	-2.908	-2.744	-1.78	-1.78	-1.808
Water bodies	-15.175	-14.701	-18.252	-18.331	-22.518
Unused land	-0.115	-0.082	-0.033	-0.033	-0.052
Total carbon sinks	-81.979	-81.289	-78.005	-78.088	-82.560
Total carbon sources	17757.472	42557.609	57599.776	61958.702	80391.885
Net carbon emissions	17675.493	42476.321	57521.771	61880.614	80309.325

The net carbon emissions for various regions in Shandong Province were classified manually into five levels: weak emission, low emission, medium emission, high emission, and strong emission. As shown in Figure 6, the increase in the levels of carbon emission from 2000 to 2020 first appeared in the municipal districts, resulting in the formation of a carbon emission hotspots centering on municipal districts. The spatial distribution tended to cluster from points into surfaces over time, and the areas with low emission and medium emission gradually increased, thus forming two high emission centers in Jinan and Qingdao.

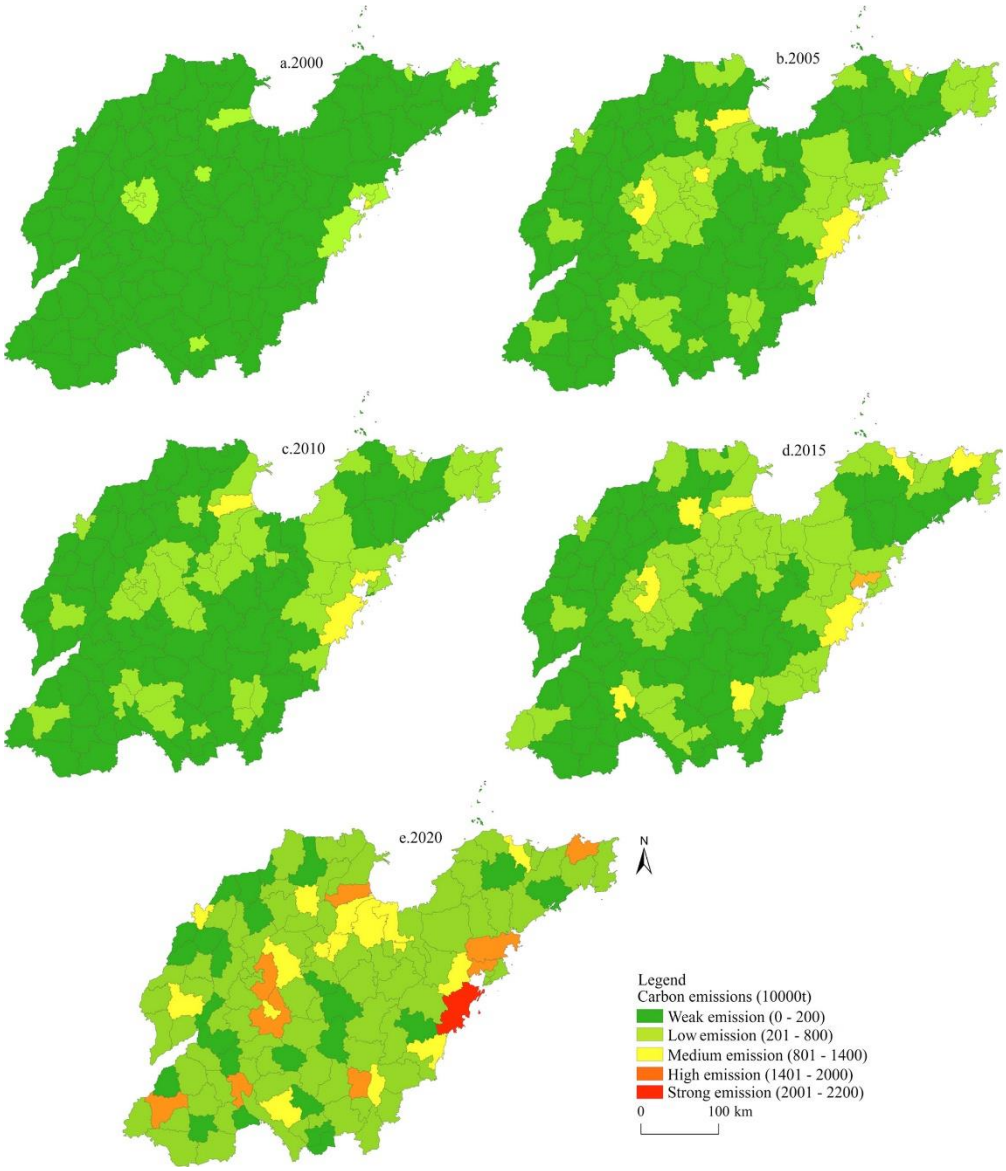

Figure 6. Spatial evolution pattern for net carbon emissions in Shandong Province from 2000 to 2020.

4.3. Decoupling between Net Carbon Emissions and Construction Land

4.3.1. Temporal evolution of the decoupling relationship

The decoupling between net carbon emissions and construction land in Shandong Province was calculated using Equation (3). Table 4 demonstrated that the decoupling between net carbon emissions and construction land in 2000-2005, 2005-2010, and 2010-2015 was expansive negative decoupling. In other words, both the area of construction land and net carbon emissions increased, but the net carbon emissions increased faster than the area of construction land. From 2015 to 2020, the decoupling evolved into a strong negative decoupling, indicating that the construction land decreased in Shandong Province in recent years, but carbon emissions were still increasing. In general, the decoupling between net carbon emissions and construction land from 2000 to 2020 was expansive negative decoupling. This showed that the relationship between net carbon emissions and construction land was unstable, and this was not conducive to the realization of carbon peaking and carbon neutrality goals. However, the reduction in construction land has helped to reduce carbon emissions and the decoupling relationship has begun to change.

Table 4. Decoupling between net carbon emissions and construction land.

Study period	ΔLC	ΔCE	T	Decoupling relationships
2000-2005	0.088	1.403	15.856	Expansive negative decoupling
2005-2010	0.230	0.354	1.538	Expansive negative decoupling
2010-2015	0.043	0.076	1.775	Expansive negative decoupling
2015-2020	-0.021	0.298	-13.986	Strong negative decoupling
2000-2020	0.367	3.544	9.664	Expansive negative decoupling

4.3.2. Spatial evolution of the decoupling relationship

To analyze the spatial evolution of the decoupling between the net carbon emissions and construction land in Shandong Province, the decoupling in the five-time periods was characterized spatially. As shown in Figure 7, the decoupling between the net carbon emissions and construction land in most areas of the province from 2000 to 2005 was expansive negative decoupling. From 2005 to 2010, the areas with expansive negative decoupling decreased, while the areas with strong decoupling and weak decoupling increased significantly, and most of them were concentrated in municipal districts. As shown in Figure 5, at this stage, the construction land in Shandong Province began to expand substantially from the center of municipal districts to the periphery. However, the speed of infrastructure construction and economic development brought about by the rapidly expanding construction land did not match it, and there was a lag in carbon emissions from energy consumption, thus enabling these regions to show an ideal decoupling. From 2010 to 2015, the areas with strong decoupling and weak decoupling decreased, and the growth rate of net carbon emissions in most areas of the province was still faster than that of construction land. From 2015 to 2020, the areas with expansive negative decoupling still dominated; however, the areas with strong negative decoupling expanded significantly, and these were concentrated mainly in the Yellow River Delta. This indicated that the construction land in these areas began to shrink, but the net carbon emissions were still increasing in recent years. In general, there was an expansive negative decoupling between net carbon emissions and construction land from 2000 to 2020 in most parts of the province. Net carbon emissions increased with the expansion of construction land, and the growth rate of net carbon emissions was faster than that of construction land. In addition, Hekou District, Zhanhua District, Wudi County, Lingcheng District, Ningjin County, Linyi County, Dong'e County, Gaoqing County, Shouguang City, Changyi City, and Taierzhuang District exhibited a strong negative decoupling. Licang District in Qingdao City had a weak decoupling, meaning that the growth rate of net carbon

emissions was slower than that of construction land. Shinan District and Shibei District demonstrated a strong decoupling, with an expansion of construction land and a reduction of net carbon emissions. It can be seen that net carbon emissions in these areas have not increased in line with the expansion of construction land. As the first low-carbon pilot city in Shandong Province, Qingdao has witnessed, in recent years, a significant decline in carbon emissions.

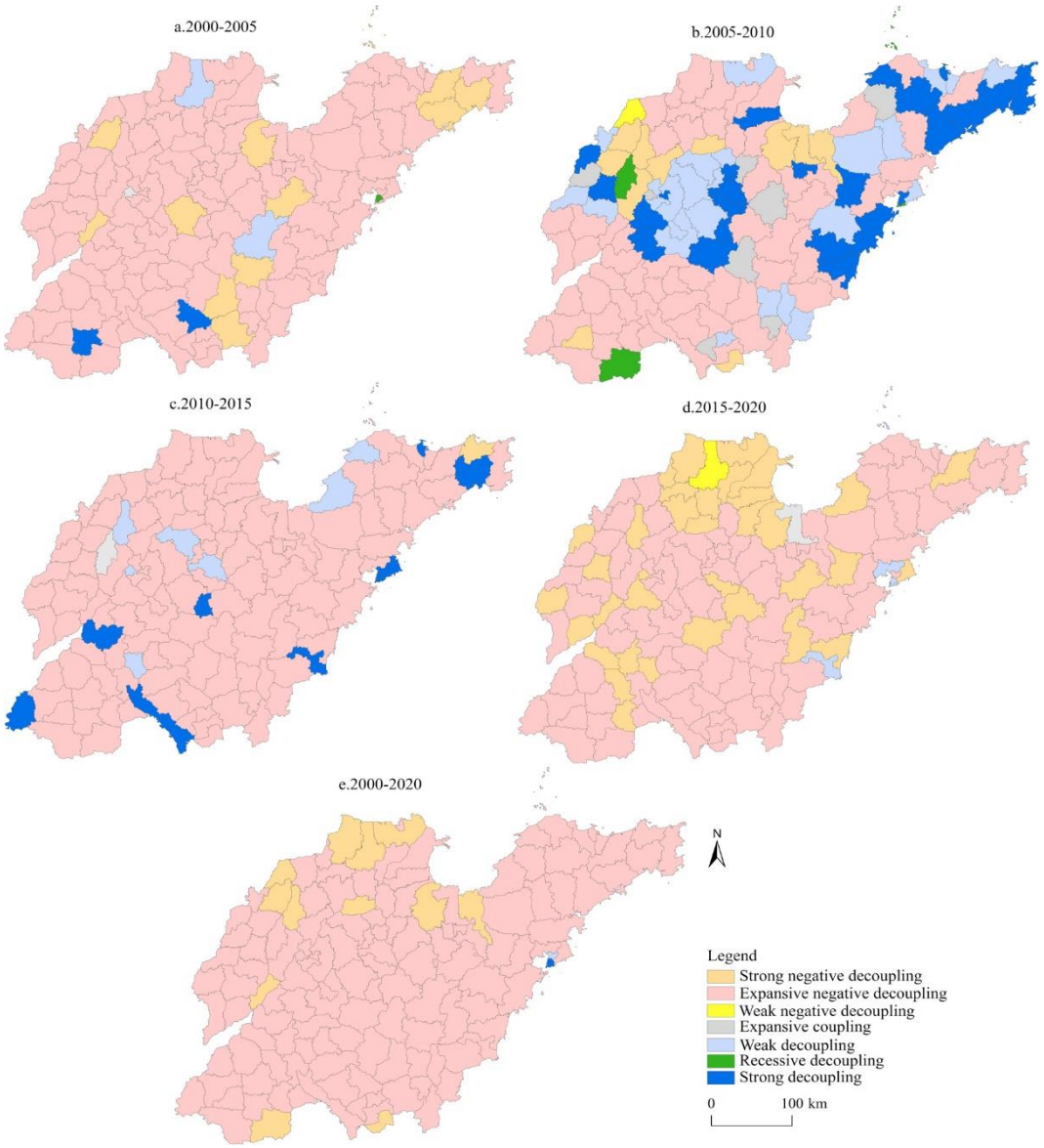

Figure 7. Spatial evolution pattern of decoupling between net carbon emissions.

4.4. Driving Factors of Decoupling between Net Carbon Emissions and Construction Land

4.4.1. Factors influencing net carbon emissions

The LMDI model was used to measure the impact of various factors on net carbon emissions, and this was expressed by the degree of the contribution. As shown in Figure 8, the contribution of the economic scale was the largest throughout the five periods of the study, which promoted an increase in carbon emissions. This indicated that Shandong Province was still in a mode of economic growth with high growth and high energy consumption. The contribution of the intensity of technological innovation was also high but tended to decline, suggesting that research and development of low-carbon technologies were insufficient. This indirectly promoted an increase of carbon emissions, but the promoting effect gradually weakened. The inhibitory effect on carbon emissions by improvements in the efficiency in technological innovation tended to increase, which showed that the improvement in research

efficiency was conducive to carbon reduction. The rate of intensive land use always inhibited the growth of carbon emissions, but its role gradually diminished. The intensity of carbon emissions evolved from an inhibitory effect to a promoting effect from 2015 to 2020, showing that the economic development of Shandong Province increased carbon emissions in recent years. The industrial structure developed from a promoting effect to an inhibitory effect from 2015 to 2020, indicating that the adjustment and upgrading of Shandong's industrial structure inhibited carbon emissions, but the effect was weak. The inhibitory effect of the size of the population on carbon emissions gradually weakened and evolved into a promoting effect from 2015 to 2020. The continuous agglomeration of the population was an important reason for the increase in carbon emissions. The degree of land use changed from a promoting effect to an inhibitory effect from 2015 to 2020, and the reduction of construction land had an effect on carbon reduction.

From the perspective of having cumulative effects, the carbon emissions promoted by the economic scale were roughly offset by the carbon emissions inhibited by the efficiency of technological innovation and the rate of intensive land use, such that the three factors reached a dynamic balance. As such, it is necessary to further reduce carbon emissions by continuously improving the efficiencies of technological innovation and the rate of intensive land use. The carbon emissions promoted by the intensity of technological innovation could be offset by the carbon emissions inhibited by efficiencies in technological innovation, and the carbon emissions were further reduced on the basis of this offset. This indicated that the development of scientific and technological innovation had an increased inhibitory effect on carbon emissions over time. In general, the total effect of each factor inhibited carbon emissions from 2000 to 2005 and promoted carbon emissions from 2005 to 2010, 2010 to 2015, and 2015 to 2020. The contributions of the inhibitory effect and the promoting effect from 2000 to 2020 could roughly offset each other, such that the critical point of each contribution was attained.

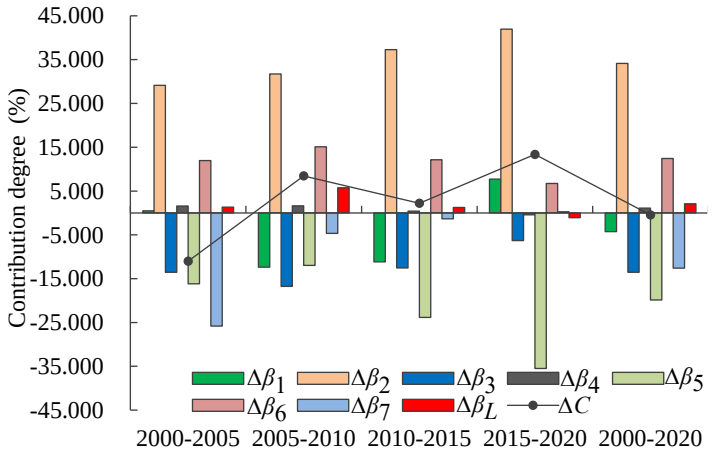

Figure 8. Relative contributions of driving factors.

4.4.2. Decoupling efforts of the driving factors

The decoupling effort index for each factor was obtained based on the decoupling effort model. As shown in Table 5, the efficiency of technological innovation and the rate of intensive land use made strong efforts for decoupling. The decoupling effort index for the efficiency of technological innovation at first decreased and then increased, reaching a peak from 2015 to 2020, and the efficiency of technological innovation played a crucial role in the ideal decoupling between net carbon emissions and construction land. The decoupling effort index for the rate of intensive land use decreased in volatility, and the efforts weakened. The intensity of carbon emission evolved from strong decoupling efforts to no decoupling efforts in 2015-2020. Similarly, the size of the population also evolved into no decoupling efforts in 2015-2020, indicating that the increase in the intensity of carbon emission and the

agglomeration of the population brought about by construction land in recent years weakened the efforts for decoupling. Conversely, the degree of land use evolved from no decoupling efforts to strong decoupling efforts in 2015-2020, confirming that the reduction of construction land can drive the evolution of the decoupling relationship towards the ideal state. The economic scale, industrial structure, and the intensity of technological innovation did not affect the decoupling efforts. Judging from the total decoupling effort index, only the period 2000-2005 exhibited strong decoupling efforts, and the other periods showed no decoupling efforts. This suggested that the various factors did not make sufficient efforts for decoupling, and the policy for carbon reduction in Shandong Province was not properly implemented.

Table 5. Decoupling effort index of driving factors.

Study period	$\Delta\alpha_1$	$\Delta\alpha_2$	$\Delta\alpha_3$	$\Delta\alpha_4$	$\Delta\alpha_5$	$\Delta\alpha_6$	$\Delta\alpha_7$	$\Delta\alpha_L$	$\Delta\alpha$
2000-2005	1.377	-22.174	10.315	-1.209	12.292	-9.105	19.635	-1.330	8.046
2005-2010	2.153	-5.519	2.911	-0.285	2.083	-2.626	0.811	-2.026	-2.499
2010-2015	8.830	-29.486	9.927	-0.338	18.843	-9.589	1.055	-2.157	-2.917
2015-2020	-8.052	-39.206	4.743	-0.618	31.331	-7.125	-1.249	2.533	-17.644
2000-2020	2.022	-16.261	6.456	-0.536	9.469	-5.919	5.992	-1.735	-0.514

To analyze the spatial distribution of the decoupling efforts for each factor, the effort index for each factor from 2000 to 2020 was studied from a spatial perspective. As shown in Figure 9, there was significant spatial heterogeneity in the degree of the decoupling efforts across the factors from 2000 to 2020. The rate of intensive land use made strong efforts for decoupling throughout the whole province, indicating that the intensive use of construction land in Shandong Province implied outstanding efforts were made to reduce carbon emissions. It is clearly necessary, however, to improve the intensive use of land continuously. The areas where the size of the population made strong efforts for decoupling were widely distributed in space, and the population agglomeration effect in most areas contributed to the decoupling. Jinan's Shizhong District, Tianqiao District, Huaiyin District, Lixia District; Yantai's Zhifu District, Laishan District; Jimo District in Qingdao; Lanshan District, and Luozhuang District in Linyi; Shizhong District of Zaozhuang had weaker efforts. The six municipal districts of Qingdao, Hekou District, Lingcheng District, Linyi County, Wudi County, and Shouguang City made no efforts. Areas with weak decoupling efforts and no decoupling efforts remind us of the need to reasonably control the scale of population agglomeration so that the population is more evenly distributed in different regions. The strong decoupling efforts linked to efficiencies in technological innovation were concentrated mainly in the municipal districts, with the municipal districts as the core in a "cluster" distribution pattern. The efficiency of technological innovation for most county-level cities and counties did not facilitate decoupling, and these areas should improve their efficiencies in technological innovation by relying on innovation initiatives in municipal districts.

From the perspective of the intensity of carbon emissions, the areas with strong decoupling efforts and weak decoupling efforts were scattered across the province, mostly in municipal districts, and spatially distributed in a "dotted" manner according to the prefecture-level cities to which they belong. These areas made efforts to reduce carbon emissions, but such efforts did not become sufficiently focused, thus the contradiction between economic development and carbon emissions was still apparent. For these areas, the transformation of the economic development mode should be accelerated. In terms of industrial structure, only Donggang District, Lanshan District, Wulian County, Ju County, and Changdao County made efforts for strong decoupling, while Muping District, Zhaoyuan City, and Rushan City made

weak efforts for decoupling, and most of the remaining areas did not make efforts to adjust. This showed that the development of non-agricultural industries in Shandong Province was not conducive to the realization of carbon reduction, therefore. there is an urgency to promote the transformation and upgrading of the industrial structure. From the perspective of land use, only a small number of areas have been striving to achieve decoupling, and Shandong Province needs to regulate the expansion of construction land to reduce the risk of increased carbon emissions. The economic scale and the intensity of technological innovation in the whole province have not contributed to decoupling, and it is necessary to achieve low-carbon and high-quality development to deal with increased carbon emissions caused by the rapid economic development in various regions. The positive role played by the intensity of technological innovation is far from sufficient. In the future, it is essential to increase investment in research and development concerning energy-saving and carbon-reduction technologies.

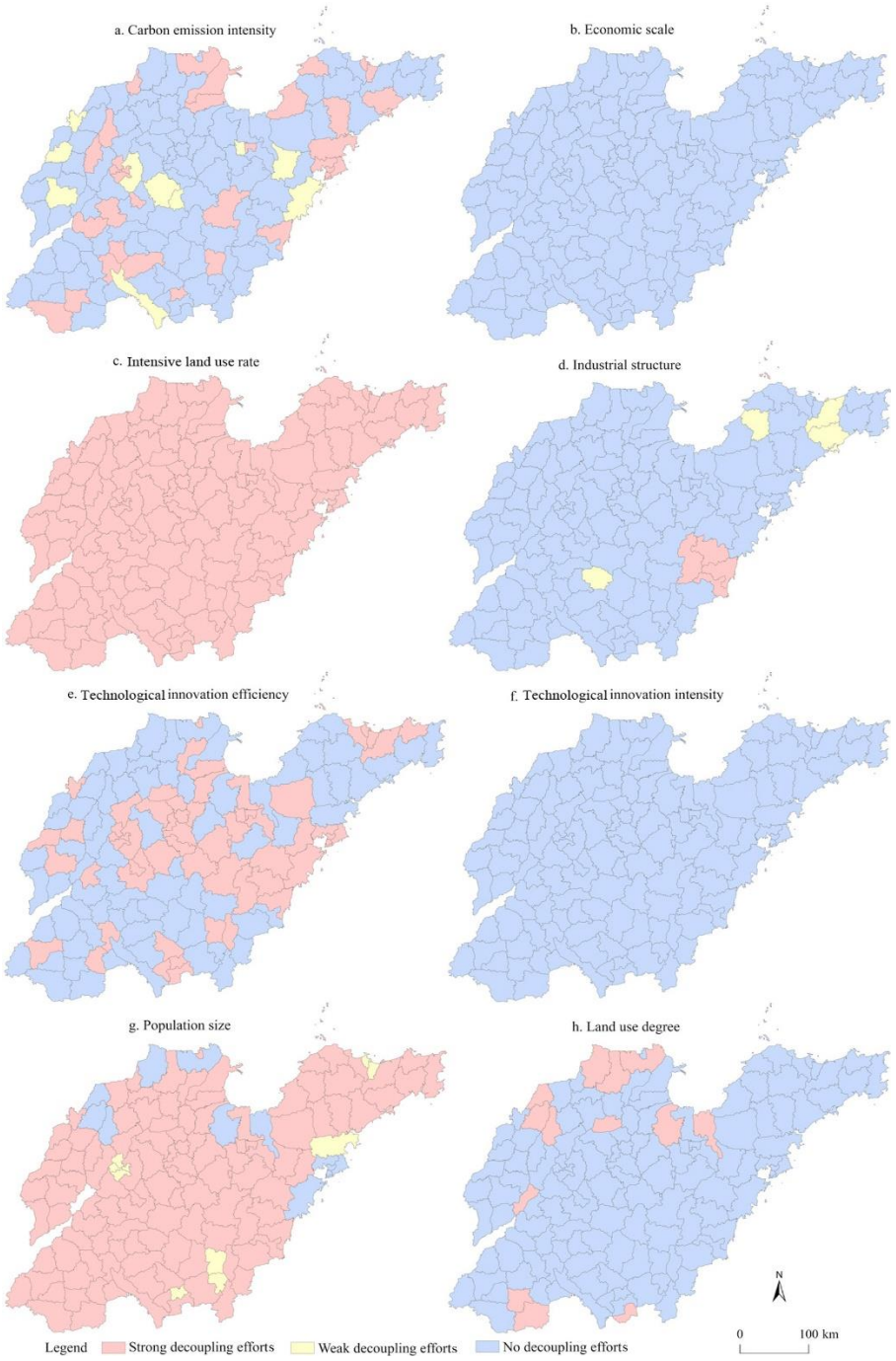

Figure 9. Spatial distribution pattern for decoupling effort index of driving factors.

5. Discussion

5.1. Accuracy of the Estimation of Net Carbon Emissions

In terms of estimating carbon emissions from energy consumption, the "China Energy Statistical Yearbook" only counts energy consumption data at the provincial level, and it is difficult to obtain energy consumption data at the county level. Although the CEAD has published carbon emissions from energy consumption at the county level in China, the data are only available up to 2017, and the publication of the carbon emissions data is not timely [77]. To ensure the timeliness and uniformity of the research data, we estimated the carbon emissions at the county level from 2000 to 2020 based on the carbon emissions from energy consumption and night-time light data in Shandong Province. Due to the different fitting and correction methods of DMSP/OLS and NPP/VIIRS night-time light images in existing studies, the types of energy chosen for the measurement of carbon emissions from energy consumption also differ [78, 79], resulting in differences in the accuracy of estimation of carbon emissions. Even if a double fitting accuracy test has been performed, the errors in estimation were still unavoidable. Therefore, to verify the accuracy of the estimation of carbon emissions, the data were compared with the carbon emissions in Shandong Province from 2000 to 2017 released by the CEAD. The verification revealed that the MRE for the two datasets was 15.450%, and the Root Mean Square Error (RMSE) was 98.332 million tons, which shows that the estimation of carbon emissions from energy consumption was accurate. However, Shandong is a coastal province, and the estimation of carbon emissions from land use only factors in the carbon sequestration of land cover and does not consider the carbon sequestration capacity of the ocean. In the future, it will be necessary to further explore the estimation method of the ocean carbon sink, thereby making the estimation of net carbon emissions more accurate and scientifically sound.

5.2. Mechanism of action of driving factors on decoupling

The analysis above demonstrates that for the estimation of net carbon emissions, the total amount of carbon sources far exceeded the number of carbon sinks, and the carbon emissions of energy consumption carried by construction land were the main carbon sources, and this finding is consistent with previous studies [80-82]. However, by comparison, our analysis of the decoupling between net carbon emissions and construction land reveals that in the first three periods, the growth rate of net carbon emissions was faster than that of construction land. The period 2015-2020 featured a strong negative decoupling where construction land was shrinking, and net carbon emissions were increasing. Studies have confirmed that the contribution of land use to net carbon emissions was relatively low in each period. This indicated that the expansion or reduction of construction land has a certain impact on net carbon emissions. From 2015 to 2020, the construction land shrank, the net carbon emissions increased, and the degree of land use showed an inhibitory effect on carbon emissions and contributed to decoupling. This means that the reduction of construction land had a positive impact on reducing net carbon emissions, but such an impact was not significant compared with other factors. Based on the results of the analysis of the drivers, this study summarizes in a systematic way the factors influencing net carbon emissions and the mechanism for the role of each factor in decoupling net carbon emissions from construction land. As shown in Figure 10, the driving factors interact with each other and constrain each other in a dynamic equilibrium situation. In the process of urbanization, the reduction of construction land in Shandong Province has started to pay for achieving the ideal decoupling condition. However, the level of the density of the population supported by construction land, the level of economic development, and the carbon emissions arising from economic development have hindered the ideal decoupling condition and are not conducive to sustainable urban development. At the same time, the industrial structure and the level of science and technology innovation in Shandong province are not sufficient to facilitate the desired decoupling of construction land

from net carbon emissions; and this is also not conducive to achieving sustainable urban development. On the contrary, the efficiency of science and technology innovation and the intensive use of construction land have been making efforts to achieve the desired decoupling and have contributed positively to the balance between urbanization and carbon emissions. In addition to controlling the uncontrolled expansion of construction land, local governments in Shandong Province should also make more efforts to adjust the economic development model, scientific and technological innovation, transformation of the industrial structure, the size of the population, and intensive land use when formulating targeted and refined reduction measures for carbon emissions.

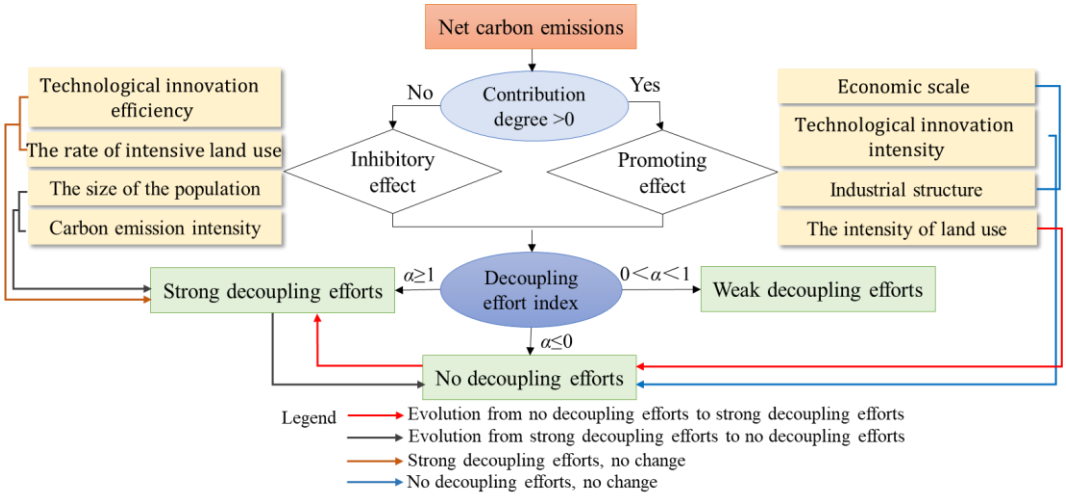

Figure 10. The mechanism of action of the driving factors.

5.3. Contributions of research findings

The method for estimation of improved net carbon emissions proposed in this study provides new data to support the long-term dynamic monitoring of carbon emissions at fine scales. A more scientific approach is clearly needed to address the difficulty of estimating carbon emissions at fine scales due to the lack of energy statistics. The basic data required for estimating net carbon emissions are mainly land use remote sensing monitoring data, night-time light data, and energy consumption data. Both land-use remote sensing monitoring data and night-time lighting data are raster data, which can meet the needs of different research scales. Therefore, the method is not only applicable at the county level but can also be readily extended to the estimation of carbon emissions at different research scales, including the net carbon emissions of other provinces and the national scale.

The results of the study found that in recent years net carbon emissions and construction land in Shandong Province have been in a state of strong negative decoupling, and the decoupling relationship was not conducive to the achievement of reduction targets in carbon emissions. However, the reduction of construction land has started to have some positive impact on reductions of carbon emissions, but not a great extent. The social and economic activities carried out on construction land are the main sources of carbon emissions. Low-carbon green development involves mutual constraints and interactions among various factors. Also, studies have shown that urbanization can lead to a large but transient carbon sink, but only a decrease in carbon emissions from fossil fuel burning will make the aim of carbon neutrality achievable [83]. Therefore, in the process of urbanization, it is unwise for local governments to achieve the “carbon peaking and carbon neutrality” goals by blindly reducing the area of construction land if they want to pursue short-lived low carbon development initiatives. The study findings contain not only valuable new information for the local governments of Shandong Province but also provide useful background and enlightenment for

the sustainable development of urbanization and carbon emissions in other countries and regions.

6. Conclusions and implications

6.1. Conclusions

(1) From 2000 to 2020, the net carbon emissions in Shandong Province continued to increase. The carbon emissions for energy consumption carried on construction land were the main carbon sources, the total carbon sources far exceeded the carbon sinks. Spatially, areas with high carbon emissions tended to from clusters centering on municipal districts, and in the case of Jinan and Qingdao, two distinct carbon emission cluster centers were formed.

(2) The first three periods featured an expansive negative decoupling between net carbon emissions and construction land in Shandong Province, and this evolved into a strong negative decoupling from 2015 to 2020. Spatially, the areas with expansive negative decoupling dominated the province. The number of areas with strong and weak decoupling increased from 2005 to 2010, and the number of areas with strong negative decoupling increased from 2015 to 2020. In general, the current decoupling between net carbon emissions and construction land in Shandong Province is not conducive to carbon reduction.

(3) From 2000 to 2020, the promoting effect of the economic scale on net carbon emissions was strengthened, while that for the intensity of technological innovation weakened. The inhibitory effect on net carbon emissions due to the efficiency of technological innovation was strengthened, whereas that for the rate of intensive land use weakened. The role of the intensity of carbon emissions and the size of the population evolved from an inhibitory one to a promoting one, and the industrial structure and the degree of land use evolved from a promoting role to an inhibitory role. In general, carbon emissions were promoted and net carbon emissions were inhibited by various factors which can basically offset each other.

(4) From 2000 to 2020, the rate of intensive land use and the efficiency of technological innovation made strong efforts with respect to achieving decoupling. Spatially, the rate of intensive land use in various regions of the province strived to achieve the ideal decoupling, and the regions where technological innovation efficiency contributed to decoupling were distributed in clusters centering on the municipal districts. The intensity of carbon emissions evolved from strong decoupling efforts to no decoupling efforts; the areas that strived to achieve decoupling were mainly municipal districts and were distributed in a "dotted" shape. The size of the population evolved from strong decoupling efforts to no decoupling efforts, the areas with strong decoupling efforts were mostly located in county-level cities and counties, while the areas with weak decoupling efforts were mostly distributed in municipal districts. The degree of land use changed from no decoupling efforts to strong decoupling efforts, and, in recent years, the reduction of construction land contributed to ideal decoupling. In general, more efforts are needed through the involvement of the above factors to realize an ideal decoupling condition.

6.2. Implications

There is a need to improve the efficiency of utilization of land resources and prevent the disorderly expansion of construction land. The study has found that the intensive use of land effectively inhibited carbon emissions, and the inhibitory effect of the degree of land use begins to appear. The Shandong Provincial Control Standards for Intensive Use of Construction Land implemented in 2019 has revised its policy regarding the extensive use of industrial land and rural residential land in construction land, by providing strong policy support for carbon reduction. Under the guidance of these policies, it is crucial to fully realize and utilize the development potential of land resources and limit land supply for high-carbon emission industries, thus favoring larger-scale economic construction with less consumption

of land resources. It is also necessary to properly control the scale and speed of the expansion of construction land, thereby avoiding the over-occupying of other land types that serve as carbon sinks.

There is a need to transform the mode of economic development and promote the optimization and upgrading of the industrial structure. This study has confirmed that economic scale plays a significant role in promoting carbon emissions, while, in recent years, industrial structure somewhat inhibited carbon emissions. Therefore, the effective way to reduce carbon emissions is to transform the economic development mode, reduce excessive dependence on energy consumption, change the structure of energy consumption, and improve the efficiency of energy utilization, thereby reducing the intensity of carbon emissions. It is important to eliminate unproductive capacity that does not meet green and low-carbon development criteria, issue guidelines to high-energy-consuming industries on how to save energy and reduce carbon emissions and promote the optimization and upgrading of industrial structure.

Attention should be paid to the role of scientific and technological innovation and vigorously develop green and low-carbon technologies. This study has revealed that the intensity of technological innovation has no significant inhibitory effect on carbon emissions, but the efficiency of technological innovation contributes to carbon reduction. In the future, it is essential to increase financial expenditure and invest in energy-saving and emission-reduction technologies. The present study also showed that most of the areas where efficiencies in technological innovation contributed to strong decoupling are mainly municipal districts. Research institutes and universities are concentrated in these regions, and the construction of scientific and technological innovation platforms and the transformation efficiency of scientific and technological achievements are a strong driver for achieving reductions in carbon emissions. By comparison, county-level cities and counties do not contribute to decoupling, indicating that the transfer of scientific and technological innovations to municipal districts is insufficient. It is necessary to promote interactions of scientific and technological innovation in regional development, optimize the innovation environment, and share scientific and technological resources.

6.3. Limitations and proposals for future research

In general, there are still some limitations to this study and thoughts and suggestions are given for future research. In terms of estimating net carbon emissions, this study has provided a scientific method for estimating carbon emissions at fine scales. However, the night-time light brightness presents an approximately linear growth pattern, and the growth rate of carbon emissions has increased in recent years. Therefore, reconciling and addressing this practical problem is an important breakthrough direction whereby we could use night-time light data to simulate carbon emissions in the future. In terms of the decoupling relationship, the Tapio decoupling coefficient was chosen to examine the relationship between net carbon emissions and construction land. However, there are differences in resource endowments, economic levels, and the intensity of energy consumption among counties in Shandong Province. The suitability of the decoupling classification types for the study area also needs to be further tested. In terms of the driving factors, it is difficult to obtain long-term series data at the county level, example, the capital investment in scientific and technological research and development, and the energy consumption of different production sectors, etc. Also, there are limitations to the selection of indicators such as the intensity of technological innovation and the efficiency of technological innovation, and the mechanism underlying the driving factors needs to be better explained.

References

1. IPCC Climate Change 2021: The Physical Science Basis, Intergovernmental Panel on Climate Change; 2021.

2. IPCC Special Report on Climate Change and Land,Intergovernmental Panel on Climate Change; 2019.
3. Jim, C. Y., Green-space preservation and allocation for sustainable greening of compact cities. Cities **2004,** 21, (4), 311-320.
4. Kaffashi, S.; Yavari, M., Land-use planning of Minoo Island, Iran, towards sustainable land-use management. International Journal of Sustainable Development & World Ecology **2011,** 18, (4), 304-315.
5. Cheng, Y.; Liu, H.; Wang, S.; Cui, X.; Li, Q., Global Action on SDGs: Policy Review and Outlook in a Post-Pandemic Era. Sustainability **2021,** 13, (11).
6. BP Statistical Review of World Energy. In East Sussex: Pureprint Group Limited, 2021.
7. Chen, B.; Zhang, H.; Li, W.; Du, H.; Huang, H.; Wu, Y.; Liu, S., Research on provincial carbon quota allocation under the background of carbon neutralization. Energy Reports **2022,** 8, 903-915.
8. Li, J.-F.; Gu, A. L.; Ma, Z.-Y.; Zhang, C.-L.; Sun, Z.-Q., Economic development, energy demand, and carbon emission prospects of China's provinces during the 14th Five-Year Plan period: Application of CMRCGE model. Advances in Climate Change Research **2019,** 10, (3), 165-173.
9. Xie, H.; Zhu, Z.; Wang, B.; Liu, G.; Zhai, Q., Does the Expansion of Urban Construction Land Promote Regional Economic Growth in China? Evidence from 108 Cities in the Yangtze River Economic Belt. Sustainability **2018,** 10, (11).
10. Li, Y.; Kong, X.; Zhu, Z., Multiscale analysis of the correlation patterns between the urban population and construction land in China. Sustainable Cities and Society **2020,** 61.
11. Wang, J.; Feng, L.; Palmer, P. I.; Liu, Y.; Fang, S.; Bosch, H.; O'Dell, C. W.; Tang, X.; Yang, D.; Liu, L.; Xia, C., Large Chinese land carbon sink estimated from atmospheric carbon dioxide data. Nature **2020,** 586, (7831), 720-723.
12. Sun, X.; Yu, C.; Wang, J.; Wang, M., The Intensity Analysis of Production Living Ecological Land in Shandong Province, China. Sustainability **2020,** 12, (20).
13. Chao, Z.; Zhang, P.; Wang, X., Impacts of Urbanization on the Net Primary Productivity and Cultivated Land Change in Shandong Province, China. Journal of the Indian Society of Remote Sensing **2018,** 46, (5), 809-819.
14. Lin, Q.; Zhang, L.; Qiu, B.; Zhao, Y.; Wei, C., Spatiotemporal Analysis of Land Use Patterns on Carbon Emissions in China. Land **2021,** 10, (2).
15. Ghosh, S.; Dinda, S.; Chatterjee, N. D.; Dutta, S.; Bera, D., Spatial-explicit carbon emission-sequestration balance estimation and evaluation of emission susceptible zones in an Eastern Himalayan city using Pressure-Sensitivity-Resilience framework: An approach towards achieving low carbon cities. Journal of Cleaner Production **2022,** 336.
16. Simmonds, M. B.; Di Vittorio, A. V.; Jahns, C.; Johnston, E.; Jones, A.; Nico, P. S., Impacts of California's climate-relevant land use policy scenarios on terrestrial carbon emissions (CO2 and CH4) and wildfire risk. Environmental Research Letters **2021,** 16, (1).
17. Janssens-Maenhout, G.; Crippa, M.; Guizzardi, D.; Muntean, M.; Schaaf, E.; Dentener, F.; Bergamaschi, P.; Pagliari, V.; Olivier, J. G. J.; Peters, J. A. H. W.; van Aardenne, J. A.; Monni, S.; Doering, U.; Petrescu, A. M. R.; Solazzo, E.; Oreggioni, G. D., EDGAR v4.3.2 Global Atlas of the three major greenhouse gas emissions for the period 1970–2012. Earth System Science Data **2019,** 11, (3), 959-1002.
18. Huisingh, D.; Zhang, Z.; Moore, J. C.; Qiao, Q.; Li, Q., Recent advances in carbon emissions reduction: policies, technologies, monitoring, assessment and modeling. Journal of Cleaner Production **2015,** 103, 1-12.

19. Guo, D.; Chen, H.; Long, R.; Ni, Y., An integrated measurement of household carbon emissions from a trading-oriented perspective: A case study of urban families in Xuzhou, China. Journal of Cleaner Production **2018,** 188, 613-624.
20. Rueda-Cantuche, J. M.; Amores, A. F., Consistent and unbiased carbon dioxide emission multipliers: Performance of Danish emission reductions via external trade. Ecological Economics **2010,** 69, (5), 988-998.
21. Nagpure, A. S.; Sharma, K.; Gurjar, B. R., Traffic induced emission estimates and trends (2000–2005) in megacity Delhi. Urban Climate **2013,** 4, 61-73.
22. Geng, Y.; Tian, M.; Zhu, Q.; Zhang, J.; Peng, C., Quantification of provincial-level carbon emissions from energy consumption in China. Renewable and Sustainable Energy Reviews **2011,** 15, (8), 3658-3668.
23. Doll, C. H.; Muller, J.-P.; Elvidge, C. D., Night-time Imagery as a Tool for Global Mapping of Socioeconomic Parameters and Greenhouse Gas Emissions. AMBIO: A Journal of the Human Environment **2000,** 29, (3), 157-162.
24. Elvidge, C. D.; Imhoff, M. L.; Baugh, K. E.; Hobson, V. R.; Nelson, I.; Safran, J.; Dietz, J. B.; Tuttle, B. T., Night time lights of the world:1994-1995. Journal of Photogrammetry and Remote Sensing **2001,** 56, (2), 81-99.
25. Matloob, A.; Sarif, M. O.; Um, J.-S., Exploring correlation between OCO-2 XCO2 and DMSP/OLS nightlight imagery signature in four selected locations in India. Spatial Information Research **2021,** 29, (1), 123-135.
26. Su, Y. X.; Chen, X. Z.; Ye, Y. Y.; Wu, Q. T.; Zhang, H. O.; Huang, N. S.; Kuang, Y. Q., The characteristics and mechanisms of carbon emissions from energy consumption in China using DMSP/OLS night light imageries. Acta Geographica Sinica **2013,** 68, (11), 1513-1526.
27. Xiao, H.; Ma, Z.; Mi, Z.; Kelsey, J.; Zheng, J.; Yin, W.; Yan, M., Spatio-temporal simulation of energy consumption in China's provinces based on satellite night-time light data. Applied Energy **2018,** 231, 1070-1078.
28. Du, X.; Shen, L.; Wong, S. W.; Meng, C.; Yang, Z., Night-time light data based decoupling relationship analysis between economic growth and carbon emission in 289 Chinese cities. Sustainable Cities and Society **2021,** 73.
29. Xu, Q.; Dong, Y.-x.; Yang, R., Urbanization impact on carbon emissions in the Pearl River Delta region: Kuznets curve relationships. Journal of Cleaner Production **2018,** 180, 514-523.
30. Baccini, A.; Goetz, S. J.; Walker, W. S.; Laporte, N. T.; Sun, M.; Sulla-Menashe, D.; Hackler, J.; Beck, P. S. A.; Dubayah, R.; Friedl, M. A.; Samanta, S.; Houghton, R. A., Estimated carbon dioxide emissions from tropical deforestation improved by carbon-density maps. Nature Climate Change **2012,** 2, (3), 182-185.
31. Carlton, R.; Berry, P.; Smith, P., Impact of crop yield reduction on greenhouse gas emissions from compensatory cultivation of pasture and forested land. International Journal of Agricultural Sustainability **2011,** 8, (3), 164-175.
32. Zhou, Y.; Chen, M.; Tang, Z.; Mei, Z., Urbanization, land use change, and carbon emissions: Quantitative assessments for city-level carbon emissions in Beijing-Tianjin-Hebei region. Sustainable Cities and Society **2021,** 66.
33. Grafius, D. R.; Hall, S.; McHugh, N.; Edmondson, J. L., How much heat can we grow in our cities? Modelling UK urban biofuel production potential. GCB Bioenergy **2019,** 12, (1), 118-132.
34. Güneralp, B.; Seto, K. C., Can gains in efficiency offset the resource demands and CO2 emissions from constructing and operating the built environment? Applied Geography **2012,** 32, (1), 40-50.

35. Feng, Y.; Chen, S.; Tong, X.; Lei, Z.; Gao, C.; Wang, J., Modeling changes in China's 2000–2030 carbon stock caused by land use change. Journal of Cleaner Production **2020,** 252.
36. Guo, X.; Chuai, X.; Huang, X., A Land Use/Land Cover Based Green Development Study for Different Functional Regions in the Jiangsu Province, China. Int J Environ Res Public Health **2019,** 16, (7).
37. Zhang, W.; Xu, H., Exploring the causal relationship between carbon emissions and land urbanization quality in China using a panel data analysis. Environment, Development and Sustainability **2016,** 19, (4), 1445-1462.
38. Tang, M.; Hu, F., How Does Land Urbanization Promote CO2 Emissions Reduction? Evidence From Chinese Prefectural-Level Cities. Frontiers in Environmental Science **2021,** 9.
39. Reid, W. V.; Ali, M. K.; Field, C. B., The future of bioenergy. Glob Chang Biol **2020,** 26, (1), 274-286.
40. Stone, B., Jr., Urban sprawl and air quality in large US cities. J Environ Manage **2008,** 86, (4), 688-98.
41. Makido, Y.; Dhakal, S.; Yamagata, Y., Relationship between urban form and CO2 emissions: Evidence from fifty Japanese cities. Urban Climate **2012,** 2, 55-67.
42. Di Vittorio, A. V.; Simmonds, M. B.; Nico, P., Quantifying the effects of multiple land management practices, land cover change, and wildfire on the California landscape carbon budget with an empirical model. PLoS One **2021,** 16, (5), e0251346.
43. Zhang, D.; Wang, Z.; Li, S.; Zhang, H., Impact of Land Urbanization on Carbon Emissions in Urban Agglomerations of the Middle Reaches of the Yangtze River. Int J Environ Res Public Health **2021,** 18, (4).
44. Cao, W.; Yuan, X., Region-county characteristic of spatial-temporal evolution and influencing factor on land use-related CO2 emissions in Chongqing of China, 1997–2015. Journal of Cleaner Production **2019,** 231, 619-632.
45. Wang, C.; Wang, F.; Zhang, X.; Yang, Y.; Su, Y.; Ye, Y.; Zhang, H., Examining the driving factors of energy related carbon emissions using the extended STIRPAT model based on IPAT identity in Xinjiang. Renewable and Sustainable Energy Reviews **2017,** 67, 51-61.
46. Hashmi, R.; Alam, K., Dynamic relationship among environmental regulation, innovation, CO2 emissions, population, and economic growth in OECD countries: A panel investigation. Journal of Cleaner Production **2019,** 231, 1100-1109.
47. Rosenlund, M.; Forastiere, F.; Stafoggia, M.; Porta, D.; Perucci, M.; Ranzi, A.; Nussio, F.; Perucci, C. A., Comparison of regression models with land-use and emissions data to predict the spatial distribution of traffic-related air pollution in Rome. J Expo Sci Environ Epidemiol **2008,** 18, (2), 192-9.
48. Ang, B. W., Decomposition analysis for policy making in energy: Which is the preferred method? Energy Policy **2004,** 32, 1131—1139.
49. Cansino, J. M.; Sánchez-Braza, A.; Rodríguez-Arévalo, M. L., Driving forces of Spain′s CO2 emissions: A LMDI decomposition approach. Renewable and Sustainable Energy Reviews **2015,** 48, 749-759.
50. Karmellos, M.; Kosmadakis, V.; Dimas, P.; Tsakanikas, A.; Fylaktos, N.; Taliotis, C.; Zachariadis, T., A decomposition and decoupling analysis of carbon dioxide emissions from electricity generation: Evidence from the EU-27 and the UK. Energy **2021,** 231.
51. Zhao, Y.; Ma, S.; Fan, J.; Cai, Y., Examining the Effects of Land Use on Carbon Emissions: Evidence from Pearl River Delta. Int J Environ Res Public Health **2021,** 18, (7).

52. Fitzpatrick, J. J.; Dooley, P., Holistic view of CO 2 reduction potential from energy use by an individual processing company. Renewable and Sustainable Energy Reviews **2017,** 77, 336-343.
53. Raza, M. Y.; Lin, B., Decoupling and mitigation potential analysis of CO2 emissions from Pakistan's transport sector. Sci Total Environ **2020,** 730, 139000.
54. Adedoyin, F. F.; Gumede, M. I.; Bekun, F. V.; Etokakpan, M. U.; Balsalobre-Lorente, D., Modelling coal rent, economic growth and CO2 emissions: Does regulatory quality matter in BRICS economies? Sci Total Environ **2020,** 710, 136284.
55. Ji, Y.; Xue, J., Decoupling Effect of County Carbon Emissions and Economic Growth in China: Empirical Evidence from Jiangsu Province. Int J Environ Res Public Health **2022,** 19, (6).
56. Karakaya, E.; Bostan, A.; Ozcag, M., Decomposition and decoupling analysis of energy-related carbon emissions in Turkey. Environ Sci Pollut Res Int **2019,** 26, (31), 32080-32091.
57. Zhao, X.; Jiang, M.; Zhang, W., Decoupling between Economic Development and Carbon Emissions and Its Driving Factors: Evidence from China. Int J Environ Res Public Health **2022,** 19, (5).
58. Xie, J.; Sun, Y.; Huo, X., Dry Port-Seaport Logistics Network Construction under the Belt and Road Initiative: A Case of Shandong Province in China. Journal of Systems Science and Systems Engineering **2021,** 30, (2), 178-197.
59. Cui, J.; Zhu, M.; Liang, Y.; Qin, G.; Li, J.; Liu, Y., Land Use/Land Cover Change and Their Driving Factors in the Yellow River Basin of Shandong Province Based on Google Earth Engine from 2000 to 2020. ISPRS International Journal of Geo-Information **2022,** 11, (3).
60. Chen, J.; Gao, M.; Cheng, S.; Hou, W.; Song, M.; Liu, X.; Liu, Y.; Shan, Y., County-level CO2 emissions and sequestration in China during 1997-2017. Sci Data **2020,** 7, (1), 391.
61. Shevliakova, E.; Stouffer, R. J.; Malyshev, S.; Krasting, J. P.; Hurtt, G. C.; Pacala, S. W., Historical warming reduced due to enhanced land carbon uptake. Proc Natl Acad Sci U S A **2013,** 110, (42), 16730-5.
62. Stokes, E. C.; Seto, K. C., Climate change and urban land systems: bridging the gaps between urbanism and land science. Journal of Land Use Science **2016,** 11, (6), 698-708.
63. Rong, T.; Zhang, P.; Jing, W.; Zhang, Y.; Li, Y.; Yang, D.; Yang, J.; Chang, H.; Ge, L., Carbon Dioxide Emissions and Their Driving Forces of Land Use Change Based on Economic Contributive Coefficient (ECC) and Ecological Support Coefficient (ESC) in the Lower Yellow River Region (1995–2018). Energies **2020,** 13, (10).
64. Huang, S.; Xi, F.; Chen, Y.; Gao, M.; Pan, X.; Ren, C., Land Use Optimization and Simulation of Low-Carbon-Oriented—A Case Study of Jinhua, China. Land **2021,** 10, (10).
65. Raupach, M. R.; Rayner, P. J.; Paget, M., Regional variations in spatial structure of nightlights, population density and fossil-fuel CO2 emissions. Energy Policy **2010,** 38, (9), 4756-4764.
66. Letu, H.; Hara, M.; Yagi, H.; Naoki, K.; Tana, G.; Nishio, F.; Shuhei, O., Estimating energy consumption from night-time DMPS/OLS imagery after correcting for saturation effects. International Journal of Remote Sensing **2010,** 31, (16), 4443-4458.
67. Katircioglu, S. T.; Feridun, M.; Kilinc, C., Estimating tourism-induced energy consumption and CO2 emissions: The case of Cyprus. Renewable and Sustainable Energy Reviews **2014,** 29, 634-640.

68. Zhao, J.; Chen, Y.; Ji, G.; Wang, Z., Residential carbon dioxide emissions at the urban scale for county-level cities in China: A comparative study of nighttime light data. Journal of Cleaner Production **2018,** 180, 198-209.
69. IPCC Guidelines for National Greenhouse Gas Inventories, Intergovernmental Panel on Climate Change; 2006.
70. Tapio, P., Towards a theory of decoupling: degrees of decoupling in the EU and the case of road traffic in Finland between 1970 and 2001. Transport Policy **2005,** 12, (2), 137-151.
71. Liu, H.; Cui, W.; Zhang, M., Exploring the causal relationship between urbanization and air pollution: Evidence from China. Sustainable Cities and Society **2022,** 80.
72. Zhang, Y.-J.; Da, Y.-B., The decomposition of energy-related carbon emission and its decoupling with economic growth in China. Renewable and Sustainable Energy Reviews **2015,** 41, 1255-1266.
73. Kaya, Y., Impact of carbon dioxide emission control on GNP growth: interpretation of proposed scenarios. In Intergovernmental Panel on Climate Change/Response Strategies Working Group,May, 1989.
74. Wu, Y.; Chau, K. W.; Lu, W.; Shen, L.; Shuai, C.; Chen, J., Decoupling relationship between economic output and carbon emission in the Chinese construction industry. Environmental Impact Assessment Review **2018,** 71, 60-69.
75. Li, Y.; Wang, X.; Chen, C.; Jing, C.; Wu, T., Exploring firms' innovation capabilities through learning systems. Neurocomputing **2020,** 409, 27-34.
76. Wang, Q.; Wang, S., Decoupling economic growth from carbon emissions growth in the United States: The role of research and development. Journal of Cleaner Production **2019,** 234, 702-713.
77. Wang, J.; Wang, C.; Yu, S.; Li, M.; Cheng, Y., Coupling Coordination and Spatiotemporal Evolution between Carbon Emissions, Industrial Structure, and Regional Innovation of Counties in Shandong Province. Sustainability **2022,** 14, (12).
78. Chen, Q.; Zha, D.; Wang, L.; Yang, G., The direct CO2 rebound effect in households: Evidence from China's provinces. Renewable and Sustainable Energy Reviews **2022,** 155.
79. Motta, S. L.; Santino, D.; Ancona, P.; Weiss, M., CO2 emission accounting for the non-energy use of fossil fuels in Italy: A comparison between NEAT model and the IPCC approaches. Resources, Conservation and Recycling **2005,** 45, (3), 310-330.
80. Ogungbile, A. J.; Shen, G. Q.; Wuni, I. Y.; Xue, J.; Hong, J., A Hybrid Framework for Direct CO2 Emissions Quantification in China's Construction Sector. Int J Environ Res Public Health **2021,** 18, (22).
81. Danish; Zhang, B.; Wang, B.; Wang, Z., Role of renewable energy and non-renewable energy consumption on EKC: Evidence from Pakistan. Journal of Cleaner Production **2017,** 156, 855-864.
82. Huang, L.; Krigsvoll, G.; Johansen, F.; Liu, Y.; Zhang, X., Carbon emission of global construction sector. Renewable and Sustainable Energy Reviews **2018,** 81, 1906-1916.
83. Xiaoxin Zhang, M. B., Xiaowei Tong, Philippe Ciais, Yuemin Yue, Xiangming Xiao, Wenmin Zhang, Kelin Wang & Rasmus Fensholt A large but transient carbon sink from urbanization and rural depopulation in China. nature sustainability **2022,** 5, 321-328.

The ecosystem service dynamics of sandy land in Northeast China during the past 30 years

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Abstract. Ecosystem service function is an important condition for the sustainable development of social economy and ecological environment. However, there are few studies on the assessment of ecosystem service function in sandy land area.Based on the InVEST model, this article evaluated the ecosystem services (ES) of water conservation, carbon storage and habitat quality of sandy land in northeast China (Horqin sandy land, Songnen sandy land and Hulunbuir sandy land) from 1990 to 2020. The results showed that the water conservation showed an overall increasing trend with an increase rate of 2.88×10^7 mm/a. The areas with high water conservation value were mainly concentrated in the southeast of Horqin sandy land, the northeast of Songnen sandy land and the east of Hulunbuir sandy land.The carbon storage increased by 0.16×10^7 t/a. The areas with high carbon storage value were mainly distributed in the northeast of Horqin sandy land, the east and west of Songnen sandy land and the east of Hulunbeier sandy land.The average habitat quality index changed little overall and it showed a trend of first increasing and then decreasing, the areas with high habitat quality value were mainly concentrated in the east and west of Songnen sandy land and the east of Hulunbuir sandy land.The results can provide reference for ecosystem protection and restoration in the sandy land area of northeast China.

Keywords: Ecosystem service function; InVEST model; Aeolian landform; Sandy land in northeast China

1. Introduction

Ecosystem is a dynamic complex formed by the interaction between biology and natural geographical environment in a certain region [1,2]. Ecosystem services (ES) are various environmental conditions and utilities that can be maintained and satisfied by human beings in the ecosystem and ecological process [3]. The function and benefit of ecosystem is an important part of the earth's life support system, and also an important condition for the sustainable development of social economy and ecological environment [4]. Quantitative analysis on the change of regional ES is conducive to the intuitive understanding of the importance of ES, and has important guiding significance for the sustainable development of regional economy, resources and environment.

As an important subsystem of terrestrial ecosystem, desert ecosystem provides human with services such as wind prevention and sand fixation, climate regulation, water conservation, biodiversity conservation and tourism culture [5]. Due to human factors, the desert ecosystem is seriously damaged, resulting in the intensification of wind desertification, which has had a serious impact on local residents and surrounding areas [6,7]. Sandy land is the most widely distributed desert ecosystem type. The sandy land in Northeast China, including Horqin sandy land, Songnen sandy land and Hulunbuir sandy land, belongs to the transition zone from semi-arid and semi humid area to semi-arid area. It is a climate change sensitive zone, a fragile ecological environment zone and a farming pastoral ecotone. The sandy land in this area has serious desertification. It is a key area for national wind prevention and desertification control and an ideal target for relevant research. Invest (integrated valuation

of ES and tradeoffs) is a comprehensive evaluation and trade-off evaluation model for ecosystem service capability [8,9]. Relevant scholars at home and abroad have conducted a lot of research and Application on ecosystem service functions [10,11]. Based on GIS and remote sensing data, Abreham *et al*. [12] used the invest habitat quality model to evaluate the spatial-temporal succession characteristics of habitat quality under different land use types in the winike basin from 1988 to 2018, and discussed the correlation between impact factors and habitat quality. Babbar *et al*. [13] used Markov chain and invest model to evaluate and predict carbon sequestration based on total carbon change under different scenarios in 2000, 2018 and 2035.

In this study, the ecosystem service functions such as water conservation, carbon storage and habitat quality of sandy land in Northeast China from 1990 to 2020 were dynamically evaluated in order to provide scientific reference for the protection of sandy land ecosystem in Northeast China.

2. Materials and methods

2.1. Research area

The sandy land in Northeast China is distributed in parts of Inner Mongolia Autonomous Region, Liaoning Province, Jilin Province and Heilongjiang Province (115°31′-129°12′ E, 42°31′-50°37′ N), covering an area of 516 600 km ^{2} (Fig. 1), located in the transition zone between the Inner Mongolia Plateau and the Northeast Plain and in the temperate monsoon climate zone in eastern Asia.

Horqin sandy land is located in the west of Northeast Plain of China, at the intersection of Daxing'an Mountains and Yanshan Mountains, covering an area of 64 400 km ^{2}, Zonal soils mainly include chestnut soil and black ridge soil, and non zonal soils mainly include aeolian sandy soil, meadow soil and saline alkali soil. The average annual temperature is 5.2~6.4 °C, the annual precipitation is 343~500 mm, and the annual evaporation is 1 300~1 800 mm [14].

Songnen sandy land is located in the Midwest of Songnen Plain, with an area of about 352600 km ^{2}, The zonal soil is chernozem, and the non zonal soil is aeolian sandy soil, meadow soil, swamp soil and saline alkali soil. The annual average temperature is 3.3 °C, the annual precipitation is 360~480mm, and the annual evaporation is 1 600~1 800 mm [15].

Hulunbuir sandy land is located in Hulunbuir high plain at the Western foot of Daxing'an Mountains. It is mainly fixed and semi fixed sandy land, with an area of about 99 700 km ^{2}, The zonal soil is chernozem, chestnut soil and some swamp soil. The non zonal soil is mainly aeolian sand soil, with an annual average of -2~0 °C, an annual average precipitation of about 235~380 mm, and an annual evaporation of about 1400~1900 mm [16].

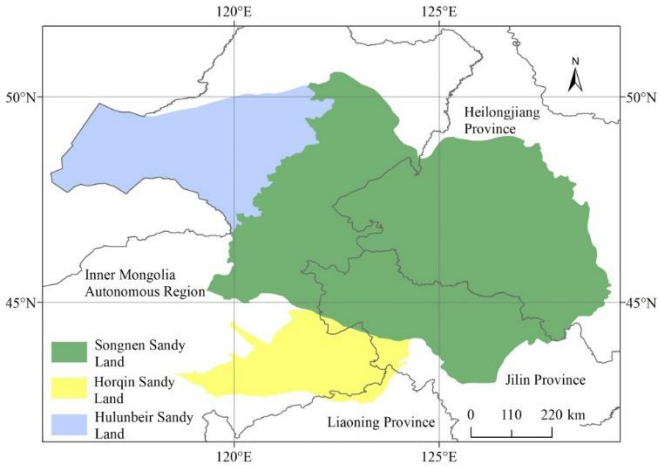

Figure 1. Location of sandy land in Northeast China.

2.2. Water conservation model

The water yield [17] was quantified by using the water yield module in the invest model. Based on the principle of water balance, the annual water supply of each pixel on each land use type *x* was evaluated by the module according to the difference between the annual average precipitation and the annual actual evapotranspiration [18,19]. The main algorithm of the model is as follows:

$$Y_x = (1 - AET_x / P_x) \times P_x \quad (1)$$

where Y_x is the annual water supply (mm); AET_x refers to actual evapotranspiration (mm); P_x is the average annual precipitation of grid unit X (mm).

2.3. Carbon storage model

The carbon storage function module (carbon) in the invest model divided the carbon storage of the ecosystem into four basic carbon pools: aboveground biological carbon, underground biological carbon, soil carbon and dead organic carbon [20]. Calculation formula of total carbon reserves:

$$C_{Total} = C_{above} + C_{below} + C_{dead} + C_{soil} \quad (2)$$

where C_{Total}: represents the total carbon reserves; C_{above} refers to aboveground carbon reserves; C_{below} refers to underground carbon storage; C_{dead} stands for dead organic carbon storage; C_{soil} refers to soil carbon storage.

2.4. Habitat quality model

The description value range of habitat quality results was 0-1, and 1 represented the highest habitat suitability [21]. The habitat quality module of the invest model assumed that the habitat quality was positively correlated with biodiversity [18,19]. The habitat quality was calculated by the degree of habitat degradation. The formula for calculating the degree of habitat degradation was as follows:

$$D_{xj} = \sum_{r=1}^{R} \sum_{y=1}^{Y_r} \left(\frac{w_r}{\sum_{r=1}^{R} w_r} \right) \times r_y \times i_{rxy} \times \beta_x \times S_{jr} \quad (3)$$

$$i_{rxy} = 1 - \left(\frac{d_{xy}}{d_{r\max}} \right) \quad (4)$$

$$i_{rxy} = \exp\left[-\left(\frac{2.99}{d_{r\max}} \right) d_{xy} \right] \quad (5)$$

where D_{xj}: the degree of habitat degradation; R: the number of stress factors; Y_r: the number of grids of stress factor layer in land use type map; w_r: the weight of stress factor r; r_y: the number of stress factors on each grid in the land use type map; i_{rxy}: the effect of stress factor r in grid y on grid x; β_x: the degree of legal protection. In this study, the degree of legal protection factor was not considered, thus β_x was set to 1; S_{jr} indicated the sensitivity of land use type j to stress factor r; d_{xy} represented the distance between grid x and grid y; d_{rmax}: the influence range of r.

The habitat degradation degree (D_{xj}) is used to calculate habitat quality:

$$Q_{xj} = H_j \times \left[1 - \left(\frac{D_{xj}^Z}{D_{xj}^Z + K^Z} \right) \right] \quad (6)$$

where Q_{xj} is the habitat quality; H_j refers to habitat attribute; K is the semi saturation constant.

2.5. Sources of land use data

The remote sensing image data were obtained by Landsat TM and OLI multispectral images (with a spatial resolution of 30 m) covering the sandy land in Northeast China in 1990, 2000, 2010 and 2020. The images were taken from June to September, and the cloud cover is less than 5%. Data were obtained from geospatial data cloud (http://www.gscloud.cn/) and the United States Geological Survey (USGS, http://glovis.usgs.gov/). The Landsat series images were preprocessed by multi band synthesis, geometric fine correction (error controlled within one pixel), image mosaic and clipping based on ERDAS software according to the scope of the study area.

According to the site conditions of sandy land in Northeast China, the land use in the study area was divided into 7 categories: cultivated land, forest land, grassland, water area, construction land, sandy land and unused land. In order to improve the interpretation accuracy, the object-oriented segmentation method was used to interpret remote sensing images based on eCognition 9.0 software platform. For ambiguous points, field investigation was used to obtain field ground verification points.

3. Results

3.1. Interannual variation of water conservation

The water conservation capacity of sandy land in Northeast China showed a fluctuating increasing trend (Fig. 2), with a net increase of 86.44 × 10^7 mm, with an average annual increase of 2.88 × 10^7 mm. From 1990 to 2000, the amount of water conservation decreased by 769.06 × 10^7 mm, with an average annual decrease of 79.61 × 10^7 mm. Since 2000, the amount of water conservation has shown an increasing trend, with a total increase of 855.50 × 10^7 mm by the year 2020, with an average annual increase of 42.78 × 10^7 mm.

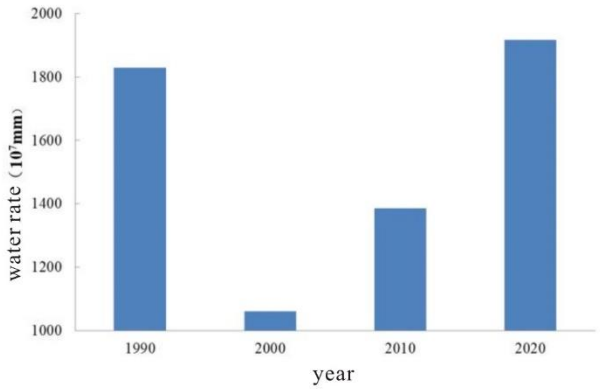

***Figure 2**. Total water yield of sandy land in Northeast China from 1990 to 2020.*

3.2. Spatial distribution change of water conservation

From 1990 to 2020, the amount of water conservation in the sandy land in Northeast China showed an increasing trend, and showed the characteristics of regional agglomeration (Fig. 3).

In 1990, the high value areas of water conservation were mainly concentrated in the southeast of Horqin sandy land, the northeast and western parts of Songnen sandy land and the east of Hulunbeier sandy land, while the low value areas were concentrated in the middle of Songnen sandy land and the west of Hulunbeier sandy land. The high value areas of water conservation in 2000 were mainly concentrated in the east of Songnen sandy land and Hulunbuir sandy land. In 2010, the high value areas of water conservation were concentrated

in the southeast of Horqin sandy land and the northeast of Songnen sandy land, and the water conservation in other areas was low. In 2020, except for the west of Hulunbuir sandy land and the west of Horqin sandy land, the water conservation capacity of other regions will be at a medium high level.

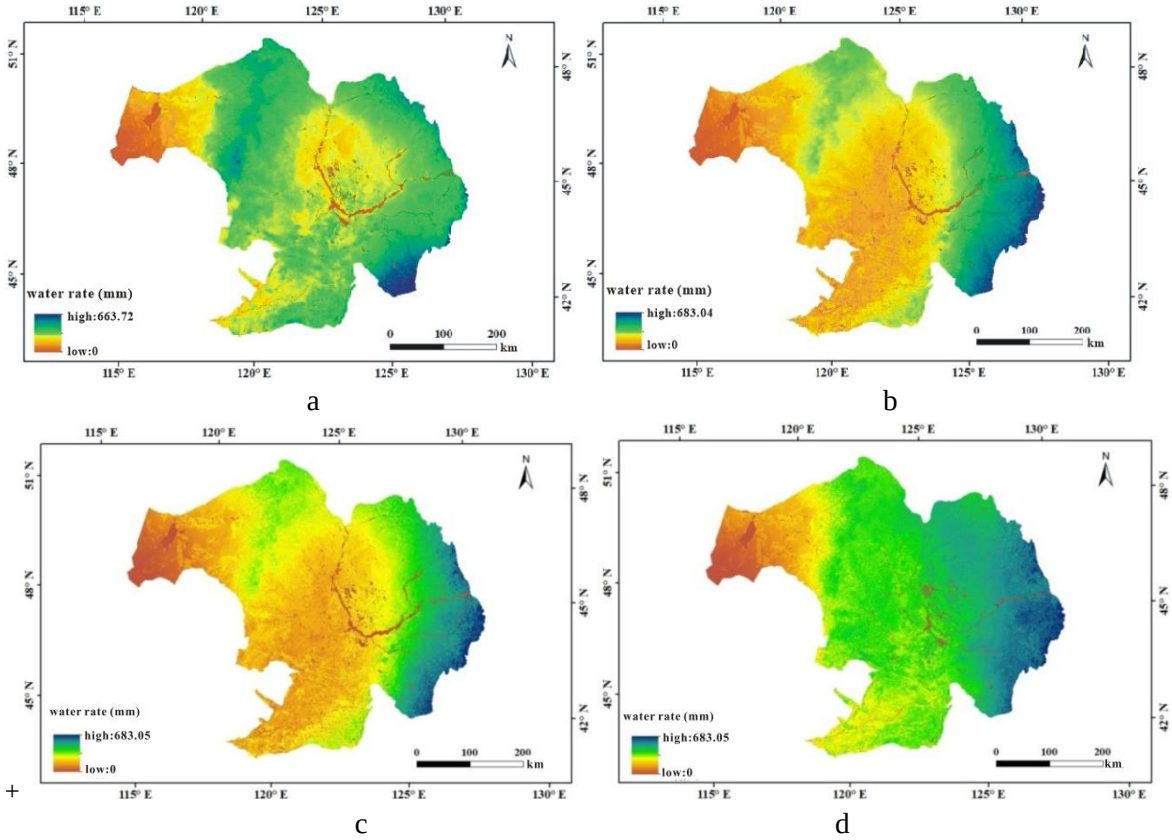

Figure 3. Spatial distribution of water volume in sandy land in Northeast China from 1990 to 2020.

Notes: a.1990; b.2000; c.2010; d.2020.

3.3. Interannual variation of carbon storage

Carbon storage in sandy land in Northeast China shows a fluctuating increasing trend (Fig. 4), with the value fluctuated between 1 451.07 × 10^7 —1 465.89 × 10^7 t. During the study period, the net increase was 4.86 × 10^7 t, with an average annual increase of 0.16 × 10^7 t. The carbon storage capacity of sandy land in Northeast China reached the maximum in 2010, which was 1465.89 × 10^7 t.

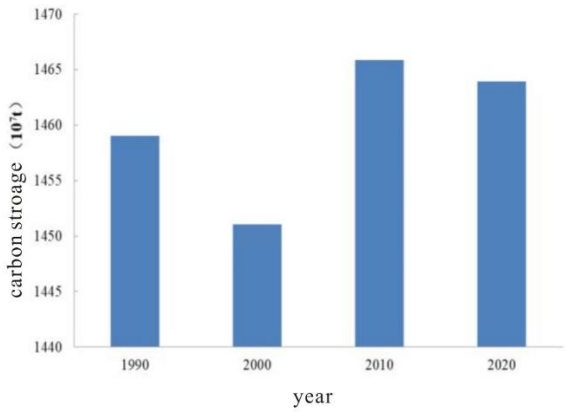

Figure 4. Total carbon storage of sandy land in Northeast China from 1990 to 2020.

3.4. Spatial distribution change of carbon storage

From 1990 to 2020, the sandy land in Northeast China was mainly distributed with medium and high level carbon reserves (Fig 5). The high-value areas of carbon reserves were mainly distributed in the northeast of Horqin sandy land, the east and west of Songnen sandy land and the east of Hulunbuir sandy land. The medium level carbon reserves were mainly concentrated in the middle of Songnen sandy land and the west of Hulunbuir sandy land. While the low value areas of carbon reserves were mainly concentrated in the southwest of Horqin sandy land, Songnen sandy land and Hulunbuir sandy land.

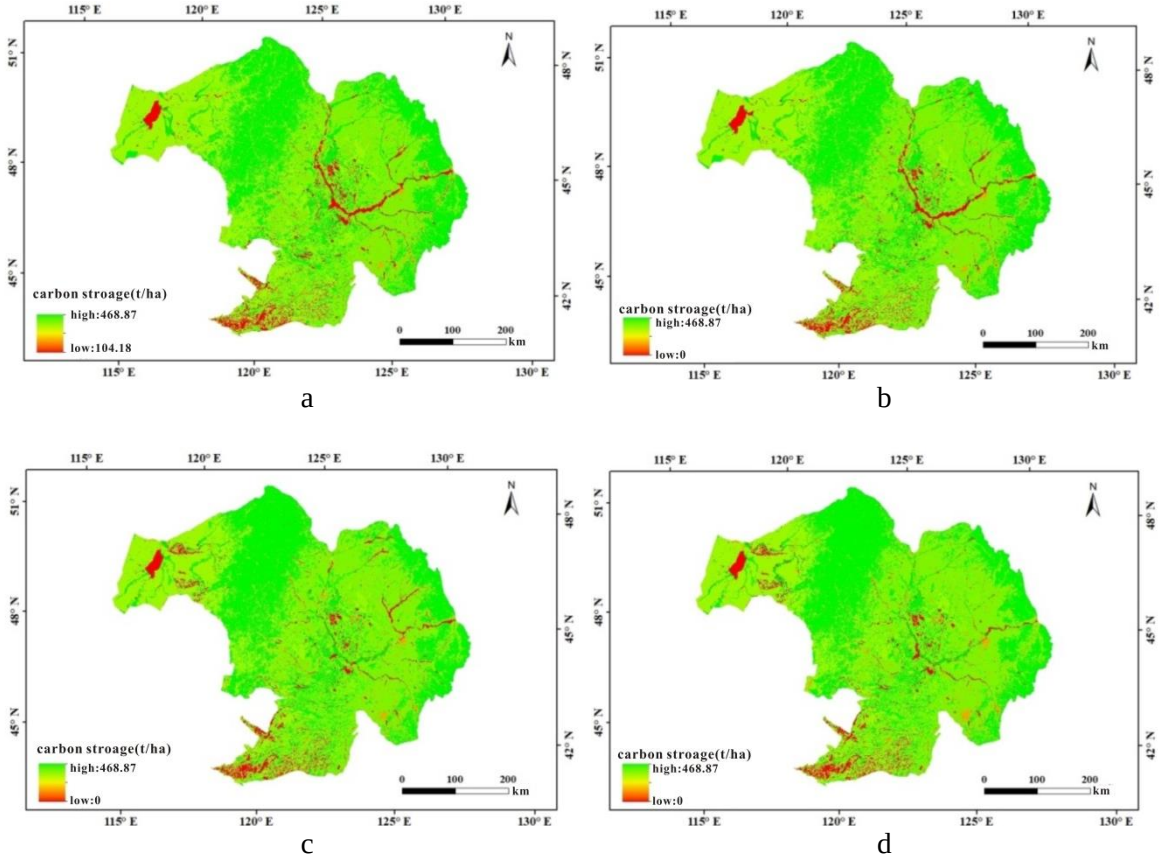

Figure 5. Spatial distribution of carbon storage services in sandy land of Northeast China from 1990 to 2020.

Notes: a.1990; b.2000; c.2010; d.2020.

3.4. Interannual variation of habitat quality

The average habitat quality index of sandy land in Northeast China had little change from 1990 to 2020, showed a trend of increasing first and then decreasing. The habitat quality of forest land was the highest, followed by grassland, water area and cultivated land.

The average habitat quality indexes in 1990, 2000, 2010 and 2020 were 0.4254, 0.4234, 0.4241 and 0.4251, respectively, showing a trend of decline first and then increase. The habitat quality of forest land was the highest, and its values in the above four years were 0.9871, 0.9863, 0.9862 and 0.9854, respectively. The second was grassland, whose values in the above four years were 0.7953, 0.7949, 0.7950 and 0.7943, respectively.

3.5. Changes in spatial distribution of habitat quality

From 1990 to 2020, the high value regions of sandy land habitat quality in Northeast China were mainly distributed in the East and west of Songnen sandy land and the east of

Hulunbuir sandy land (Fig. 6). The median area was mainly concentrated in some areas of Horqin sandy land, the west of Hulunbuir sandy land and the middle of Songnen sandy land. The low value areas were mainly concentrated in the middle of Songnen sandy land.

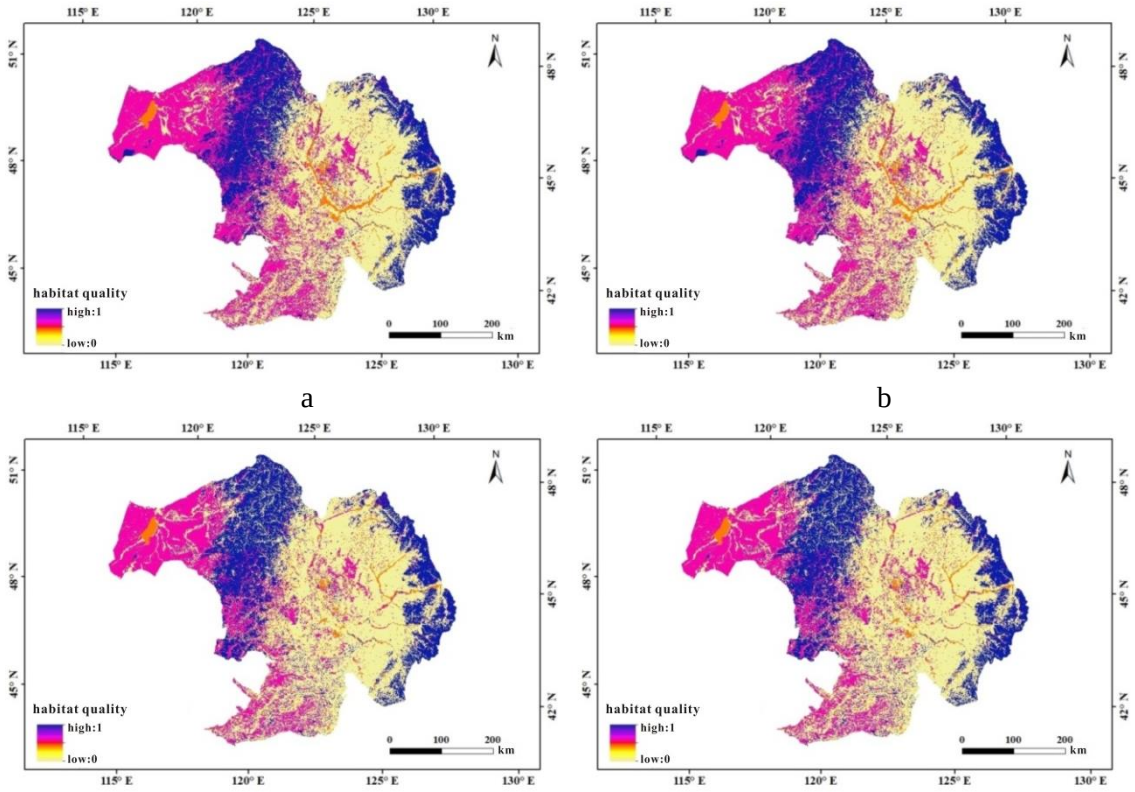

Figure 6. Spatial distribution of habitat quality service in sandy land of Northeast China from 1990 to 2020.

Notes: a.1990; b.2000; c.2010; d.2020.

4. Discussion

From the results of ecosystem service function in the sandy land of Northeast China in the past 30 years, the change trend of ecosystem service work energy in the region was roughly the same. The results showed that the changes of water conservation, carbon storage and habitat quality index in the region all took 2000 as the node, and generally showed the characteristics of first decline and then rise; And the ES value of grassland and water accounts for a relatively high proportion, which is similar to the results of Zhang *et al*. [22] in Horqin sandy land.

From the perspective of spatial change, the spatial distribution of high-value areas of various ecosystem service functions was generally consistent. The change of ecosystem service functions has a certain spatial agglomeration, which was related to the drastic change of land use in the study area. Land use change is the root cause of the change of ecosystem service functions, which is more consistent with the results of Song *et al*. [23] and Sun *et al*. [24].

The sandy land area in Northeast China is located in the farming pastoral ecotone in the arid and semi-arid region, and the ecological environment is relatively fragile. In this research stage, the change of various ecosystem service functions was based on the year 2000, which was related to a series of ecological restoration policies implemented at the end of the 20th century in response to deteriorating environmental problems, such as the construction of the 'Three North' shelter forest project, sand closure for forest and grass cultivation, and returning farmland to forest and grass [25].

With the implementation of various policies, the ecosystem service functions in the area have gradually improved. Therefore, various ecological protection policies should continue be implemented, to ensure the sustainability of ecological construction in the region.

This study systematically analyzed the spatiotemporal dynamic changes of three ecosystem service functions, namely, water conservation, carbon storage and habitat quality, in the sandy land of Northeast China. However, other types of ecosystem service functions, such as net primary productivity, water quality purification and habitat risk assessment, are also crucial to regional ecology and sustainable development. Thus, it is necessary to evaluate other typical ecological functions in this area in future research to comprehensively reveal the spatial and temporal changes of ecosystem service functions in sandy land in Northeast China. Moreover, the model estimation of ecosystem service function needs accuracy verification. The follow-up work on field investigation and data acquisition based on positioning and semi positioning test will be systematically carried out, to test and optimize model parameters and further improve the estimation accuracy.

5. Conclusion

From 1990 to 2020, the water conservation capacity of sandy land in Northeast China was 1830.35 × 10^7, 1 061.29 × 10^7, 1 385.31 × 10^7 and 1916.79 × 10^7 mm, with an overall increasing trend. The spatial distribution of water conservation changes obviously. The high value areas of water conservation were mainly concentrated in the southeast of Horqin sandy land, the northeast of Songnen sandy land and the east of Hulunbuir sandy land. Carbon storage was 1459.06 × 10^7, 1 451.07 × 10^7, 1 465.89 × 10^7 and 1463.92 × 10^7 t, respectively. In general, the level of total carbon reserves has been increasing from 1990 to 2020. The spatial distribution of carbon reserves changes obviously, and the high value areas are mainly distributed in the northeast of Horqin sandy land, the East and west of Songnen sandy land and the east of Hulunbuir sandy land. The average habitat quality index had little change, showing a trend of rising first and then declining. The habitat quality of forest land is the highest, followed by grassland, water area and cultivated land. The spatial distribution pattern of sandy land habitat quality in Northeast China was basically the same, and the overall distribution state has not changed much. The high value areas of sandy land habitat quality in Northeast China were mainly distributed in the east and west of Songnen sandy land and the east of Hulunbuir sandy land.

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References

1. Yin N, Wang S, Liu Y X 2021 Valuation of ecosystem services: Progress and prospects. Chinese Journal of Ecology 40(01) 233-244
2. Liu P and Zhang L 2020 Study on valuation of ecosystem services. Bulletin of Biology 55(06) 1-6
3. Yu Y N and Peng S L 2010 Research progress in valuation of ecosystem services. Ecology and Environmental Science 19(9) 2246－2252
4. Chen Z X and Zhang X S 2000 The value of ecosystem benefits in China. Chinese Science Bulletin 45(1) 17-22
5. Ren X X 2012 Methodology for monitoring and evaluating desert ecosystem services. Chinese Academy of Forestry

6. Li J and Ren Z Y 2011 Study on the function value of land use windbreak and sand fixation in loess Plateau of Northern Shaanxi. Journal of Land Resources and Environment 25(7) 183-187
7. Liu Y, Du X L, Zou M M, Zhang J J, Li J L 2017 Research progress in theories and methods of quantitative assessment of ecosystem function and ecosystem service value. Tianjin Agricultural Sciences 23(11) 106-112
8. Pan T, Wu S H, Dai E F, Liu Y J 2013 Spatial-temporal changes of water supply services in the three-river Headwaters region based on InVEST model. Chinese Journal of Applied Ecology 24(1) 183-189
9. Chen Y 2020 Ecosystem service emergy of Zhoushan Islands based on InVEST model. Zhejiang Ocean University
10. Pan Y, Bao H J, Huang L Y, Zhu J X 2020 Spatial-temporal pattern evolution of coastal urbanization and its impact on habitat quality in Zhejiang Province: based on InVEST model. Shanghai Land & Resources 41(03)18-24
11. Jia W L, Wu S N, Chen A 2020 Evaluation of ecosystem services in The Chishui River Basin based on InVEST model. Journal of China Institute of Water Resources and Hydropower Research 18(04) 313-320
12. Abreham B A, Tomasz N, Teshome S, Elias E 2020 The InVEST Habitat Quality Model Associated with Land Use/Cover Changes:A Qualitative Case Study of the Winike Watershed in the Omo-Gibe Basin,Southwest Ethiopia. Remote Sensing 12(7) 125-129
13. Babbar D, Areendran G, Sahana M, Sarma K, Raj K., Sivadas A 2021 Assessment and prediction of carbon sequestration using Markov chain and InVEST model in Sariska Tiger Reserve,India. Journal of Cleaner Production 278 123333
14. Du H S, Hasi E, Li S, Zhao Y Y, Sun X X 2018 Eolian sand and lake landscape evolution and its influencing factors in Horqin Sandy Land. Scienta Geographica Science 38(12) 2109-2117
15. Du H S, Wang L Y, Chen Z W, Liu J P 2018 Distribution and change of lake groups in Songnen Sandy Land in five periods since 1980. Wetland Science 16(03) 352-356
16. Yu N, Zhao Y Y, Ding G D, Cui X, Yang L 2018 Sustainable assessment of four sandy land areas in China based on ecological footprint. Arid Land Geography 41(06) 1310-1320
17. Zhou B, Yu X X, Chen L H, Zhang Z M, Lv X Z, Fan M R 2010 Soil erosion simulation in Beijing mountainous area based on InVEST model. Research of Soil and Water Conservation 17(06) 9-13
18. Schirpke U, Kohler M, Leitinger G, Fontana V, Tasser E, Tappeiner U 2017 Future impacts of changing land-use and climate on ecosystem services of mountain grassland and their resilience. Ecosystem Services 26 79-94
19. Kadaverugu R., Gurav C, Rai A, Sharma A, Matli C, Biniwale R 2021 Quantification of heat mitigation by urban green spaces using InVEST model—a scenario analysis of Nagpur City, India. Arabian Journal of Geosciences 14(2) 1-13
20. Shi M J, Wu H Q, Jia H T, Zhu L, Dong T, He P X, Yang Q J 2021 Spatial-temporal evolution and prediction of carbon storage in Yili Valley based on McE-ca-markov and InVEST models. Journal of Agricultural Resources and Environment 38 (06) 1010-1019
21. Liu Y 2020 Spatial-temporal evolution of ecosystem services in the Shule River Basin based on InVEST model. GanSu Agricultural University
22. Zhang H, Zhang A P, Yang J 2007 Change of ecosystem service value in Horqin Sandy Land. China Population,Resources and Environment 17(03) 60-65

23. Song J, Wen L, Wang F G, Li K, Wu C, Zhang H W, Zhnag X F 2021 Temporal and spatial dynamics of ecosystem service value in Ulan Buh Desert. Acta Ecologica Sinica 41(06) 1-11
24. Sun X H, Jin L, Zhang W L 2020 Temporal and spatial changes of land ecosystem service value in Inner Mongolia. Journal of Inner Mongolia University of Finance and Economics 18(06) 99-103
25. Xue Z B 2017 Evaluation of ecosystem services in Yanhe River Basin based on InVEST model. Northwest University

Culture and regional Innovation: An empirical analysis based on 31 Provinces in China

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Abstract. Innovation has always been regarded as the core of modern economic development. However, a great deal of early innovation research focused on economic and institutional drivers, while cultural forces seem to have been neglected. From the 1990s, more attention was given to the influence of culture on innovation, and while frameworks inspired by Hofstede's cultural dimension theory provided a theoretical and empirical basis for examining the relationship between culture and innovation, these frameworks generally have some shortcomings. First, cultural dimensions surveys based on Europe and the United States do not reflect accurately the cultural characteristics of Eastern countries, and are not applicable to China since they do not account for differences between East and West. Second, the research scale is limited to countries, ignoring the geographical diversity and imbalance of domestic culture and innovation. This paper, therefore proposes a cultural analysis framework that includes four dimensions: cultural base, cultural level, cultural vitality and cultural diversity, and uses the geographical detector to empirically analyze 31 provincial units in China to explore the impact and interaction of the four cultural dimensions and specific indicators on the two innovation stages of initiation and implementation. The empirical results suggest that our proposed cultural framework can effectively explain the impact of culture on innovation. To be specific, the cultural dimensions and indicators not only differ in their impact on the two stages of innovation, but they also interact with each other. Theoretically, it provides a broader and more operational analytical framework for dealing with the relationship between culture and regional innovation. Practically, the research scale is extended to the regional level within a country and reveals the differential influence of various dimensions and indicators of culture on the two stages of innovation.

Keywords: culture; cultural dimensions; innovation; innovation initiation; innovation implementation; China

1. Introduction

In the 1990s, the development of new regionalism drove the formation of a new economic geography with an institutional, cultural, and relational turn that emphasized the role of non-economic factors on economic behavior, drawing academic attention to non-economic factors such as institutions and culture (Boschma et al., 2007; Scott, 2004). Culture does not directly contribute to economic growth, but is driven through innovation. Since the introduction of Schumpeter's (1934) innovation theory, innovation has been considered as the dominant advantage of modern economic development (Jaffe & Trajtenberg, 2005), and its positive correlation with economic growth has been fully confirmed (Freeman, 1996; OECD, 2013). In this research topic, the influencing factors regarding innovation have been completely discussed. After the 1980s, innovation, as a contextual, path-dependent, and place-specific phenomenon (Mytelka & Smith, 2002), redefined the causal relationship between innovation and social factors and triggered an exploration of the sociocultural determinants of growth promotion (Švarc et al., 2019). Efrat (2014) suggested that an influential factor worthy of attention is the internal dynamics represented by the national culture, such as the quality of

governance, the political system, and openness (Fagerberg & Srholec, 2008). There is strong empirical evidence that national culture influences specific areas of innovation production and adoption (Harrison & Hutington, 2000; Kumar, 2014), and culture is the key influencing factor of innovation (Jaffe & Trajtenberg, 2005; Jones & Davis, 2000; Strychalska-Rudzewicz, 2016).

Moreover, in the global economy, explicit knowledge is no longer exclusive to regions, instead tacit knowledge is the source of competitive advantage for regions (Maskell & Malmberg, 1999). However, tacit knowledge is "context laden" (Gertler, 2003) and arises from the social and institutional context in which it is embedded, requiring relevant actors to share the same language, practices, and norms (Asheim & Gertler, 2005). This environmental context is precisely the cultural values that have been institutionalized. Innovation is embedded in the respective culture (Hochgerner, 2009) and influences the innovative capacity of a particular society by fostering spirit, shaping development scale and guiding direction (Herbig & Dunphy, 1998). Therfore, the impact of culture on innovation has become a subject worthy of study.

A large number of literatures on the relationship between culture and innovation have emerged, mainly focusing on both national and organizational cultures (Tian et al., 2018). The national cultural dimension is based on Hofstede's six cultural dimensions — Power Distance, Uncertainty Avoidance, Individualism VS Collectivism, Masculinity VS Femininity, Long-term VS Short-term, and Indulgence VS Restraint— as the dominant theoretical framework. Subsequent scholars have integrated or developed other cultural dimensions, such as Inglehart and Baker (2000), Schwartz (2006), House et al. (2004), and Deckert and Schomaker's (2019) cultural dimensions model, to explore the impact of different dimensions on national innovation. Regarding the organizational culture dimension, the Competing Value Framework is widely used (Quinn & Rohrbaugh, 1983; Cameron & Quinn, 2006) to study the influence of six cultural dimensions such as hierarchical culture, clan culture, etc., on innovation within the organization represented by the firm (Cameron & Quinn, 1999; Deshpandé and Farley, 2004).

Although existing research has provided abundant findings to help us understand the impact of culture on innovation, the following gaps remain. First, the current models of cultural dimension analysis derived from Western sample surveys, which can only represent the cultural characteristics of Western country backgrounds and cannot widely reflect the cultural characteristics of other countries in the world, especially the Eastern countries with distinct cultural differences from the Western countries. Second, the prevailing division of the cultural dimension is limited to the values perspective. Innovation, however, is a complex process that involves multiple elements. In addition to individual values, the culture that influences innovation also involves organizational and social dimensions as well as material support. Therefore, dividing culture only at the values perspective cannot fully reflect the overall characteristics of culture. Third, the meso-scale regional scale has always been neglected in previous studies, implying that the spatial diversity and difference of culture and innovation within a country has been ignored.

China is a particular case. In terms of cultural differences, the diverse natural environment and long history of development shaped by the vast territory (9.6 million km^2 of land area) have created a diverse regional cultural system in China, making regional cultural diversity an important feature of Chinese culture (Qu & Meng, 2014). China has already shown signs of the origin of civilization around 5800 years ago, and after many intermingling of nations and dynastic changes, a unified multi-ethnic (56 nationalities), multilingual (more than 80 languages and local dialects that cannot speak to each other) and multicultural country has been formed. In terms of innovation differences, the regional innovation pattern in China

shows significant spatial and temporal difference, both at the provincial and urban scales, due to the combined effect of the "cumulative effect" and "spillover effect" of regional innovation development elements (He et al., 2017). This regional innovation variation implies that innovation resource endowment and innovation performance are not exactly positively correlated, which requires consideration of influences beyond traditional innovation drivers such as factor inputs, environmental base, and development level, i.e., culture, which has been neglected in research. The only few studies on China adopted Hofstede's cultural dimension and failed to correctly reflect the cultural characteristics of China due to the significant cultural differences between China and the West. Yet, a model of cultural dimensions applicable to the Chinese context has not yet been developed.

This paper intends to fill the above gaps. First, a broader cultural dimension model is developed from the four dimensions of cultural base, cultural level, cultural vitality and cultural diversity. Second, Chinese provinces are chosen as the research scale to empirically analyze the differences in the explanatory power of the dimensions of culture on innovation initiation and innovation implementation stages, and to reveal which aspects of culture are influential in different stages. This paper is organized as follows. The next section provides an overview of research on culture and innovation and proposes an analysis framework of the cultural dimensions and research hypotheses. The third section provides a description of the study area, methodology, and data. The fourth section reports the results. Finally, the conclusion and discussion are presented.

2. Literature review and theoretical framework

2.1. Literature review

Research on the relationship between culture and innovation originates from the intersection of two research themes. One is the relationship between culture and economic output. Numerous scholars agree that culture determines, to some extent, the economic development of a country (Guiso et al., 2006; Greif, 2006), where the explanation of the mechanisms of influence involves innovation. Culture influences not only social norms, but also economic behavior. This explanation encompasses the role of culture on innovation, specifically that culture influences the propensity to innovate (Gorodnichenko & Roland, 2015) and that culturally influenced economic creativity positively contributes to the implementation of innovation (Williams & McGuire, 2010). Another is the study of the factors influencing innovation as a new development driver. Scholars have realized that, beyond general economic factors, cultural factors such as institutions, governance, openness, and social values need to be considered to explain innovation differences across countries and regions (Williams & McGuire, 2010; Bukowski & Rudnicki, 2019). Because innovation does not emerge from a social vacuum, but is deeply rooted in a complex interaction of sociocultural and political factors (Furman, 2002), its character and effects are influenced by specific social, structural, and cultural contexts (Tura & Harmaakorpi, 2005).

Direct research on the relationship between culture and innovation emerged in the 1980s, with early theoretical and case-based analyses describing the influence of cultural characteristics on innovation (Feldman, 1988; O'Reilly, 1989). From the 1990s to the early 21st century, relevant research at the national level received widespread attention. Hofstede's national culture model provides the theoretical framework for this theme, and empirical analysis using this model was led by Shane (1992; 1993), who validated the relationship between Hofstede's cultural dimensions and national innovation. Subsequent studies all build on Shane's research (Švarc et al., 2019; Jaffe & Trajtenberg, 2005; Freeman, 1996; Deshpandé & Farley, 2004; Morris et al., 1994; Taylor & Wilson, 2012; Zhu et al., 2018), replicating and extending it to additional cultural dimensions and regions, continually reinforcing the correlation between Hofstede's cultural dimensions and national or regional innovation. The

more consistent conclusion widely drawn is that high individualism, low power distance, low uncertainty avoidance, and high or moderate masculinity have a positive effect on innovation. Besides Hofstede's cultural dimensions model, several scholars have adopted Schwartz's cultural values approach (Taylor & Wilson, 2012), GLOBE's cultural dimensions (Morris et al., 1994), Inglehart-Welzel cultural values (Khosrowjerdi & Bornmann, 2021).

In the 21st century, organizations, represented by companies, have gradually taken the lead in innovation, and research on the relationship between culture and innovation has revolved around the organizational level. At this level, the most widely applied theoretical model is the Competing Value Framework (Quinn & Rohrbaugh, 1983; Cameron & Quinn, 2006), where culture is divided into six dimensions: hierarchical culture, clan culture, adhocracy/developmental culture, rational/market culture, innovation-oriented culture, and learning culture, to explore the relationship between organizational culture and innovation in different contexts.

Apparently, the theme of the relationship between culture and innovation has been widely discussed, but the following shortcomings remain. First, the Western cultural dimension theory is not fully applicable to Eastern countries. Although Hofstede's cultural dimension is widely used, it has also been criticized (Minkov, 2018). The first is the unreliability of the database, which includes only middle managers from IBM around 1970 who were influenced by specific values related to their jobs. Not only is the data outdated, but a single sample is not broadly representative of cultures in different social contexts. The second is the non-replicability of the cultural dimensions. This model is based on the Western cultural context of European and American countries, and the six dimensions show different effects on innovation in different regions, and cannot be widely applied (Hochgerner, 2009; Asheim & Gertler, 2005; Mytelka & Smith, 2002). Finally, there is intra-dimensional unreliability. This theory rests on some key assumptions, such as the positive relationship between societal anxiety that supports for universal access dimensions and societal restrictions on rules and laws, with the hypothesized relationship to be confirmed (Minkov, 2018). Anyway, the inapplicability of Western cultural dimension theory in the Chinese context is reflected in the following aspects. (1) The Western cultural dimension cannot fully reflect the Chinese culture. Beyond the formal system, the informal system, especially the traditional Chinese culture represented by Confucianism, has a deep-rooted and profound influence that has been passed down for thousands of years. It remains an important part of China's social construction and development today, and has had a profound impact in shaping the spirit, guiding behavior, establishing values, and making policy decisions. Obviously, this is not involved in the Western cultural dimension model. (2) In the Chinese context, the relationship between some cultural dimensions of the West and innovation does not hold. For example, among Hofstede's cultural dimensions, high individualism positively influences innovation in the West. However, in China where collectivist ideas prevail, the collision of collective ideas is more likely to stimulate innovation. The other is low power distance, whereas in China high power distance maintains the stability of the social organization structure, where major strategic innovations are organized by the government and power is crucial in innovation. Besides, the long-term orientation/short-term orientation values emphasized by Hofstede are both prominent in China, influenced by the Confucian culture's pursuit of "harmony", i.e., the golden mean, which rejects favoring either pole.

Second, mesoscopic-scale studies have been neglected. The cultural dimension theoretical framework led by Hofstede asserts that cultural differences and similarities are reflected in the national scale (Macnab et al., 2010; Minkov & Hofstede, 2012; Bailey, 2014; Sivakumar & Nakata, 2001), and this identification makes the study of culture and innovation consistently towards the national level. But, innovation activities are not evenly distributed within a country (Williams & McGuire, 2010), some cultural identities associated with

"innovation" do not always overlap with national identities (Beugelsdijk et al., 2006), and culture is not synonymous with nation (Baskerville, 2003). McSweeney (2002) suggested that culture has no clear boundaries and its study cannot be conducted in a national unit. Moreover, the five dimensions of proximity (geographical, cognitive, social, institutional, and organizational) proposed by Boschma and Cooke's study on regional innovation systems sufficiently confirm the spatial differences of culture within a country (Boschma, 2005; Cooke, 2001), implying the existence of subcultural zones within countries (Škerlavaj et al, 2010). Other studies focus on the micro-organizational level, examining the impact of organizational culture on individual and organizational innovation in different contexts. In conclusion, studies at the national and organizational levels have neglected the spatial differences of culture and innovation at the regional scale, resulting in a lack of research at the meso-regional scale.

Third, there are fewer studies on culture and innovation in emerging countries and regions. Previous research has focused more on Europe and North America (Herbig & Dunphy, 1998). With the rise of emerging market countries like China, which have introduced innovative ideas and disruptive technologies to the world (Deng et al., 2017), there has been a significant impact on the world's innovation landscape. However, these emerging countries and regions, which represent the potential power of innovation, have not received much attention.

2.2. Theoretical framework

Until now, there is still no unified and recognized standard definition of culture. General culture, as opposed to nature, i.e. humanization or socialization, refers broadly to the sum of the material and spiritual products created by human beings in the course of practice and the material and spiritual productive capacities acquired (Schwartz, 1992). However, general culture is often equated with society itself, leading to confusion with its distinction from institutions and social structures (Small et al., 2010). The traditional definition of culture, on the other hand, leans towards a narrow sense, referring to the production and productive capacity of the spiritual dimension, including all forms of social consciousness, such as values, modes of thinking, customs, etc (Hofstede, 2001; Geertz, 1973; DiMaggio, 1997). However, this definition represents only the spiritual dimension, while the materiality, endogeneity and regionality of culture are not taken into account (Polavieja, 2015). As a result, the division of cultural dimension is limited to the level of individual values, which cannot fully reflect the cultural characteristics of the region. In response to the shortcomings of previous studies, this paper defines culture as the spiritual activities and products of human beings.

The cultural dimension is determined by the mediating effect of culture on innovation (Figure 1). People are the carrier of culture and the subject of innovation. Therefore, the influence of culture on innovation is mediated by human beings and realized through human thinking process, which includes three basic stages. The first is the cognitive stage — the process of initial understanding and awareness of information in order to acquire knowledge — which requires the support of a knowledge base that provides the basic knowledge and relevant experience for cognitive activities. Reflected in the cultural dimension, that is, the cultural base dimension that can provide the knowledge basis for innovation. The second is the analyze & reasoning stage — the process of handling and processing information and thus forming self-knowledge — which requires certain professional skills and thinking capabilities. Reflected in the cultural level, that is, the higher the level of literacy, the better the individual's ability to learn and the higher the technical level of exposure, the more conducive to the improvement of innovative abilities. The third is the create stage — the process of creating something new by connecting multiple concepts or things in a certain way based on the original understanding. Psychologist Lewin (2013) proposed that behavior is a complex function of the person and the environment, and creative activity belongs to behavior, so

creativity arises as a result of the interaction between the person and the environment. Therefore, the environment is the main supporting element in this stage. Reflected in the cultural level, the way culture participates in the construction of the innovation environment is reflected in the two dimensions of cultural vitality and cultural diversity, which represent the static and dynamic environment, respectively.

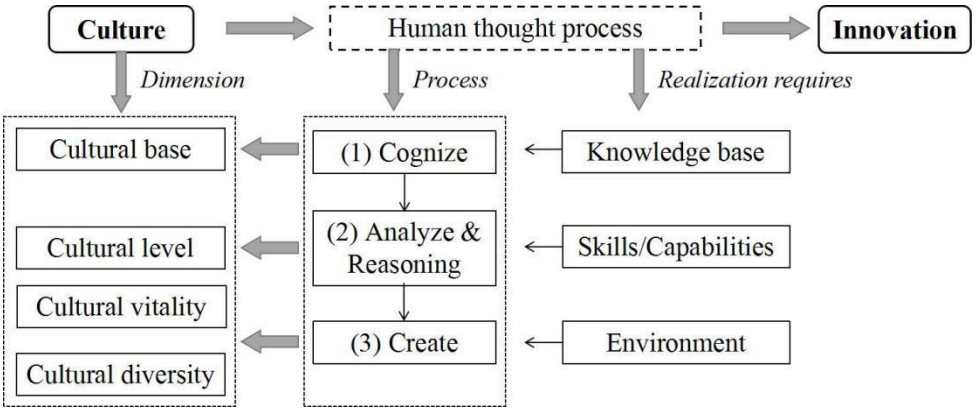

Figure 1. Intermediate relationships of the influence of culture on innovation

Accordingly, based on the above discussion, this paper divides culture into four dimensions: cultural base, cultural level, cultural vitality, and cultural diversity. The cultural base reflects the knowledge reserve of the region and is the basic level that constitutes the culture, which is closely related to regional innovation as the culture of knowledge and science. The cultural level not only reflects the quality of regional cultural development, but also determines its status, and a high cultural level is often characterized by a high educational level. Cultural vitality reflects the direction of culture and represents the environmental atmosphere created by culture. Cultural diversity reflects the dynamic evolution of regional cultural structures, realized in the form of the import of foreign cultures, and the import of tacit knowledge at a distance that constantly reshapes and renews local cultures.

Culture has distinct functions in different stages of innovation. Innovation — the process of applying new ideas to create new processes or products (Galbraith, 1982) — originates in the generation of new ideas, but this is only the beginning of innovation, which is completed by the successful implementation of creative ideas (Amabile, 1996). Thus, innovation has been described as a process that includes multiple stages, such as the three-stage (invention, innovation, and adoption) (Schumpeter, 1942), and four-stage (knowledge generation, technology, invention, leading to innovation) (Von Braun, 1997) process models. A large number of scholars, represented by Glynn (1996), supported the generalization of innovation into two stages: invention (the beginning of innovation) and implementation (the realization of innovation) (Nakata & Sivakumar, 1996), which is generally accepted for its simplicity and accuracy. The first stage is innovation initiation, a process of generating new ideas, which originates from the cognitive discovery process in which individuals perceive, learn, encode, remember and reason about new knowledge. And the innovation actors in this stage are the innovators, who are committed to transforming tacit knowledge into explicit knowledge and codifying new ideas. Moreover, the dominant intelligence of this process is the technical knowledge of the individual related to the field or issue (Lewin, 2013).

The second stage is innovation implementation, a process whereby new ideas are transformed into products, services and practices and scaled up for application, which implies that the new ideas are formally adopted and marketed. This process involves several links in the innovation chain and therefore depends on organizations to complete it. The innovation actors are the applicators (adaptor), including industry, universities, research institutions, government, intermediaries and other organizations, which participate in different links of

innovation implementation. Therefore, interorganizational relationships are particularly critical in this process, and the dominant intelligence is the contextual environment of social and interpersonal interactions associated with the organization (Lewin, 2013).

In this paper, innovation is divided into initiation and implementation stages, and the influence mechanism of culture on innovation is described as follows (Figure 2). All four dimensions of culture influence regional innovation, with cultural base and level providing internal motivation, while cultural vitality and diversity providing external incentives. In the initiation stage, culture influences the individual (innovator): (1) Provide the knowledge base. The local cultural base, i.e., the knowledge base, provides the basic scientific, intellectual foundation that allows the innovative individual to acquire declarative knowledge (i.e., factual information, causal beliefs, or perceptual orientations); the cultural level, through the education of the individual to develop expertise in the field, allows the innovative individual to acquire procedural knowledge (i.e., strategies, rules, and skills for acquiring, storing, retrieving, and processing declarative knowledge) (Cantor & Kihlstrom , 1989). (2) Stimulate the generation of new ideas. Culture influences individual's cognition, communication, and interaction, and individuals with different cultural backgrounds and modes of thinking gather to produce a collision and fusion of ideas, forming more inclusive new norms, ideas, and values, releasing tremendous innovative energy in the process (Lyu et al., 2019). (3) Fostering entrepreneurship. Culture influences the individual's sense of innovation and motivates entrepreneurs to engage in innovative practices, thus promoting the formation of an entrepreneurial class.

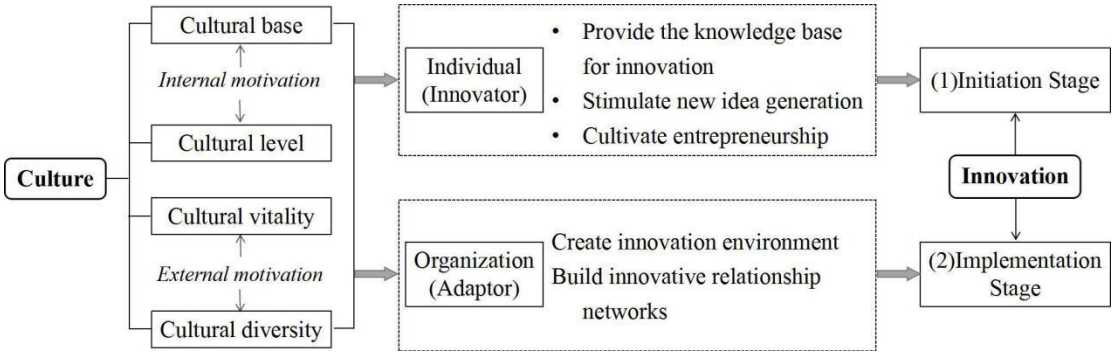

Figure 2. Analytical framework for the influence of culture on regional innovation

In the implementation stage, culture influences the organization (adaptor): (1) Create innovation environment. On the one hand, the cultural background, as the spiritual foundation of the institutions, guides, dominates and restricts the formulation and implementation of organizational institutions, and determines the direction of institutional change, thereby influencing the institutional environment for innovation; on the other hand, the diverse culture enhances the inclusiveness of the region and forms a unique and tolerant cultural atmosphere, which is conducive to the generation and transformation of innovation. (2) Build formal and informal networks of innovation relationships. Including three types of influence mechanisms, one is trust mechanism. The value consensus and common sense of culture increase trust between individuals and organizations, creating more formal and informal communication and establishing emotional connections based on trust. Leads to more opportunities for collaborative innovation, resulting in close innovation relationship networks. Second is the information mechanism (Mao & Mao, 2021). On the one hand, the same cultural attributes will facilitate the replication of tacit knowledge and promote the dissemination of knowledge and learning ability (Huang et al., 2017), forming a knowledge dissemination network. On the other hand, social networks based on cultural proximity can generate multiple channels of information dissemination and form a network of information flow based on social relationships. Third is the penetration mechanism. Culture influences the values, modes of

thinking, and behavior of individuals, which in turn affects the management mode, operating mechanism, and institutional arrangements of the organization, thus determining the value orientation and strategic choices of the inter-organizational relationship networks.

2.3. Research hypothesis

Based on the above theoretical analysis, this paper proposes three research hypotheses.

There is sufficient research evidence that culture significantly influences innovation. Hypothesis 1: All four dimensions of culture proposed in this paper significantly influence innovation, and the higher the dimension score, the higher the level of innovation capability of the region.

Numerous empirical results show that the various dimensions of culture have different effects on innovation, such as Hofstede's six dimensions, with significant differences in their effects on innovation across regions and dimensions. Hypothesis 2: The four dimensions of culture have different effects on innovation and play different roles in promoting innovation output.

Innovation is widely divided in research into initiation and implementation stages, in which innovation actors and innovation elements perform differently. Hypothesis 3: Culture affects the initiation and implementation stages of innovation differently.

3. Research Methodology and Data Description

3.1. Study area

A challenge for research at the regional scale is the delineation of culture region, as culture lacks a uniform definition and there are no clear criteria for delineation (Škerlavaj et al., 2010). Current research on Europe involves both supranational and subnational scales. The supranational scale is derived from the EU-designed administrative regionalization (NUTS), which has the disadvantage that administrative subdivisions do not reflect the historical heritage and cultural identity of the regions, while the subnational scale relies on "ethnic groups" but ignores the influence of foreign populations (Asheim & Gertler, 2005).

In the Chinese context, we use China's provincial-level administrative region divisions to classify each province as a culture region, which is divided into 31 culture regions (excluding Hong Kong, Macao and Taiwan) . There are two reasons for this division. One is that China's development context is consistent with the constructivist view that social construction in China is a top-down institutionalized process, with the same cultural outlook advocated under the same administrative system (Hu et al., 2017). And another is the principle of geographic proximity. Natural geographical features create natural barriers to cultural transmission, and regions in geographic spatial proximity share similar historical heritage and form similar mentality, values and behavioral habits, thus constituting distinctive regional cultures. And the division of China's provincial-level administrative region divisions greatly takes into account the natural geographical factors, and some of the provincial boundaries come from the natural barriers formed by mountains or rivers.

3.2. Research Methodology

3.2.1. Range, coefficient of variation, and Gini coefficient

The Range (*R*) reflects the absolute differences of the samples, while the Coefficient of Variation (*CV*) and Gini Coefficient (*G*) reflect the relative differences. These three indicators are used to explore the differences in the spatial distribution of innovation initiation and implementation in China, and are calculated as:

$$R = P_{\max} - P_{\min} \qquad (1)$$

$$CV = \frac{\sigma}{\overline{P}} \qquad (2)$$

$$G = \frac{1}{2n^2\overline{P}} \sum_{i=1}^{n} \sum_{j=1}^{n} \left| P_i - P_j \right| \qquad (3)$$

Where: P_{max} and P_{min} are the maximum or minimum values of innovation initiation or implementation, σ is the standard deviation, $\overline{P}$ is the average value, P_i and P_j are the indicator values of innovation initiation or innovation implementation of region *i* and region *j*, and *n* is the number of regions. The higher the score of these three indicators, the more unbalanced the development of innovation initiation or innovation implementation in the region.

3.2.2. Geographical Detector

Geographical Detector is a new statistical approach to detecting spatial heterogeneity and revealing the driving factors underlying it, including four detection tools of factor, interaction, risk and ecological (Wang et al., 2010). It has the advantages of almost no conditional assumptions, elegant form and clear physical meaning, which can effectively overcome the limitations of traditional models and identify the association between multiple factors. The expressions are as follows.

$$q = 1 - \frac{1}{n\sigma^2} \sum_{l=1}^{L} n_i \sigma_i^2 \qquad (4)$$

Where, q is the degree of explanation of the spatial variation of the dependent variable by the detection factor, and takes the value [0,1], the higher the value indicates the greater the influence of the factor on the variation of the regional innovation level. By comparing the q values of each factor, the determinants that influence the innovation differences in the study area can be identified. n is the number of samples; σ^2 is the total discrete variance; and L is the number of sub-regional samples. In this paper, the four dimensions of culture and specific indicators are geographically probed for the initiation and implementation stages of innovation, respectively.

3.3. Index selection

Based on our cultural dimensions analysis framework, the indicators shown in Table 1 were selected. P_1 innovation initiation is measured using the number of patent granted. While patents have been widely used to measure regional innovation output, granted patents imply that new ideas are formally recognized and therefore better reflect the level of innovation activity in a region during the innovation initiation stage. P_2 innovation implementation is measured using transaction value in technical markets, which reflects the conversion and application of technology and implies the marketability of patents. C_1, C_2, C_3, and C_4 are cultural base, cultural level, cultural vitality and cultural diversity, respectively, measured by the entropy-weighted calculation sum of each dimension containing indicators.

In C_1, the knowledge stock (X_1) and human capital (X_2), the carrier of knowledge, are the two main aspects reflecting the regional knowledge base. X_1 chooses the codable explicit knowledge measure, i.e., the number of books in public library collections and papers published. Highly skilled labors is the main carrier of scientific knowledge, so X_2 chooses the measure of the proportion of employees with college degree or above.

C_2 includes three aspects: educational environment (X_3) determining the level of cultural development, mass literacy (X_4) representing widespread culture, and elite culture (X_5) representing advanced minority culture. The agglomeration of universities implies abundant educational resources and favorable educational environment, therefore, the level of

educational environment is measured by the number of regular higher education institutions. Formal educational attainment is a direct manifestation of knowledge acquired by individuals, therefore, the mass literacy level is measured by the average number of years of education. R&D personnel constantly create new knowledge, belonging to the elite class that promotes the development of scientific knowledge in the professional field, which can be used to measure the level of elite culture.

In C_3, first, the active innovation atmosphere is reflected in the innovation spirit of the actor, i.e. entrepreneurship (X_6). However, the number of new enterprises is influenced by the taxation system and the concentration of registration in "tax havens", which does not accurately reflect the innovation spirit of the region. Therefore, the indicators are selected for the number of unicorns representing large-sized enterprises and gazelles representing small and medium-sized enterprises, which are representatives of successful implementation of innovative ideas. Secondly, in the context of China, foreign cultures have influenced and impacted coastal areas, bringing diversified cultural vitality that facilitates the development of individual innovation values. Coastal and inland areas are distinguished by great cultural differences, namely marine and inland culture (X_7), which are measured by the distance from the provincial capital to the nearest coastal port. Finally, the level and extent of market development (X_8) is also an important aspect that affects cultural vitality. An open market means the free flow of factors that stimulate cultural vitality, which is measured by NERI Index of Marketization[20].

In C_4, immigration brings multiculturalism and forms new cultural identities, and is a key source of cultural diversity. Cultural diversity (X_9) is characterized using the diversity of the provinces of the migrating population, and Shannon-Weaver diversity index (Shannon & Weaver, 1958) is used to calculate the cultural diversity index with reference to existing studies.

Table 1 Variable description

	Dimension	Variable	Symbol		Variable definitions
Innovation	Initiation stage	Innovation output	P	P_1	Number of patent granted
	Implementation stage	Innovation transformation		P_2	Transaction value in technical markets
Culture	Cultural base	Knowledge stock	C_1	X_1	Number of books in public library collections and papers published
		Human capital		X_2	Proportion of employees with college degree or above
	Cultural level	Educational environment	C_2	X_3	Number of regular higher education institutions
		Mass literacy		X_4	Average number of years of education
		Elite culture		X_5	R&D personnel

[20] A continuous study by the National Economic Research Institute on the marketization process in various regions of China.

	Entrepreneurship		X_6	Number of unicorns and gazelles enterprises
Cultural vitality	Marine/inland culture	C_3	X_7	Distance from the provincial capital to the nearest coastal port
	The level and extent of market development		X_8	NERI Index of Marketization
Cultural diversity	Cultural diversity	C_4	X_9	Cultural diversity index

3.4. Data description

Considering the availability and timeliness, data from 2019 were selected for the study. Specifically, data on relevant indicators were obtained from the China Culture and Heritage Statistical Yearbook 2020, China Science and Technology Statistical Yearbook 2020, China Tertiary Industry Statistical Yearbook 2020, and China Statistical Yearbook 2020; data on enterprises were obtained from the 2019 China Unicorn Enterprise Research Report and the 2019 China Gazelle Enterprise Data Report; the distance between the provincial capital and the nearest coastal port was calculated by using Stata16 software; the marketability index was obtained from the wind database (https://www.wind.com.cn/); the cultural diversity index was calculated using the Shannon-Weaver diversity index method (Shannon & Weaver, 1958; Lyu et al., 2019), with the following formula.

$$H = -\sum_{i=1}^{n} p_i \ln p_i \quad (5)$$

Where, H represents the cultural diversity index of province i in year t, and p_i represents the proportion of migrant population from other provinces (autonomous regions and municipalities) to the total population of province i in year t, where n=30 (excluding Hong Kong, Macao and Taiwan). The migrant population data were obtained from the 2010 Census of China (the 6th Census data were used because the data of the 7th Census was not published).

4. Research results

4.1. Spatial heterogeneity analysis of innovation initiation and innovation implementation

To determine the differences in the spatial distribution of innovation initiation and innovation implementation in China, the Range (R), Coefficient of Variation (CV) and Gini Coefficient (G) were calculated for the two innovation stages. The results show (Table 2) that the absolute and relative differences in innovation initiation and innovation implementation in China are large, indicating an uneven spatial distribution. To be specific, the values of R in two stages are both larger, reflecting a larger range of variation and dispersion of innovation. The CV are both greater than 0.36, which belong to the high variability category, indicating that the spatial heterogeneity of innovations is significant. The G are both greater than 0.50, which belong to the disparity category, indicating a very high degree of unevenness in innovation.

Table 2 Statistics of Innovation Initiation and Innovation Implementation Differences in China

	R	*CV*	*G*
Innovation initiation	25036396	1.330	0.641

Innovation implementation	1765528556	1.566	0.616

Further visualization analysis was performed using ArcGIS 10.2 Jenks optimal natural break method and the study area was classified into four types of Low, Lower, Higher, and High. The results show that both innovation initiation and innovation implementation exhibit obvious spatial differentiation characteristics. The spatial gradient of innovation initiation is "east-middle-west", with High-type distributed in the southeast coast and Low-type distributed in the northeast and west regions. In terms of innovation implementation, the High-type is only in Beijing, the Higher-type and Lower-type are concentrated in the eastern and central regions, and the Low-type is widely distributed in the western and northeastern regions, with sporadic distribution in the eastern and central regions.

4.2. Detection of the impact of culture on innovation

The four sub-dimensions of culture and nine specific indicators were discretized into four categories using ArcGIS 10.2 natural break method, and then the impact of cultural dimensions and cultural indicators on innovation initiation and innovation implementation were calculated using geographical detectors, respectively.

4.2.1. Factor detector

Factor detector was used to calculate q-values to determine the main driving force of cultural influence on innovation, with larger q-values indicating a more significant influence. According to Table 3, first, the p-values for C_1, C_2, C_3, and C_4 are all significant at the 10% level, indicating that the four dimensions of culture significantly influence the innovation both in the stage of initiation and implementation confirming that Hypothesis 1 is established. Second, the different q-values of C_1, C_2, C_3, and C_4 indicate that the four dimensions of culture have different influences on innovation, confirming that Hypothesis 2 is established.

Table 3. Factor detector results for the cultural dimension

Cultural dimension	Innovation initiation		Innovation implementation	
	q statistic	*p value*	*q statistic*	*p value*
C_1	0.6484	0.0000	0.6763	0.0000
C_2	0.7374	0.0000	0.5387	0.0066
C_3	0.7033	0.0000	0.4873	0.0131
C_4	0.3218	0.0763	0.3971	0.0308

In addition, according to Figures 6 and 7, the four dimensions of culture C_1, C_2, C_3, and C_4 are ranked differently in terms of influence during the initiation and implementation stages of innovation, indicating that the same cultural dimension has different explanatory power at different stages of innovation, confirming that Hypothesis 3 is established.

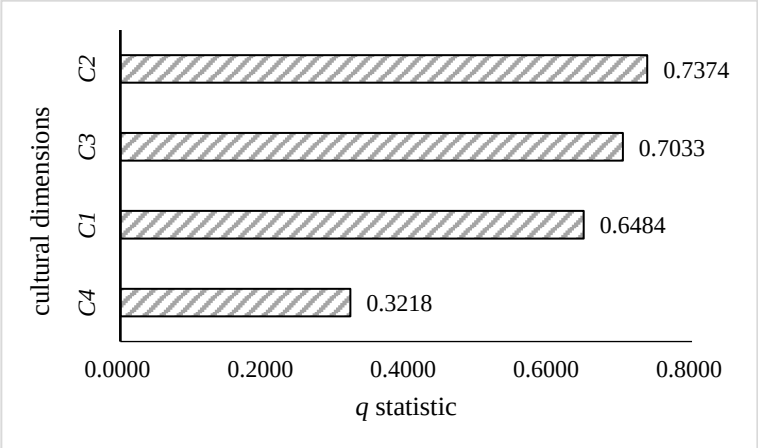

Figure 3. Influence of cultural dimension on spatial heterogeneity of innovation initiation

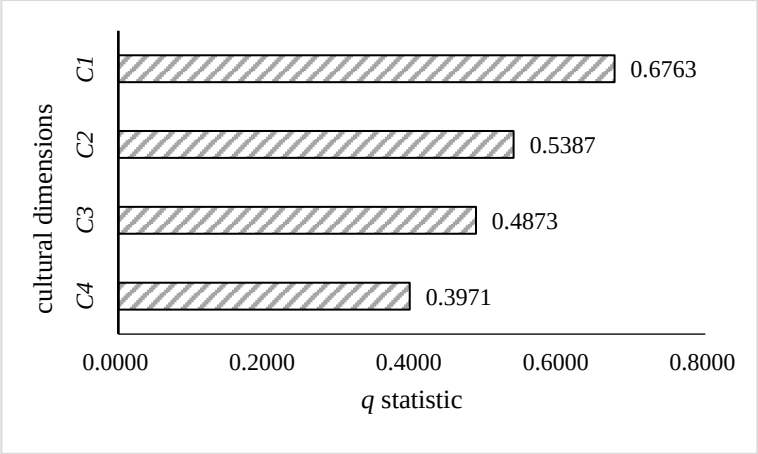

Figure 4. Influence of cultural dimension on spatial heterogeneity of innovation implementation

Figure 3 shows that the explanatory power of the four dimensions of culture on innovation initiation is ranked as $C_2>C_3>C_1>C_4$, i.e., cultural level>cultural vitality>cultural base>cultural diversity, indicating that culture level is the most significant influencing factor in this stage. New ideas come mainly from innovators with professional skills/abilities, they are the "elite" in the city, or the "creative class" as suggested by Florida (2002), with a high level of education and professional skills, creative thinking activities, personalization and openness values. The second is cultural vitality, suggesting that an inclusive and open innovation environment is a key factor in stimulating new ideas. Finally, cultural base and cultural diversity also influence innovation initiation to some extent.

Figure 4 shows that the explanatory power of the four dimensions of culture on innovation implementation is ranked as $C_1>C_2>C_3>C_4$, i.e., cultural base>cultural level>cultural vitality>cultural diversity, indicating that cultural base is the most significant influencing factor in this stage. In the marketization stage of new ideas, the knowledge base in the relevant fields in the region determines the development of the relevant industries and technology markets, thus affecting the technology transformation capacity. The second is the cultural level and cultural vitality, which provides expertise and environmental support for the transformation of innovation achievements. The weakest impact of cultural diversity is partly attributed to the fact that it is difficult for cultural diversity to profoundly affect the long-established technological development foundation, market structures, and social network relationships of a region in a short period of time.

To further clarify the influence of indicators within each sub-dimension of culture, factor detection was performed on the indicators, and the results are shown in Figure 5 and Figure 6. When specific to the indicators, some indicators are not significant. In the innovation initiation stage, the influence of X_2 human capital, X_3 educational environment, and X_7 marine/inland culture is not significant, and the influence of other indicators is ranked as $X_6>X_1>X_4>X_8>X_5>X_9$. In the innovation implementation stage, the influence of X_2 human capital, X_5 elite culture, and X_7 marine/inland culture is not significant, and the influence of other significant indicators is ranked as $X_1>X_6>X_4>X_9>X_3>X_8$. X_2 human capital and X_7 maritime culture/inland culture are not significant in both stages of innovation. For human capital, not all employed person with tertiary education or above are involved in innovation activities, which are dominated by the "creative class", so the impact of all employed person on regional innovation is not significant. For marine/inland cultures, with the rapid development of ICT and transportation networks, the limitations of geographical distance on the flow of elements in space are weakened and the influence and impact of foreign cultures

reach into inland areas. Therefore, the mere geographical distance to the nearest coastal port cannot significantly influence innovation.

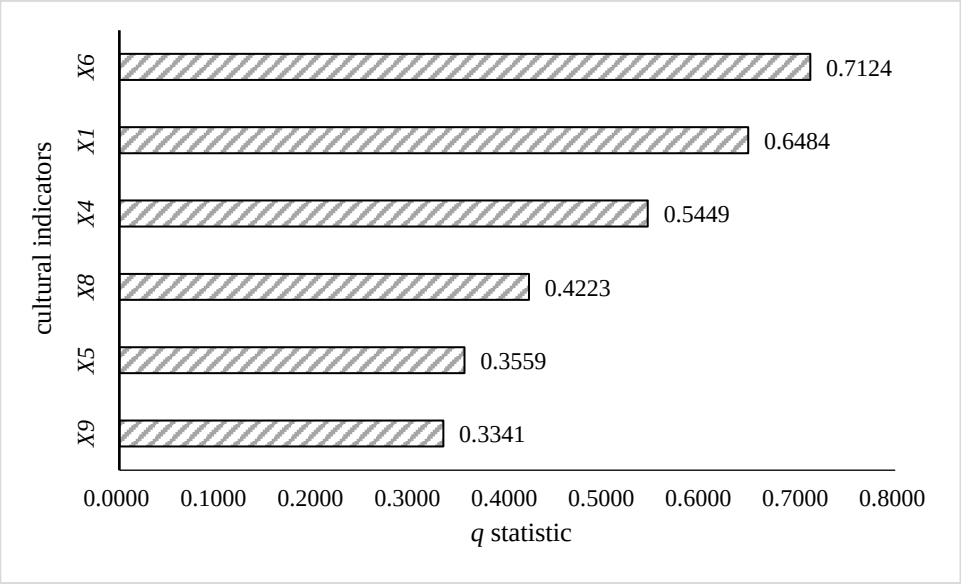

Figure 5 Influence of cultural indicators on spatial heterogeneity of innovation initiation

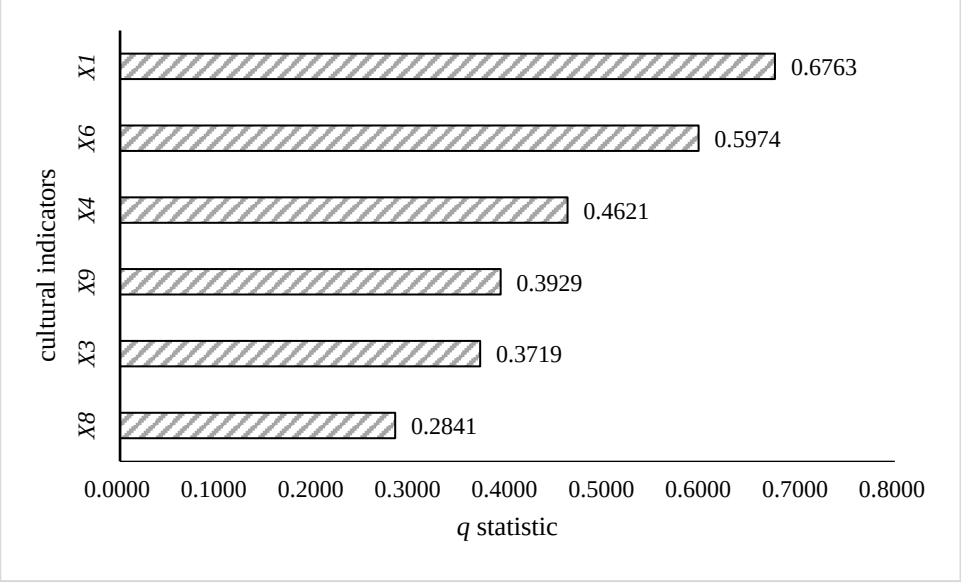

Figure 6 Influence of cultural indicators on spatial heterogeneity of innovation implementation

4.2.2. Interaction detector

The interaction detector was used to analyze the effect degree of two factors jointly affecting the innovation. The value of interaction force is 0-1, and a larger value indicates a stronger force. The results (Table 4) show that the mean interaction forces were all high (≥0.6675) and the minimum interaction forces were all greater than those of the individual factors. The interaction type is bifactor-enhanced or non-linearly enhanced, which indicates that there is an interaction between the influence of culture dimensions and indicators on innovation. The influence of different dimensions and indicators of culture on innovation is neither a single factor acting nor a simple superposition process, but a bifactor-enhanced or non-linearly enhanced relationship under the interaction of different factors.

Table 4. Statistical analysis of the interaction of cultural factors

	Strength of interaction effect			Types of interaction between two covariates				
	Min	Max	Average	Non-linearly weakened	Univariate non-linearly weakened	Bifactor-enhanced	Independent	Non-linearly enhanced
The influence of cultural dimensions on innovation initiation	0.6846	0.8539	0.7515	—	—	100%	—	—
The influence of cultural dimensions on innovation implementation	0.5473	0.9653	0.6846	—	—	100%	—	—
The influence of cultural indicators on innovation initiation	0.4303	0.9799	0.7402	—	—	73.3%	—	26.7%
The influence of cultural indicators on innovation implementation	0.3092	0.9843	0.8930	—	—	55.6%	—	44.4%

For the cultural dimensions, the interaction types are all bifactor enhanced. It indicates that the explanatory power of any two dimensional interactions is greater than that of a single dimension and less than the sum of the explanatory power of the two dimensions. For cultural indicators, the interaction types include bifactor enhanced and non-linearly enhanced, indicating that the explanatory power of any two indicator interactions is greater than that of a single indicator. Indeed, the proportion of two-factor enhanced interaction factors in the influence on innovation initiation and innovation implementation is 52.8% and 66.7%, respectively, indicating that most indicators are interactive and synergistic, and the cultural factors affecting the spatial differentiation pattern of innovation are not unilaterally caused, but the result of the combined effect of multiple cultural indicator factors.

Specifically, in terms of cultural dimension, the TOP3 explanatory power pairs in the innovation initiation stage include $C_2 \cap C_4$, $C_3 \cap C_4$ and $C_1 \cap C_2$, which are 0.7708, 0.7672 and 0.7663 respectively, indicating that the cultural level C_2 and the cultural diversity C_4 are the dominant correlates of the innovation initiation stage and are closely related to the cultural base and cultural vitality dimensions, respectively. The TOP3 explanatory power pairs in the innovation implementation stage include $C_1 \cap C_4$, $C_1 \cap C_3$ and $C_1 \cap C_2$, which are 0.8122, 0.6954 and 0.6928, respectively, indicating that the cultural base C_1 is the dominant correlate of the innovation implementation stage and is closely related to the other three dimensions. In terms of cultural indicators, the TOP3 explanatory power pairs in the innovation initiation stage include $X_5 \cap X_9$, $X_6 \cap X_7$, and $X_3 \cap X_6$, which are 0.9520, 0.9290, and 0.9252, respectively, indicating that entrepreneurship X_6 plays a correlated role in this stage, and interaction with marine/inland culture X_7 and educational environment X_3 increases influence. The TOP3 explanatory power pairs in the innovation implementation stage are $X_1 \cap X_2$, $X_1 \cap X_3$, and $X_1 \cap X_7$, which are 0.9661, 0.9649, and 0.9628, respectively, indicating that the knowledge stock X_1 plays a correlated role in this stage, and interaction with human capital X_2, educational environment X_3, and marine/inland culture X_7 increases influence.

5. Conclusion and Discussion

In light of the shortcomings concerning the traditional cultural dimension analysis framework, this paper seeks to propose a new analysis framework from four dimensions of cultural base, cultural level, cultural vitality and cultural diversity, and determines the quantifiable indicators of each dimension. Further, geographical detector was used to explore the explanatory power and interaction of four dimensions and nine specific indicators of culture on the impact of innovation initiation and implementation. The following conclusions are drawn:

(1) The empirical results show that the influence of C_1, C_2, C_3 and C_4 on P_1 and P_2 is significant at the 10% level, suggesting that the analytical framework of the four dimensions of culture proposed in this paper can effectively explain the influence of culture on innovation theoretically.

(2) The results of the factor detector show that the q-values vary, implying that the four cultural dimensions differ in their role in influencing innovation and that they act differently in the two stages of innovation. Specifically, in the innovation initiation stage, the explanatory power of cultural dimensions is ranked as: cultural level>cultural vitality>cultural base>cultural diversity; in the innovation implementation stage, the explanatory power of cultural dimensions is ranked as: cultural base>cultural level>cultural vitality>cultural diversity.

(3) The results of interaction detector show that the interaction types are concentrated in bifactor-enhanced and non-linearly enhanced, illustrating that the influence of the interaction between different dimensions and indicators of culture on innovation is greater than the influence of each single dimension and indicator, and the cultural factors affecting the spatial differentiation pattern of innovation are the result of the combined effect of multiple factors. Specifically, cultural level, cultural diversity and entrepreneurship are the dominant correlates of innovation initiation, and cultural base and knowledge stock are the dominant correlates of innovation implementation.

The contributions of this paper include: (1) The logical mode of thinking of traditional research has been changed. Based on Inductive Reasoning, previous studies began with a questionnaire survey, developed the understanding of general laws of cultural characteristics from individual cultural performance, summarized several dimensions of culture, and then empirically tested the impact of culture on innovation. However, the limitation of this logical mode of thinking is that individual samples fail to characterize universal laws, and the current cultural survey samples are all from Western countries or single companies, which cannot fully reflect the cultural characteristics of other regions. To overcome this, our study adopts Deductive Reasoning, which proposes four dimensions of culture from culture-related theories and sets up hypotheses, and finally verifies the impact of culture on innovation using China as an example.

(2) In response to the limitations of applicability of the traditional cultural dimension analysis framework, we propose a broader cultural framework applicable to both Eastern and Western countries with quantifiable cultural indicators selected and validated, which has the advantages of being more operational, more widely applicable, and more comprehensive in reflecting cultural characteristics.

(3) Traditional studies on measuring innovation often select a composite indicator, such as GII, which can reflect the comprehensive innovation level of a region but cannot reveal the role of culture on different stages of innovation. Our study divides innovation into initiation and implementation stages, revealing the influence of culture on different process stages of

innovation, which is important for regions at different stages of economic development to formulate precise policies.

(4) Quantifying the explanatory power of different dimensions of culture on the impact of innovation and confirming the interaction between different cultural dimensions, the practical insight derived is to emphasize the overall impact of regional culture.

In addition, among the vast literature on the prevalence of cross-national cultures, this study is one of the very few that takes a provincial scale within a country, and thus stands out for its ability to provide direction for targeted interventions to promote innovation in local culture within a unified administrative system. On the one hand, culture can indeed influence the initiation and implementation of innovation, and the active development of local culture will promote innovation. In the initiation stage, local authorities are expected to value the improvement of cultural level, raise the literacy level of the masses, and actively attract talents; in the implementation stage, they are advised to value the accumulation of cultural base, increase the local knowledge stock, and provide support for technology transformation. On the other hand, considering the interaction between the four dimensions of culture, the formulation of culture enhancement policies should not only focus on a single dimension, but also take into account the combined effect of the related dimensions.

Of course, one of the most obvious limitations of this paper is its failure to capture the dynamic characteristics of culture and its impact on innovation, as it was limited by data, with only cross-sectional data for 2019. In addition, there is an insurmountable methodological limitation in that the geographical detector, while revealing the explanatory power of culture on innovation, does not reflect whether it is positive or negative. Finally, the above two limitations are directions for our further research.

References

1. Amabile, T. M. (1996). Creativity and innovation in organizations. Boston: Harvard Business School Press.
2. Asheim, B., & Gertler, M. (2005). The geography of innovation: regional innovation systems. The Oxford handbook of innovation.
3. Bailey, J. (2014). Social Europe: unity and diversity–an introduction. In Social Europe (pp. 1-14). Routledge.
4. Baskerville, R. F. (2003). Hofstede never studied culture. Accounting, organizations and society, 28(1), 1-14.
5. Beugelsdijk, S., Van Schaik, T., & Arts, W. (2006). Toward a unified Europe? Explaining regional differences in value patterns by economic development, cultural heritage and historical shocks. Regional studies, 40(03), 317-327.
6. Boschma, R. A. (2005). Proximity and innovation: a critical assessment. Regional studies, 39(1), 61-74.
7. Boschma, R. A., & Martin R. (2007). Constructing an Evolutionary Economic Geography. Journal of Economic Geography, 7(5): 537-548.
8. Brettel, M., & Cleven, N. J. (2011). Innovation culture, collaboration with external partners and NPD performance. Creativity and innovation management, 20(4), 253-272.
9. Bukowski, A., & Rudnicki, S. (2019). Not only individualism: The effects of long-term orientation and other cultural variables on national innovation success. Cross-Cultural Research, 53(2), 119-162.
10. Cameron, K. & Quinn, R. (1999), Diagnosing and Changing Organizational Culture, Addison Wesley, Reading, MA.
11. Cameron, K. & Quinn, R. (2006), Diagnosing and Changing Organizational Culture: Based on the Competing Values Framework, Jossey-Bass, San Francisco, CA.

12. Cantor, N., & Kihlstrom, J. F. (1989). Social intelligence and cognitive assessments of personality. Lawrence Erlbaum Associates, Inc.
13. Cooke, P. (2001). Regional innovation systems, clusters, and the knowledge economy. Industrial and corporate change, 10(4), 945-974.
14. Deckert, C., & Schomaker, R. M. (2019). Cultural impacts on national innovativeness: Not every cultural dimension is equal. Cross-Cultural Research, 53(2), 186-214.
15. Deng, P., Yang, X., Wang, L. and Doyle, B. (2017), Chinese investment in advanced economies: opportunities and challenges. Thunderbird International Business Review, 59(4), 461-471.
16. Deshpandé, R., & Farley, J. U. (2004). Organizational culture, market orientation, innovativeness, and firm performance: an international research odyssey. International Journal of research in Marketing, 21(1), 3-22.
17. DiMaggio, P. (1997). Culture and cognition. Annual review of sociology,23:263-287.
18. Efrat, K. (2014). The direct and indirect impact of culture on innovation. Technovation, 34(1), 12-20.
19. Fagerberg, J., & Srholec, M. (2008). National innovation systems, capabilities and economic development. Research policy, 37(9), 1417-1435.
20. Feldman, S. P. (1988). How organizational culture can affect innovation. Organizational dynamics, 17(1), 57-68.
21. Florida, R. (2002). The rise of the creative class. New York: Basic books.
22. Freeman, J. (1996). Innovation and growth. In M. Dodgson & R. Rothwell (Eds.), The handbook of industrial innovation (pp. 78-93). Cheltenham, UK: Edgar Elgar.
23. Furman, J. L., Porter, M. E., & Stern, S. (2002). The determinants of national innovative capacity. Research policy, 31(6), 899-933.
24. Galbraith, J. (1982). Designing the innovating organization. Organizational Dynamics, 11(3), 5-25.
25. Geertz, C. (1973). The interpretation of culture. New York, NY: Basic Books.
26. Gertler, M. S. (2003). Tacit knowledge and the economic geography of context, or the undefinable tacitness of being (there). Journal of economic geography, 3(1), 75-99.
27. Glynn, M. A. (1996). Innovative genius: A framework for relating individual and organizational intelligence to innovation. Academy of Management Review, 21, 1081-1111.
28. Gorodnichenko, Y., & Roland, G. (2015). Culture, institutions and democratization (No. w21117). National Bureau of Economic Research.
29. Greif, A. (2006). Institutions and the path to the modern economy: Lessons from medieval trade. Cambridge University Press.
30. Guiso, L., Sapienza, P., & Zingales, L. (2006). Does culture affect economic outcomes?. Journal of Economic perspectives, 20(2), 23-48.
31. Harrison, L. E., & Hutington, S. P. (2000). Culture maters: How values shape human progress. New York: Basic books.
32. He S., Du D., Jiao M., & Lin Y. (2017). Spatial-Temporal Characteristics of Urban Innovation Capability and Impact Factors Analysis in China. Scientia Geographica Sinica, 37(07):1014-1022.
33. He, C., Guo, Q., Ma, Y., Fan, S., & Zhao, Y. (2014). Progress of economic geography in the West: A literature review. Acta Geographica Sinica, 69(08):1207-1223.
34. Herbig, P., & Dunphy, S. (1998). Culture and innovation. Cross Cultural Management: An International Journal, 5(4): 13-21.

35. Hochgerner, J. (2009). The analysis of social innovations as social practice. Published in original German language under the title Die Analyse sozialer Innovationen als gesellschaftliche Praxis, Vienna and Berlin, LIT.
36. Hofstede, G. (2001) Culture's Consequences: Comparing Values, Behaviors, Institutions and Organizations Across Nations, 2nd ed., Sage Publications, Thousand Oaks, California.
37. Hofstede, G., Hofstede, G. J., Minkov, M. (2010). Cultures and organizations: Software of the mind (3rd ed.). New York, NY: McGraw Hill.
38. House, R. J., Hanges, P. J., Javidan, M., Dorfmann, P. W., & Gupta, V. (2004). Culture, leadership, and organizations: The GLOBE study of 62 societies. Thousand Oaks, CA: SAGE.
39. Hu, Z., et. al. (2017). Overview of Chinese Cultural Geography (4th ed.). Peking University Press.
40. Huang, X., Wang, X., & Yang, Z. (2017). Population heterogeneity, economic exchange and international R&D spillover. China Economic Quarterly, 2, 1119-1142.
41. Inglehart, R., & Baker, W. E. (2000). Modernization, cultural change and the persistence of traditional value. American Sociological Review, 65, 19-51.
42. Jaffe, A. B., Trajtenberg, M., (2005). Patents, Citations, and Innovations: A Window on the Knowledge Economy. The MIT Press.
43. Jones, G. K., & Davis, H. J. (2000). National culture and innovation: Implications for locating global R& D operations. MIR: Management International Review, 40, 11-39.
44. Kaasa, A., & Vadi, M. (2010). How does culture contribute to innovation? Evidence from European countries. Economics of innovation and new technology, 19(7), 583-604.
45. Khosrowjerdi, M., & Bornmann, L. (2021). Is culture related to strong science? An empirical investigation. Journal of Informetrics, 15(4), 101160.
46. Kumar, V. (2014). Understanding cultural differences in innovation: A conceptual framework and future research directions. Journal of International Marketing, 22(3), 1-29.
47. Lewin, K. (2013). Principles of topological psychology. Read Books Ltd.
48. Lyu L., Sun F., & Huang R. (2019). Innovation-based urbanization: Evidence from 270 cities at the prefecture level or above in China. Journal of Geographical Sciences, 29(08):1283-1299.
49. Macnab, B., Worthley, R., & Jenner, S. (2010). Regional Cultural Differences and Ethical Perspectives within the United States: Avoiding Pseudo-emic Ethics Research. Business and Society Review, 115(1), 27-55.
50. Mao, Q., & Mao, X. (2021). Cultural barriers, institutional distance, and spatial spillovers: Evidence from regional industrial evolution in China. Growth and Change, 52(3), 1440-1481.
51. Maskell, P., & Malmberg, A. (1999). Localised learning and industrial competitiveness. Cambridge journal of economics, 23(2), 167-185.
52. McSweeney, B. (2002). Hofstede's model of national cultural differences and their consequences: A triumph of faith-a failure of analysis. Human relations, 55(1), 89-118.
53. Minkov M. (2018). A revision of Hofstede's model of national culture: Old evidence and new data from 56 countries. Cross Cultural & Strategic Management, 25(2):231-256.
54. Minkov, M., & Hofstede, G. (2012). Is national culture a meaningful concept? Cultural values delineate homogeneous national clusters of in-country regions. Cross-Cultural Research, 46(2), 133-159.

55. Morris, M., Davis, D., & Allen, J. (1994) Fostering Corporate Entrepreneurship: Cross-Cultural Comparisons of the Importance of Individualism Versus Collectivism. Journal of International Business Studies, 25, 65-89.
56. Mytelka, L. K., & Smith, K. (2002). Policy learning and innovation theory: an interactive and co-evolving process. Research policy, 31(8-9), 1467-1479.
57. Nakata, C., & Sivakumar, K. (1996). National culture and new product development: An integrative review. Journal of Marketing, 60(1), 61-72.
58. O'Reilly, C. (1989). Corporations, culture, and commitment: Motivation and social control in organizations. California management review, 31(4), 9-25.
59. Organisation for Economic Co-Operation and Development. (2013). OECD science, technology and industry scoreboard 2013: Innovation for growth. Paris, France: Author. doi:10.1787/sti_scoreboard-2013-en
60. Polavieja, J. G. (2015). Capturing culture: A new method to estimate exogenous cultural effects using migrant populations. American Sociological Review, 80(1), 166-191.
61. Qu A., & Meng Z. (2014). Study on spatial-temporal pattern of cultural diversity and its affected factors in China. Human Geography, 29(6): 53-59.
62. Quinn, R. and Rohrbaugh, J. (1983), A spatial model of effectiveness criteria: towards a competing values approach to organizational analysis, Management Science, 29(3): 363-377.
63. Schumpeter, J. (1942). Capitalism, Socialism, and Democracy. Allen&Unwin, London.
64. Schumpeter, J. A, (1934). The Theory of Economic Development. Cambridge M A: Harvard University Press.
65. Schwartz, S. (2006). A theory of cultural value orientations: Explication and applications. Comparative Sociology, 5, 137-182.
66. Schwartz, S. H. (1992). Universals in the content and structure of values: Theoretical advances and empirical tests in 20 countries. In Advances in experimental social psychology (Vol. 25, pp. 1-65). Academic Press.
67. Scott, A. J. (2004). A Perspective of Economic Geography. Journal of Economic Geography, 4(5): 479-499.
68. Shane, S. (1992). Why do some societies invent more than others? Journal of Business Venturing, 7, 29-46.
69. Shane, S. (1993). Cultural influences on national rates of innovation. Journal of Business Venturing, 8, 59-73.
70. Shannon, C. E., & Weaver, W. (1958). The mathematical theory of Communication. California: University of California Press.
71. Sivakumar, K., & Nakata, C. (2001). The stampede toward Hofstede's framework: Avoiding the sample design pit in cross-cultural research. Journal of international business studies, 32(3), 555-574.
72. Škerlavaj, M., Song, J. H., & Lee, Y. (2010). Organizational learning culture, innovative culture and innovations in South Korean firms. Expert systems with applications, 37(9), 6390-6403.
73. Small, M. L., Harding, D. J., & Lamont, M. (2010). Reconsidering Culture and Poverty. The ANNALS of the American Academy of Political and Social Science, 629(1), 6-27.
74. Strychalska-Rudzewicz, A. (2016). The impact of national culture on the level of innovation. Journal of Intercultural Management, 8(1), 121-145.
75. Švarc, J., Lažnjak, J., & Dabić, M. (2019). Regional innovation culture in innovation laggard: A case of Croatia. Technology in Society, 58, 101123.

76. Taylor, M. Z., & Wilson, S. (2012). Does culture still matter?: The effects of individualism on national innovation rates. Journal of Business Venturing, 27(2), 234-247.
77. Tian, M., Deng, P., Zhang, Y., & Salmador, M. P. (2018). How does culture influence innovation? A systematic literature review. Management Decision. 56(5), 1088-1107.
78. Tura, T., & Harmaakorpi, V. (2005). Social capital in building regional innovative capability. Regional Studies, 39(8), 1111-1125.
79. Von Braun, C. (1997). The innovation war. Upper Saddle, NJ: Prentice-Hall.
80. Wang, J. F., Li, X. H., Christakos, G., Liao, Y. L., Zhang, T., Gu, X., & Zheng, X. Y. (2010). Geographical detectors-based health risk assessment and its application in the neural tube defects study of the Heshun Region, China. International Journal of Geographical Information Science, 24(1), 107-127.
81. Williams, L. K., & McGuire, S. J. (2010). Economic creativity and innovation implementation: the entrepreneurial drivers of growth? Evidence from 63 countries. Small Business Economics, 34(4), 391-412.
82. Zhu, B., Habisch, A., & Thøgersen, J. (2018). The importance of cultural values and trust for innovation—A European study. International Journal of Innovation Management, 22(02), 1850017.

Authoritarian Resilience and Institutionally Social Learning: an Asymmetric Comparative Study between the Enning Road Regeneration in Guangzhou, China and the Okhta Centre Project in Saint Petersburg, Russia

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Abstract. This paper aims to employ two recent and significant cases, the Enning redevelopment project (2006-date) in Guangzhou, China and the Okhta Centre project (2006-2018) in Saint Petersburg, Russia to join the forum about authoritarian resilience in Chinese politics and other context. Authoritarian resilience is a crucial angle to explain the survival and development of China's authoritarian regime after several political and economic crises since the late 1980s (Li, 2012; Nathan, 2003). Methodologically, this research plans to contribute to this perspective through two ways. Firstly, it aims to establish an actually existing authoritarian resilience perspective to analyse the materialisation process of authoritarian regime in urban level while other literature are more focus on abstract political actions in national level. Secondly, an asymmetrical comparison between Chinese case and similar Russian one will be established by more emphasizing Chinese part; such a comparative perspective to other authoritarian regimes is more or less missed in scholarship about authoritarian resilience in Chinese politics. Based on these two innovations in research method, the third contribution will emerge after empirical analysis.

Relevant data have been collected by semi-structured interviews, secondary data and participation observation in two cases, especially in three field trips to Guangzhou in 2013, 2015 and 2019 and two trips to Saint Petersburg in 2013 and 2014. Compared to data collected from Guangzhou case, we have gathered fewer from Saint Petersburg case; therefore, it is an asymmetric comparison while Guangzhou has more data to analysis and become the starting point and destination of our comparative research. The Okhta Centre case acts as a mirror to reflect features of Guangzhou case. Based on these data and such asymmetric comparison, both cases initiated projects with capital in authoritarian orders under an entrepreneurial urban environment; however, there were various resistances to such projects not only from affected community members but also from broad civil society entities. Responsively, authorities in Guangzhou and Saint Petersburg had to transform their plans, discourses, agendas and strategies to adapt external challenges, in different manners. Finally, both projects had been significantly changed their functions and forms compared to their initiatives.

Based on these similar processes and outcomes, this paper argues that authoritarian style urban regime in Guangzhou, China displayed relatively better resilience against challenges from civil society than Saint Petersburg did. Its authority can take timely and corresponding actions to response to societal requirements in a politically depressed environment. Going beyond that, it learns from social actors to set up new agendas which are in advance designed to steer future actions of social actors. At the same time, Guangzhou government demonstrated stricter social control over political mobilisation against redevelopment. Legislative sectors have been excluded from political process in Enning Road Project. Professionals have been separated into individuals to benefit social control. No foreign forces, such as UNESCO, can be involved.

Therefore, compared to Saint Petersburg, political regime in Guangzhou is more authoritarian, because it has stricter social control to de-institutionalise social actors to prevent broad political mobilisations; and this regime is more resilient, because it can change its plans and strategies more frequently and more timely to response to changed circumstance. This dialectic characteristic of authoritarian regime in Guangzhou may due to its institutionally social learning capacities (Steyaert and Jiggins, 2007; Wenger, 2010). The local state monopolies the power to design, build and operate institutions. Through social learning, governmental actors with institutional power can continually update its strategies, approaches and instruments. In contrast, due to lack of capacities to set and run institutions, social actors cannot be organised and only act and learn as individuals. Their knowledge and resources are then limited. To conclude, regime in Guangzhou is more resilient and more authoritarian; such a Guangzhou characteristic can be explained by institutionally social learning capacities of the local state; these capacities are coming from the monopoly of power to design, build and operate institutions in local state. This finding is the third contribution of this research.

Keywords: authoritarian resilience, urban redevelopment, asymmetric comparison, institutionally social learning

1. Introduction

Within a time-space compressed world, cities seem to be closely connected; however, in global urban studies, non-western cities are seldom connected as comparative urban studies. China and Russia, as examples, are similar in terms of non-west roles, authoritarian political system and socialist influences, but different in their geography, culture, economy, identity and so on. A comparison involving them might be productive to produce better understanding about Chinese cities. Two recent and significant cases, the Enning redevelopment project (2006-date) in Guangzhou, China and the Okhta Centre project (2006-2018) in Saint Petersburg, Russia will be analysed to establish such a comparison. To achieve this, an asymmetric comparison, in terms of similarities and differences, will be built based on empirical findings in two cases as actually existing authoritarian politics. After a comparing, a conclusion will emerge as following: political regime in Guangzhou is more authoritarian, and more resilient at the same time. To explain it, this paper will argue that such a new understanding of urban politics in Chinese cities could be explained as social learning capacities within an institutionally monopolised context operated by local state. Such institutionally monopolised social learning capacities produce both authoritarian potentials and resilient abilities.

The remainder of this study is organized as follows. Section 2 is literature review and research design. Section 3 introduces the Guangzhou case about its authoritarian governance in redevelopment. Section 4 is about the redevelopment in Saint Petersburg. Section 5 provides the comparative analysis and explanations about comparison. The last section is a conclusion and discussion.

2. Literature review and research design

Authoritarianism is a popular term to descript China's political regime (Liberthal, 1992; Nathan, 2007; Mertha, 2009; Li, 2012). Along with its frequent usage, the meaning of authoritarianism remains vague since its origins. Linz (1964, p.55) defines it as a political system with limited, not responsible, political pluralism, without an elaborate guiding ideology, but with distinctive mentalities, without neither extensive nor intensive political mobilisation, except at some points in their development. A leader, or occasionally a small group, exercises power within formally ill-defined limits but actually quite predictable ones. This definition was abstracted from political operation of Francoist Spain between 1939 and

1975. Therefore, the concept, authoritarian regime, is operationally problematic when it is transferred into other context such as China. However, the idea of authoritarian is applied in various circumstances. For instance, the Wikipedia has listed 41 countries under the umbrella of authoritarian regime. These 41 nations have extremely diverse political characteristics. The problematic application of authoritarianism is not only limited to its ambiguous meaning, but also includes its ideological bias. The concept of authoritarian state is belonging to the 'evil' family which includes dictatorships, totalitarian regime, and so on so forth. From this perspective, authoritarian regime has the natural tendency to embrace self-destruction; therefore, the only way to survive is pursuing its resilience by various methods. Of cause, authoritarian regimes have unavoidable negative feature and internal contradictions which may lead to their own destruction; however, such ideological bias might eclipse the potential of the concept in analysing political practice. This point will be discussed later.

Though the idea of authoritarian regime has at least two advantages, it still functions as the non-substitution player in the field of Chinese political studies. Fragmented authoritarianism (Liberthal, 1992), fragmented authoritarianism 2.0 (Mertha, 2009), authoritarian resilience (Nathan, 2003), pro-growth authoritarian governance (Lai, 2010), authoritarian deliberation (He and Warren, 2011) and networked authoritarianism (2011) are representatives of its popularities. They are applied to investigate why China's communist regime can survive and develop when it does not follow the Western democratic political mode. It seems authoritarian, or authoritarianism has become a 'buzzword'; it is a fashion to analyse China's politics under an authoritarian perspective, and everyone apply it in an individual and distinct approach. Among these 'x + authoritarian (authoritarianism)' or 'authoritarian (authoritarianism) + x' concepts, fragmented authoritarianism and authoritarian resilience are the mainstream ones. Fragmented authoritarianism emphasise the description and explanation of the regime's operation while authoritarian resilience concerns more about the normative aspect of the regime. This paper will focus on authoritarian resilience perspective. This perspective establish its analysis in two ways with normative concerns, firstly, how to resolve the problems of authoritarian regime; and secondly, how to enable an authoritarian regime to grasp advantages in democratic systems. Nathan (2003) follow the first pathway to reveal how China's political regime can overcome weakness of authoritarian regime, such as weak legitimacy, relying on coercion, over centralisation power and person over institution. The solution in his context means four aspects of institutionalisation in communist regime, namely a norm-bound succession process, the meritocratic promotion system among leaders, the differentiation between departments in government and more public participant in political process. This concept has been developed by Cai (2008) in terms of division of functions and duties between central and local authorities to increase institutional resilience to face increased popular resistance. Central state grants limited autonomy to local state to deal with protesting; this autonomy means the local authorities could switch between concession and repression in different situation of resistance. In terms of this, the local state could be more resilient; the central state avoids legitimate problems in front of popular resistance. In the second pathway, Heilmann and Perry (2011) employ concepts such as political resilience and adaptive governance to explain how communist regime to realise significant economic growth and political stability in changing domestic and international circumstances. Such advantages are normatively belonging to democratic regime. They argue that these resilience and adaptability are based on political heritages from Zedong Mao; who governed China for decades in the 20th century. Such heritages include setting policy by central level and developing policy instruments by the localities, generating policy by experimental experiences, managed campaigns for applying policy and so on. Shambaugh (2008) displays how atrophy and adaptation work in Chinese communist party system; through atrophy and adaptation the political process obtains institutional resilience. However, Li (2012) claims that authoritarian resilience could not work in China anymore because of

changed relationship between leaders, party, government and interest groups. Contemporary communist regime could not resilient any more, the transition to a democratic regime is unavoidable.

Following these literatures, this paper aims to join such argument with two different concerns. Firstly, this research prefers to surpass the normative nature of authoritarian resilience. Instead, it will reveal an actually existing authoritarian resilience in the operation of authoritarianism, namely, the redevelopment process in urban level. Away from ideological bias, authoritarianism or democracy is analytical perspective to understand politics. Actually existing authoritarian resilience is concrete and observable vision of authoritarian practice, or, is the materialisation process of authoritarian resilience. In the investigation of urban redevelopment, resilience does not mean authoritarian regime needs to overcome its internal and natural problems; however, the concept resilience here is mainly focus on the external adaptation of the regime at local level. More specifically, resilience in this practical perspective directly means the connection between changed circumstance and the authoritarian regime's action to response to such changes. Under this perspective, possibly urban political regime is also authoritarian because the homogeneous nature between the central and the local (Liberthal, 2003; Gel'man and Ryzhenkov, 2011). Secondly, this study employs a comparative method to analyse Enning Road Project in Guangzhou, China and Okhta Centre Project in Saint Petersburg, Russia. This is because there are dozens of countries are defined as authoritarian, only comparative studies can display the Chinese characteristics as an authoritarian regime. Enning Road Project and Okhta Centre Project are both urban redevelopment in municipalities which are under market-oriented transition and authoritarian regime. These similarities are the ground for comparison. Furthermore, these 2 authoritarian regime are both resilient to response to changed political, economic and social circumstance, but in different manners. This paper aims to analyse these similarities and differences.

This research is mainly a qualitative one because of the features of two research concerns. These questions require details about cases to analyse policies and social interactions rather than statistical data. To collect such data, two field trips in Guangzhou and two in Saint Petersburg were conducted. These two Guangzhou trips were operated in four months (from October 2013 to January 2014) and one month (June 2015). In these two trips, semi-structured interviews were conducted with interviewees from various positions, such as governmental officers, urban planners, scholars, citizens, and journalists. The Saint Petersburg trip was realized in February 2013 and August-September 2014 with 5 interviews. Secondary data were also utilized and sourced from governmental documents, mass media, professional reports, academic papers, and dissertations.

Compared to data collected from Guangzhou case, we have gathered fewer from Saint Petersburg case; therefore, it is an asymmetric comparison while Guangzhou has more data to analysis and become the starting point and destination of our comparative research. The Okhta Centre case acts as a mirror to reflect features of Guangzhou case. The aim of this research is applying Russian case to develop our understanding about Chinese urban political, within the perspective of actually existing authoritarian resilience. Based on these data and such asymmetric comparison, both cases initiated projects with capital in authoritarian orders under an entrepreneurial urban environment; however, there were various resistances to such projects not only from affected community members but also from broad civil society entities. Responsively, authorities in Guangzhou and Saint Petersburg had to transform their plans, discourses, agendas and strategies to adapt external challenges, in different manners. Finally, both projects had been significantly changed their functions and forms compared to their initiatives.

3. The Enning Road Regeneration Project, Guangzhou

Commonly referred to as the Flower City and Goat City, Guangzhou is the third largest metropolis in China and is the capital of Guangdong Province. In 2013, Guangzhou reported a gross domestic product (GDP) of 1,542,014 million Chinese Yuan, which is equal to 119,695 CNY per capita GDP (http://www.gzstats.gov.cn/, May 20, 2015). Guangzhou is the political, economic, and cultural center of Guangdong Province and South China. As a sub-provincial municipality, Guangzhou has more autonomy than other normal municipal cities. Guangzhou reported a population of 12.9 million in 2013 and it covers an area of 7434.4 square kilometers within 11 urban districts. In 2010 its fiscal income was 293 billion CNY; within which 206 billion has been submitted to the central state and left 87 billion are controlled by Guangzhou government. Financial return from the central to Guangzhou is very limited; Guangzhou every year contributes to the central billions of revenues which will be transferred to other less developed provinces. In return, Guangzhou has relatively high autonomy in economic development, especially in urban development. Urban redevelopment, as an important part of urban development and planning, is control by Guangzhou city and mainly operated by district level.

Generally speaking, head of Guangzhou government, the Mayor, is taking charge in urban development and economic growth. Besides, the secretory of Communist Party at city level controls personnel matters and ideology, and involves in significant economic issues. Bureau of Urban Planning controls planning issues while Bureau of Land Management controls land issues. District level has similar power structure.

The Enning Road redevelopment project was located in the centre of an historical area in the Liwan District. On the project site buildings in the Xiguan style (the style from the west part of the historical city of Guangzhou) were everywhere. It is also the place of former homes for several famous Chinese people, such as Bruce Lee's family and several Guangdong Opera stars (Tan, 2013). Besides these historical buildings the majority of housing in this area were private housing constructed before 1949. It is a typical old town in the city centre. In 2006, in response to the mobilisation from the municipal governmental to improve the building environment in central Guangzhou under the spatial strategy 'adjusting the centre', Liwan District Government started the Enning Road Project (Z1, urban planner, interview, 2013). The Enning Street redevelopment project is famous for its historical significance for Guangzhou, and its changeable process of planning and public discussion. The roles of mass media and semi-NGOs, as new elements in the field of urban redevelopment, are both crucial in such changes.

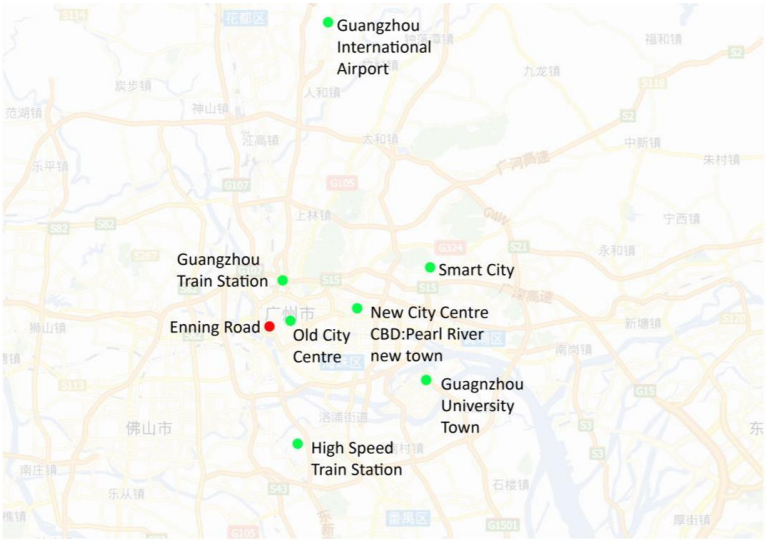

Figure 1 location of the Enning Road Project

Source: author's drawing based on http://map.baidu.com/, 2016

The Enning Road project comprised 11.37 hectares of land, 1,352 buildings and more than 1,900 households. Of these buildings, 297 were in public ownership, 831 were private ones, and the ownership of 224 was unclear (Wang et al., 2011). Redevelopment in Enning Road has taken place in different stages. In the first stage there were two plans in 2006 and 2007 by the district government to demolish buildings in Enning Street and store the land so cleared in its land storage. These lands could be leased to developers for fiscal income (Tan, 2013; L2, resident of Enning Road, interview, 2014). In May 2007, the Bureau of Foreign Trade and Economic Cooperation of Guangzhou and Liwan District Government had organised the 2007 New Spring Business Conference of Guangzhou (2007 广州荔湾新春招商会) in Hong Kong. The Enning Road redevelopment project was introduced in this conference and Ruian Real Estate Ltd had expressed their interest in the project (Chen and Peng, 2007). In July 2007, the Detailed Development Control Plan (DDCP) of Duobao Road was displayed on the official website of the Bureau of Urban Planning of Guangzhou for its public participation procedure before its approval. The plan had been criticised because it would destroy the historical landscape not only by demolishing historical buildings, but also through its new planned roads with 18-26 metre width to separate the whole historical area which included Enning Road. In September 2007 an announcement about demolition was posted in Enning Street and was also met with criticism. The announcement was posted earlier than the approval of the planning document for this area and it had less consideration about historical preservation. Under the plan in this stage, 1,950 householders would be displaced by the demolition process. The majority of the householders signed the agreement with the government agreeing to the terms of compensation, but 183 householders were unsatisfied. They wrote a public letter to the district government to protest about the planning document because there was more consideration of commercial than public interests (Tan, 2013). Their motivations were questioned as it was suspected that they aimed to increase the price of compensation through the excuse of historical preservation and public interests (H2, official, interview, 2014; Y2, scholar and planner, interview, 2014).

Due to such criticism from residents and mass media, the principles of government planning were modified from a focus on fiscal income to an emphasis on historical preservation in the second stage of the project. On 25 June 2011, the Revised Guidance for the Urban Regeneration Plan of Enning Road, the official plan for the Enning Road Regeneration Project, was finally approved by the Planning and Development Strategy Committee of Guangzhou. This approval became front-page news in nearly all the local newspapers (interview, journalist 1, 2013). Such a plan reserved more historical housing and abandoned the logic of cost recovery. On 12 December 2012, the Enning Road area was approved as the 23rd historical and cultural block in Guangzhou (H.Y. Liu, 2012), after the historical scenery in this area had already been destroyed by demolishment.

During this period, a semi-NGO (non-governmental organisation), Eninglu Concern group investigated and supported historical and cultural activities in Enning Street. This group included university students, journalists and independent artists; they connected with external resources, such as mass media and lawyers, to help residents (about 30 householders) who insisted on staying in the partly destroyed area of Enning Street. Mass media needed news from the Enning Road Redevelopment Project to attract people's attention while the project satisfied the desire of expression to protest against the government. These householders tried to understand the purpose of mass media and used them to announce their requirements.

Mr Zhang (as a resident in Enning Road) knows many journalists with their mobile numbers; he really can remember these numbers. At the very beginning, he called me every time in terms of small issue such as in which family the electricity has been stopped, or the water supply has been paused. Later on, they have realised the strategy of mass media that

media would not report some small issues; therefore, these residents would find some good reasons for the issues they want to be reported, not just small issues.

(X1, Journalist, interview, 12/2013)

Enning Road is significant for its involvement with social groups, such as semi-NGOs, mass media, lawyers and scholars, even those from overseas. These groups had increased the capacity of residents to negotiate with the local state when developers were not participating in the main process. The local state and its sectors had to change their policy about planning, demolition and re-establishment because of pressure from residents and social forces. At the same time, a few residents made too many demands because of social support from outside.

The function of Eninglu Concern Group in the early stage is a recorder; we record something in Enning and spread them by mass media. In the later stage, we have our own position; we often express our viewpoint to the government and mass media. Recently, because the demolishment process has been accelerated, in order to deal with these demolishment, we organise some special activities, such as setting poster in the site of demolishment with live telecast in Weibo (a Chinese social media, like Twitter). It works; the demolishing activities in this site pause.

We invited some friends with lawyers background to help residents in Enning.

(D1, semi-NGO member, interview, 12/2013)

After seven years and 1.8 billion CNY in public funding had been consumed (Chen, 2018), the Enning Road area became a historical and cultural block in 2012, and the progress of the Enning Road Regeneration Project stagnated. This stagnation is due to a relatively low FAR after regeneration, certificates of land ownership cannot be approved because of unfinished demolition, and resistance against removing, 168 households remained in Enning until February 2012 (New Express, 2014). In 2012, Mr Ziliu Li, the former mayor of Guangzhou, put forward a suggestion to build a museum of traditional opera of Guangzhou. His idea was supported by the new mayor, Mr Jianhua Chen; therefore, this redevelopment project in Enning Street seemed to become a cultural project. The government cannot obtain an income from it; but needed to spend millions of pounds on the costs of building it (D1, semi-NGO member, interview, 2013; X1, journalist, interview, 2013).

The museum is in the process of construction after the former mayor suggested it should be built as part of the project. The redeveloped area became a chaotic place after demolition; the physical condition of the environment is horrible for the residents who insisted on remaining there. The site is still waiting for redevelopment. The Eninglu Concern Group has been disbanded because they found there was nothing to do until 2016.

Figure 2: Enning Road in 2014

In a new stage, after municipal government has announced new rules about urban regeneration which introduced ‘micro-regeneration’ as a new mode to operate urban regeneration. In , Guangzhou municipal government initiated ‘micro-regeneration’ mode as new strategies. This mode means main structure of buildings will not be changed; only details and internal decorations will be rebuild to improve physical qualities. This new mode can avoid difficulties of demolish-rebuilding mode, such as compensations and relocations. In February 2016, Vanke has wined the contract to operate the first stage of ‘micro-regeneration’ in Enning Road, Yongqing Fang. After micro-regeneration, this tiny area becomes an internet celebrity and full of small business, such as stores of creative goods, milk-tea bars and studios (Zhang & Chen, 2018). In 2018, Xi Jinping, the highest leader of China, has visited Yongqing Fang, Enning Road (Zhang & Xie, 2018).

Behind the successful story of Yongqing Fang, residents, newspapers and experts have criticised the project for its disfigurement of history and disturbance to the everyday lives of the area''s residents. In response to this criticism, a quasi-independent academic organisation, the Professional Committee for Urban Regeneration in the Chinese Society for Urban Studies, established an evaluation project about the process and results of the Yongqing Fang Project. In August, 2017, the final report claimed that the project had significantly improved cultural identity, the physical environment, economic returns and attractiveness for tourists, but still lacked public participation (interview, official 1, 2019). One of the leaders in the Urban Regeneration Bureau, Qingkan Huang, admitted that the main problem with this project was the absence of public participation (Chen, 2018).

Figure 3: President Xi’s visiting in Enning

After opening of Yongqing Fang, the second stage of ‘micro-regeneration’ in Enning Road has been established. On 16 August 2018, Vanke Guangzhou again won first place in an open auction for the second stage of the micro-regeneration of Enning Road. To respond to the lack of public participation in the first stage, accompanied by the pressure from residents’ xinfang to a higher level, the district government strove to involve the opinions and ideas of communities, experts and mass media in the second stage (interview, developer 1, 2019). On 7 September 2018, the Joint Creation Committee was established, an organisation that includes 25 representatives, from urban planners, residents, renters in the area, experts, and mass media, such as New Express. Fourteen of them are residents and renters. This committee has several tasks, namely, explaining the plan to the public, coordinating conflicts between different interests and summarising comments of the plans to the headquarters of the Enning Road Micro-regeneration Project (He et.al, 2018a). On 15 November 2018, a demonstration of the second stage in the micro-regeneration, which involved regenerating the verandas, was presented by the Joint Creation Committee, and some key comments were sent to the project headquarters. On the same day, new plans were introduced to the public through the platform of the Joint Creation Committee (He , et al., 2018b). However, behind their harmonious image, the Joint Creation Committee simply does not work (interview, urban planner 3, 2019).

Problems in the former phases, such as missed administrative procedures, threats to history and ignoring residents' opinions, have reappeared. Such issues are even worse, because this project reflects a high political priority due to the visit of the country's top leader.

4. Okhta Centre Project in Saint Petersburg

St Petersburg, the 'window on Europe' found by the Peter the Great in 1703, was capital of Tsarist Russia between 1703 and 1917. It was named Leningrad from 1924 to 1991. This city is declared as 'cultural capital' of Russia while it has huge number of historical building, a great art collection, as well as 80 theatres as a baroque city, it also has 5 million population and 0.6 thousand square kilometres area in 2010 and the second largest researching, industrial and transport centre in the stage of USSR (Mellor, 1997; Trumbull, 2003; Golubchikov, 2010). The whole historical center of St. Petersburg, as a crucial part of city cultural identity, has been labeled as a World Heritage Site since 1990 by UNESCO.

St Petersburg has special administrative system as a 'federal city' like Moscow; these two cities are the urban federal subjects called 'City of federal importance' in Russia. Their fiscal incomes have the same status at the level of region. Distinction between federal, regional and local taxes depends on the level of legislature that is entitled to establish rates for that kind of tax. Federal rates are explicitly set by the Tax Code; regional tax rates are limited by the Code but set by regional laws. VAT and tax on mineral resource extraction (MRET) are the most important recourse for federal level. Corporate profit tax (CPT) is the largest source of regional revenues, such as St Petersburg. The personal income tax is also important income for this city (Milchakov, 2014 interview). Recently, the CPT from big oil companies are not belong to the city with their headquarters, but the regions have more real productive activities. This significantly has reduced the fiscal income in St Petersburg (Axenov, 2014 interview). The rates of tax for companies are flexible in St Petersburg; therefore there are negotiation processes between private capital and the government and their rates are very diverse. The price of land rents has the similar situation with different level between projects and enterprises (Milchakov, 2014 interview).

Okhta Centre Project has been initiated in 2006, which has been called Gazprom City before March 2007. To attract oil capital, Saint Petersburg government has promised to build an office skyscraper, Gazprom City, by 60 billion rubles public funding and delivery it to Gazprom, the largest oil company in Russia. At this period, companies were required to pay their taxes to the local government where their headquarters located. Corporate profit tax (CPT) is crucial for St Petersburg due to tax system, and Gazprom has the potential to contribute millions of fiscal income to the government from its energy business. Therefore, municipal government urged to provide bonus to Gazprom, such as the public money funded Gazprom City. This planed skyscraper is planned as offices for Gazprom, museums, library, concert hall, sports and leisure facilities. Its location was on the right bank of the River Neva and quite close to historical centre and considered as a poential threaten for historical landscape. In 2006 November, an international design competition has been established: the winner brought a 396 m plan to build Gazprom City as a new symbol of St Petersburg.

At the same, official height regulation in this historical area, even it is not the core site, is 48 m; it is a huge contradiction between this regulation and 396 m planned height of Gazprom City. In particular, citizens in this city are proud of their cultural heritage as urban identities. A large scale of disagreement against this proposed skyscraper occurred. Around 2006 November, elites protests have been organised, such as Union of Architects, City Architecture and Planning Advisory Committee, Federal Council for the preservation of Cultural Heritage, UNESCO officials and several local cultural figures (Trumbull, 2010). For the young generation, small scale street protest and art activities were organised by NGOs, such as the Living City (Zhivoi Gorod), a St-Petersburg based preservationist NGO founded

in 2006 (interview, Minchenok, 2014). A group of professional musician have organised a special concert to support these protests. In 2007 February, this disagreement has reached a highlight moment, legislative deputies aimed to build a referendum among citizens about Okhta Centre. However, under political pressure, this referendum is disallowed (Dixon, 2010).

These protesting and disagreement have influenced the local government and Gazprom. In 2007 March, project name has been changed from Gazprom City to Okhta Centre, planned function changed from 'office complex' to 'community and business centre'. It was considered as a soft position and a positive response to social pressure. In 2007, newspapers reported that officials planned to revise height regulation for Okhta Centre project. This is an official action to release pressure by increasing limited height in this area. Such an adjustment of height occurred in December 2007, without public consultation a new regulation has went public. In terms of new regulation, Okhta Centre has been permitted to no more than 100 m. Urban population became angry about this modifying because now it is more than two times of former limit, 48 m as a UNESCO standard regulation. Because of no consultation before this announcement, ordinary citizens have demanded more transparency instead of more promises of a bright economic future with Gazprom. Internationally, the World Monuments Fund put historical skyline of St Petersburg into 2008 Watch List of 100 Most Endangered Site. In 2009, it reported that the tower 'would damage the image of Russia' (Trumbull, 2012a).

Facing growing disagreement, in 2009 St Petersburg government decided to quit from funding Okhta Centre project, left the controversial project to the hand of Gazprom. In 2010 November, one more step has been realised, Governor Matvienko announced that Okhta Centre will not be built in historical centre. Around this period, Russian rules about cooperative tax has been modified, these taxes will be paid to the government where the productive actions happened, not where the headquarters located. Gazprom cannot contribute to St Petersburg as planned before, but still a large amount due to its scale (Trumbull, 2012b). In 2012, this skyscraper has been moved to Lakhta, more than 10 km away from historical centre, and renamed as Lakhta. Construction of this building started around October 2012 and finished in January 2018. Its realised height is 462 m, as tallest building in Europe. This number is 66 m higher than its original design in 2006, but faraway from the historical centre.

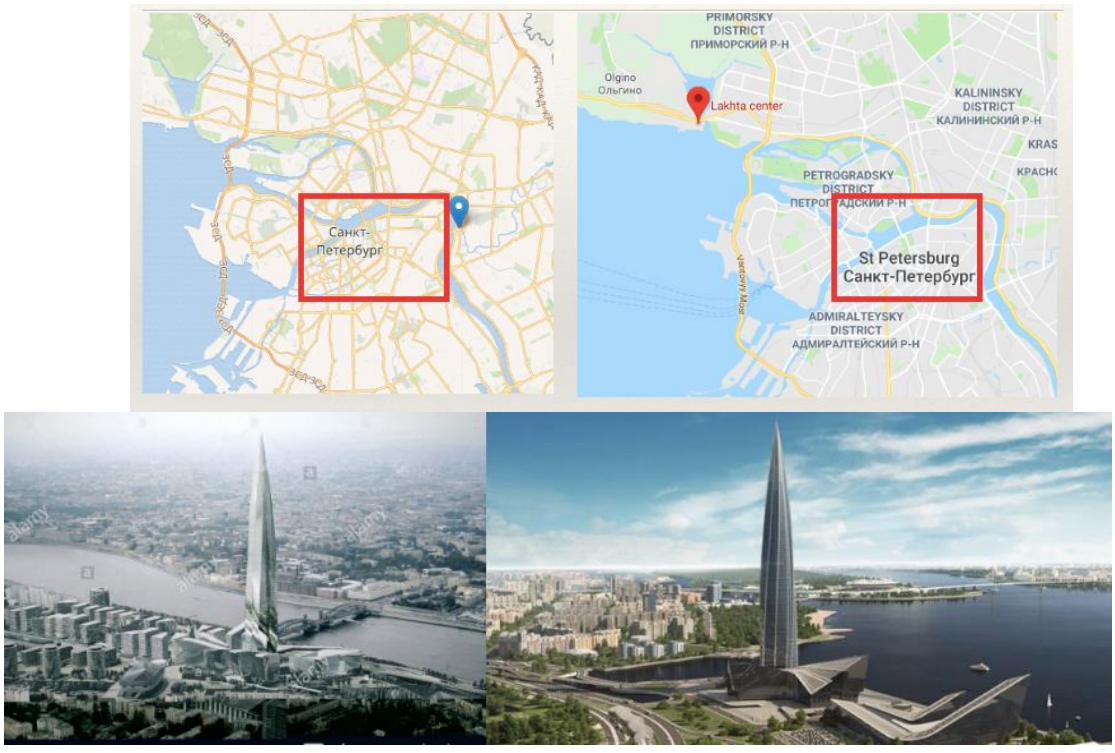

Figure 4: location and image of project in 2006 (left) and in 2018 (right).

5. An Asymmetric Comparison and Possible Explanations

These two cases, Enning Road case in Guangzhou and Okhta Centre in St Petersburg, are compared within the framework of authoritarian resilience, in particular, the resilient interaction between society and local as urban political within an authoritarian context. First, state-society politics in these two cases are authoritarian due to their national political system. Such a system is differed from pluralistic one due to centralised political power and exclusive political procedures along with weak ideological controls. Second, state-society interaction is resilient because there are space for disagreement in both cities and the local authorities have finally more or less responded to social demands and revised original proposals. An asymmetric comparison, in terms of similarities and differences, will be built based on empirical findings in two cases as actually existing authoritarian politics. After a comparing, a conclusion will emerge as following: political regime in Guangzhou is more authoritarian, and more resilient at the same time. To explain it, this paper will argue that such a new understanding of urban politics in Chinese cities could be explained as social learning capacities within an institutionally monopolised context operated by local state.

5.1. Similarities

From the similar perspective, two cases have both involved historical preservation issues. Such an issue is political, but not too much. It is not real and dramatics political conflicts between difference social groups to pursue real interests. They are cultural conflicts about memory and identities, and are not serious political challenge against ruling state. Therefore, these local state can more or less tolerate social protest against and caused by governmental actions. These protests have suspended the progress of projects at different stages, at diverse degrees and in various forms. To respond to these social pressure, government has changed directions of projects in different manners. As mechanism, urban planning is crucial instrument in both cases to negotiate between government and civil society. As a political power, urban planning is the state tool to influence the production and reproduction of urban space; social actors are living such space but have a few institutionalised power to influence such a planning, they have to find new pathways outside formal and designed channel in planning to protest. In these various social mobilisation and protests, mass media and scholars are quite active to rise the temperature of public discussion. Scholars have knowledge power to legitimate claims from society; mass media has the media power to expand these professional thoughts to the public, to educate people and mobilise the mass. Finally, as a characteristic of authoritarian political regime, top leaders of these two cities have strong influence over the decisions about projects and planning regulation. The mayor of Guangzhou and the governor of St Petersburg are key actor to make influences. Besides, higher level often has even stronger impacts, maybe not intentionally and directly. For the Enning case, President Xi's visiting is a crucial factor to stimulate the channel of regeneration after 2018; for the Okhta Centre case, national policy about tax is crucial driving force behind the political landscape of urban regeneration.

5.2 Differences

Similarities are bases for comparison, differences are purposes to establish a comparative research. Enning Road Project has changed its mode of redevelopment for three times with enormous times to change its planning. From the beginning, it was a project pursue the logic of cost-recovery; in the second stage, such a logic has been abandoned, this project has been redefined as historical preservation; when such a new function faced stagnation, a new mode, micro-regeneration has been invented to push project forwards. To follow changed mode of regeneration, urban planning in this project has also changed accordingly. At the same time, social demands in this project is also changed significantly, it has been shifted from pursuing better compensation, to historical preservation, and to public participation and to improve

quality of institutions in the micro-regeneration period. Such demands are mainly expressed by mass media, especial the New Express as local market-oriented newspaper. Okhta Centre Project has changed its planning mainly twice, the first time is about it function, the second time is about location. Interestingly, Okhta Centre has changed its name two time, but the mode of regeneration has remained.

Besides, Enning Road Project has less mobilised broad political forces than Okhta Centre Project has. Media, NGOs, ordinary citizens and professionals are all mobilised in both cases. But in the Okhta Centre regeneration, it has deeply engaged legislative branch at least two times. The first one is its proposal to set a referendum; though this proposal has failed, but it may inspired people from a legal perspective and mobilised more population. The second one is the revision of regulation about height in historical area. Fortunately, this time it succeed, but unfortunately, such a success lead to more dissatisfaction from the population due to such an inappropriate revision. Whatever the result, the function of legislative in municipal government is active in Okhta Centre case. In Enning case, the legislative branch, the local Congress of People, has fully absent as an institutional actor. In Okhta Centre Project, professional organisations, such as Union of Architects, City Architecture and Planning Advisory Committee, are more active as both institutions and individuals. In Enning Road Project, professionals are more acting as individuals rather than as institute or organisation. Apart from these two differences, there is no foreign forces can really influence the Enning case; but in Okhta Centre case, international actors, such as UNESCO, is a crucial actor.

5.3. Conclusion of Comparison

First, authoritarian state-society interaction in Enning case, Guangzhou is more resilient. Mode of regeneration and planning in Enning case has been timely changed to adapt various demands from the whole society. Such dramatic transformations have not occurred in Okhta Centre St Petersburg. Accordingly, social actors are also more resilient, the have found different goals to pursue in different periods.

Second, politics in Enning case, Guangzhou is more authoritarian. Legislative sectors have been excluded from political process in Enning Road Project. Such an absence has reflected the political landscape in national scale that legislative departments have less political power to balance other branches. In Guangzhou, people are separated into individuals to benefit social control in Guangzhou; especially for professionals, they have not been organised. Individuals is weaker than organised people to act collectively; therefore, there is stricter social control in Guangzhou case as an authoritarian. Besides, there is oo foreign forces, such as UNESCO, have been involved in Guangzhou; it is more exclusive for international organisations. St Petersburg has set fewer obstacles for international forces which can be external supervision to balance the political power of local state.

5.4 Possible Explanation: Institutionally Monopolised Social Learning Capacities

Such a conclusion, Enning case is more resilient and more authoritarian, can be explained as social learning capacities for Guangzhou government. Social learning is differ from individual learning in terms of its social interaction, learning circle from action to methods and to values, and collective natures (Steyaert and Jiggins, 2007; Wenger, 2010). Mode of regeneration and planning in Enning case has been timely changed to adapt various demands from the whole society. Why could this happen? Because the Guangzhou local state can learn by doing, can learn from social actors. Government can learn from civil society in terms of themes, languages and strategies. For instance, they have started to use terms about public participation after 2018 to build the Joint Creation Committee to legitimate its actions; but not really empower this committee to mobilise people and to resist planning procedures. Local state can not only learn the words and contents, but also understand the values behind the

words; however, such an understanding is not applied to use these words and values, but to achieve governmental goals.

A further question may emerge, why Guangzhou local state can obtain this social learning capacities? This is because the local state has monopolised the power to design, apply and supervise institutions. After this monopolising, social demands cannot be inputted by social actors into the newly established institutions, such as rules, regulations and plans. Because social actors are excluded from the production of institutions, they cannot be organised to express their interests to shape institutions. This also reduced the political power of social actors to negotiate with state. At the same time, due to the exclusion of social voice in institutional production, the local state has to hear, to watch and to learn from social actors, otherwise they cannot find the real demands from society. Instead of including real social actors in designing institutions, local state in Guangzhou pushes themselves to express the social demands. This is institutionally monopolised social learning. It both the origins of resilience and authoritarian power.

6. Conclusion

This paper aims to employ two recent and significant cases, the Enning redevelopment project (2006-date) in Guangzhou, China and the Okhta Centre project (2006-2018) in Saint Petersburg, Russia to join the forum about authoritarian resilience in Chinese politics and other context. Methodologically, this research plans to contribute to this perspective through two ways. Firstly, it aims to establish an actually existing authoritarian resilience perspective to analyse the materialisation process of authoritarian regime in urban level while other literature are more focus on abstract political actions in national level. Secondly, an asymmetrical comparison between Chinese case and similar Russian one will be established by more emphasizing Chinese part; such a comparative perspective to other authoritarian regimes is more or less missed in scholarship about authoritarian resilience in Chinese politics. Based on these two innovations in research method, the third contribution will emerge after empirical analysis.

Compared to data collected from Guangzhou case, we have gathered fewer from Saint Petersburg case; therefore, it is an asymmetric comparison while Guangzhou has more data to analysis and become the starting point and destination of our comparative research. The Okhta Centre case acts as a mirror to reflect features of Guangzhou case. Based on these data and such asymmetric comparison, both cases initiated projects with capital in authoritarian orders under an entrepreneurial urban environment; however, there were various resistances to such projects not only from affected community members but also from broad civil society entities. Responsively, authorities in Guangzhou and Saint Petersburg had to transform their plans, discourses, agendas and strategies to adapt external challenges, in different manners. Finally, both projects had been significantly changed their functions and forms compared to their initiatives.

Based on these similar processes and outcomes, this paper argues that authoritarian style urban regime in Guangzhou, China displayed relatively better resilience against challenges from civil society than Saint Petersburg did. Its authority can take timely and corresponding actions to response to societal requirements in a politically depressed environment. Going beyond that, it learns from social actors to set up new agendas which are in advance designed to steer future actions of social actors. At the same time, Guangzhou government demonstrated stricter social control over political mobilisation against redevelopment. Legislative sectors have been excluded from political process in Enning Road Project. Professionals have been separated into individuals to benefit social control. No foreign forces, such as UNESCO, can be involved.

Therefore, compared to Saint Petersburg, political regime in Guangzhou is more authoritarian, because it has stricter social control to de-institutionalise social actors to prevent broad political mobilisations; and this regime is more resilient, because it can change its plans and strategies more frequently and more timely to response to changed circumstance. This dialectic characteristic of authoritarian regime in Guangzhou may due to its institutionally social learning capacities (Steyaert and Jiggins, 2007; Wenger, 2010). The local state monopolies the power to design, build and operate institutions. Through social learning, governmental actors with institutional power can continually update its strategies, approaches and instruments. In contrast, due to lack of capacities to set and run institutions, social actors cannot be organised and only act and learn as individuals. Their knowledge and resources are then limited. To conclude, regime in Guangzhou is more resilient and more authoritarian; such a Guangzhou characteristic can be explained by institutionally social learning capacities of the local state; these capacities are coming from the monopoly of power to design, build and operate institutions in local state. This finding is the third contribution of this research.

References

1. Baogang He and Mark E. Warren (2011) Authoritarian Deliberation: The Deliberative Turn in Chinese Political Development. Perspectives on Politics. 9(2). pp. 269-289.
2. Cai. Y. S. Power Structure and Regime Resilience: Contentious Politics in China. British Journal of Political Science. 2008.03(38). Pp.411-432.
3. Deng, H.P. 邓海平. (2005) 'Guangzhou weifang gaizao: bingqi kaifanshang qingjie' 广州危房改造：摒弃"开发商"情结 [The reconstruction of dilapidated building in Guangzhou: Abandon the "developer" complex]. Jingji ribao 经济日报, 20 May, pp. 13.
4. Dixon, M. Gazprom versus the skyline: Spatial displacement and social contention in st. Petersburg. International Journal of Urban and Regional Research. 2010. 34(1): 35-54.
5. Hilemann. S. and Perry. E.J. (2011). Mao's Invisible Hand:The Political Foundations of Adaptive Governance in China. Cambridge: Harvard University Asia Center.
6. Huang, H.M. 黄慧明. (2013) 1949nian yilai Guangzhou jiucheng de xingtai yanbian tezheng yu jizhi yanjiu 1949 年以来广州旧城的形态演变特征与机制研究 [The characteristics of urban morphological transformations and development mechanisms: A case study of Guangzhou since 1949]. PhD Thesis. South China University of Technology.
7. Golubchikov, O. 2010. World-city-entrepreneurialism: globalist imaginaries, neoliberal geographies, and the production of new St Petersburg. Environment and Planning A 42(3), pp. 626-643. (10.1068/a39367)
8. pLai, Hongyi (2010) Uneven opening of China's society, economy, and politics: pro-growth authoritarian governance and protests in China. Journal of Contemporary China, 19 (67). pp. 819-835. ISSN 1067-0564
9. Li, C. The End of the CCP's Resilient Authoritarianism? A Tripartite Assessment of Shifting Power in China, the China Quarterly, 2012 (211), pp 595-623.
10. Lieberthal, K. G. (1992) "Introduction: The 'Fragmented Authoritarianism Model' and Its Limitations". Lieberthal, K. G. and Lampton, D.M. (ed.) Bureaucracy, Politics, and Decision Making in Post-Mao China. Berkeley: University of California Press.
11. Liberthal, K.G. (2003) Governing China：From Revolution to Reform. London: W. W. Norton & Company.

12. Linz, J. J. (1964) 'An Authoritarian Regime: Spain', in Allardt, E., and Littunen, Y. (eds.) Cleavages, Ideologies and Party Systems: Contributions to Political Sociology. Helsinki: Transactions of the Westermack Society.
13. Linz, J.J. (2000) Totalitarian and authoritarian regimes. Colorado: Lynne Rienner Publishers.
14. MacKinnon, R (2011) China's "Networked Authoritarianism" Journal of Democracy Volume 22, Number 2 pp. 32-46 | 10.1353/jod.2011.0033
15. Nathan. A.J., Authoritarian Resilience, Journal of Democracy, 2003/01(14), pp 6-17.
16. Shambaugh. D.L. 2008. China's Communist Party: Atrophy and Adaptation. Oakland :University of California Press
17. Tan, X.H. 谭肖红. (2013). Chengshi guanzhi shijiaoxia de chengshigengxin juece jizhi yanjiu- yiguangzhoushi engninglu gaizao weili 城市管治视角下的城市更新决策机制研究 --以广州市恩宁路改造为例 [Research on decision making mechanism of urban regeneration from the perspective of urban governance --a case study of Enning Road in Guangzhou City]. M.A. Dissertation. Peking University.
18. Trumbull NS (2010). Challenges to Western Participation in Shaping the Urban Landscape of Post-Socialist St. Petersburg: The Failure of International Competitions for Iconic Architectural Projects. 51(6): 788-802.
19. Trumbull NS (2012a) Redevelopment and conservation in the built fabric of post-socialist St. Petersburg. Urban Geography 33 (3), 370-400
20. Trumbull NS (2013) St. Petersburg, Russian Federation. Cities 31, 469-490
21. Trumbull NS (2012b) Urban pulse—Claiming" The Right to the City": Architectural preservation in St. Petersburg as cultural and political Catalyst. Urban Geography 33 (7), 1000-1007
22. Vladimir Gel'man and Sergei Ryzhenkov. (2011) Local Regimes, Sub-national Governance and the 'Power Vertical' in Contemporary Russia. Europe Asia Studies 63(3):449-465
23. Zhang, H.Y. 章鸿雁. (2015) 'Chanye shengji daoxiangxia de jiuchengqu gengxin jianshe- yi guangzhoushi weili' 产业升级导向下的旧城区更新建设——以广州市为例 [Urban regeneration oriented by industrial upgrade- A case study of Guangzhou]. Zhonghuajianshe 中华建设, 2015 (1), pp. 82-85.

Analysis of international labor migration and its trends in Nepal

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Abstract. Labor migration is a salient factor contributing of Nepal's economy. Since many years, everyday several Nepalese young people migrate to abroad for jobs. Remittance is the main source of our nation's sources of money and it is generated from migrants. This study has analyzed based on various existing research papers, national and international reports and data. This article tries to show the historical trends of labor migration of Nepal and also presents the new destinations for labor migration. In the present scenario, male labor migrant from Nepal is decreasing and women labor migration gradually increasing. A noticeable new destination is increasing in recent years such a developed country. This study finds that the country is benefited from labor migration and supporting to country's economic condition but due to the new challenge.

Keywords: Labor migration; Destination; Nepal

1. Introduction

Labor migration is a common issue in the world. People crossing the national borders to work is one of the main reasons behind international migration. In 2019, more than 169 million people across the national borders for working purposes, which covers around 5% of global labor manpower in the destination countries (Habti & Elo, 2019). People from low-income countries migrating to a high-income country is the world's latest trend. In 2019, 24.2% of people shifted to Europe, and 22.1% of people were shifted to North America (Lichter et al., 2020). International labor migration is mainly occurring in the low-income country, where they cross the national borders for a better life and opportunity (Balbo & Marconi, 2006; Sv Helgason, 2015) Economic inequalities, job opportunity, and a better life are the driving force for labor migration. Unstable government and politics, different natural disasters, poverty, decreasing agricultural productivity, and influence of friends, relatives, and well-wishers are the contributor to labor migration. Male and female genders are equally migrant for work, according to the International labor organization (ILO) in 2019, 58.5% male and 41.5% female was migrant for working purpose (ILO, 2020). Migration, unlike fertility and mortality, is the least researched and understood component of demographic dynamics in Nepal although many of Nepal's social and political problems are interwoven with the process of both internal and international migration (Gartaula, 2009; KC, 1998; Magar, 2016). Internal migration does not change the population of the country but it does change the population of the specific place (Rees et al., 2017). Migration has a greater implication in the growth and distribution of both population and resources.

Over the decades, labor migration for seasonal work has been a vital livelihood for Nepali people. The international labor migration from Nepal has a long history, which goes back for about 200 years (Seddon et al., 2002; Singh, 2015). In the past, international migration from Nepal was mainly to India and Tibet. People start to go to their neighbor's country for pilgrims' purposes. They also cross the borders for war as a soldier. People start Lahore (present in Pakistan) to join the army of the Sikh emperor. After the war, the Nepalese people has become a symbol of bravery and famous become the nickname lahure and joined the armed

forces of India, Hongkong, and the UK (Kharel, 2016; Thieme & Wyss, 2005). Many people from Nepal cross the borders to work in India, many people still go to India for seasonal work (Poertner et al., 2011a). After the panchayat regime in 1990, we follow the liberalized economy and free political environment of the nation. As the result of the political scenario change, the government of Nepal started to send the people to the middle east as low-skill manpower. We formalized labor migration as a national opportunity. Lack of job opportunity and political conflict, people from rural areas attracted for labor migration. Poverty and fewer job opportunity become push factors for the youth to search for life in a developed country (Mannan, 2017; White, 2010). Developing countries face massive international labor migration, as well as there is also a high rate of internal migration (Ling & Liu, 2005; A. Sharma & Jose, 2020). People migrate from rural areas to urban areas for a better life, education, health, and better job. Most of the countries face a decreasing rate of the working-age population but in Nepal, the working-age population was continuously increasing. 2.7 million working-age people increase in Nepal between the 2001 to 2011 census in Nepal, which is around a 6% increase (CBS, 2011). Annually millions of Nepalese youth come into the labor market but the country can't provide a proper job for them. In Nepal, there is a 2% growth rate of the working-age population, and expected that five million people entering the labor market by 2025. Lack of job opportunities in Nepal, most of them will go abroad, which also increases international labor migration in near future.

Migration is a complex phenomenon marked by socio-economic, political, cultural, demographic, environmental, and psychological causes in which push and pull factors work in the place of origin and the place of destination respectively (Bijak, 2006; Dako-Gyeke, 2016; Gautam, 2005). People migrant to a new destination to get, availability of fertile land, development of infrastructures, opportunities for employment, development of new technologies, better education, health housing, transportation, and communication facilities (Haggblade et al., 2010; von Braun, 2007). They are seeking a high payable job, modern society, agglomeration of government, developments of industries, business, trade, probity of constrictive works, high security of urban areas. Human civilization started from the initial stage, becoming a modern society. The world has been experiencing a high rate of movement of people from one place to another. Millions of people across the nation's borders for different purposes and they permanently settle in another new country. International labor migration become a common issue for all country and the extraordinary change in labor migration during the period has transformed human mobility into a serious global issue. It became a common issue of the twenty-first century. This paper tries to attempt the present trends of labor migration from Nepal.

2. Methods and materials

2.1. Study area

Nepal is located in the central part of the Himalaya region with occupying an area of 147,516 km^2 area, which extends from 26°22' to 30°27' N in latitude and 80°04' to 88°12' E in longitude (Figure 1). Administratively, the country is divided into 7 provinces and 77 districts and three ecological regions; Mountain, Hill and Tarai. Hill and Mountain regions covers 86% and 14% land covers by Tarai region (east-west southern low land of country). The elevation range of the study area starts from the Indian Gangetic plain less than 50m to the high Himalayan region of more than 8,848.86 m. Due to diverse topography, it has a large variation in climate and social diversity. A large number of people belong to different castes, ethnicity, religion, culture, and language. Based on 2011 census, a total of 27.04 million people is living within in various regions of the country. A total of 6.73%, 43.0%, 50.27% people are living in Mountain, Hill and Tarai region, respectively.

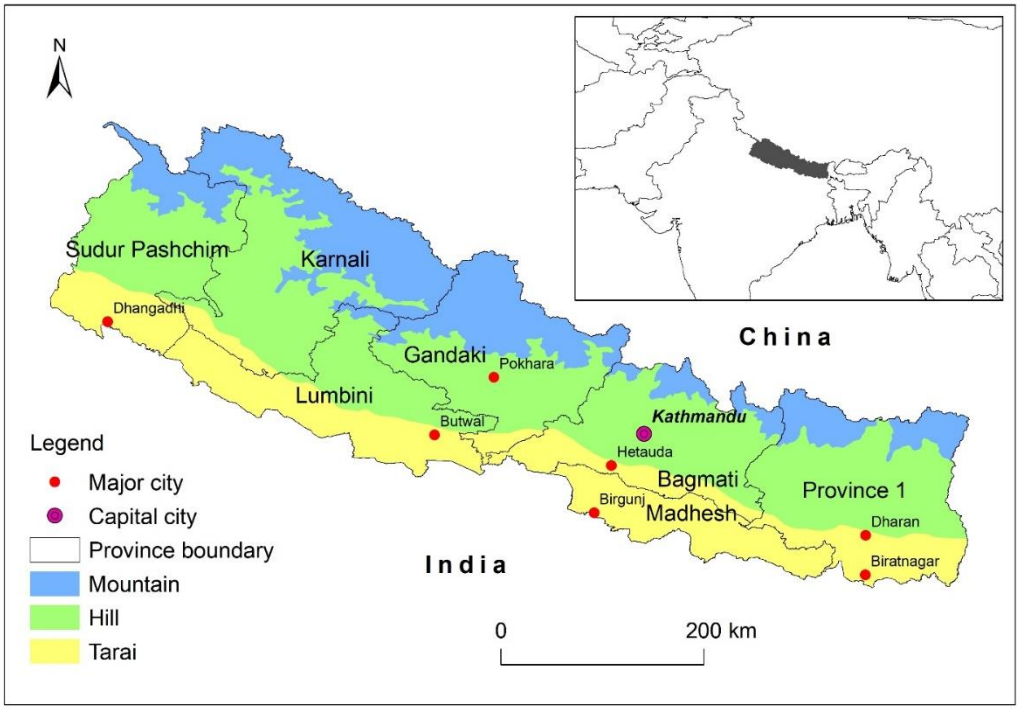

Figure 1. Location of Nepal with ecological and province boundary. Data source: Survey Department of Nepal.

2.2. Data sources

This review study analyzed based on existing available papers, books and reports. The reports published by the Government of Nepal, International Labor organization, Center bureau of statistic, the International Organization for Migration and The Asia Foundation report were used in the study. The papers related to labor migration were searched by keywords such as labor migration, foreign labor migration, and international migration from Nepal. Google scholar, research gate and web of science internet portal were used to search existing literature. In addition, government and various organization's official websites were also visited to find related reports.

3. Results and discussion

3.1. Labor migration trends

Since historical times, Nepalese workers are distributed all over the world. The government of Nepal approve 110 countries for labor migration. Nepalese people can find job opportunities all over the world except in some prohibited countries, Iraq, Afghanistan, Sudan where the government of Nepal do not issue visa for working purpose. From 2008 to 2010, the government of Nepal, Department of foreign employment has received over five hundred thousand labor visa approvals for Nepalese workers, who want to work across Nepal (Sharma et al., 2014). The trend of labor migration has rapidly increased since 2014. More than five hundred thousand application for labor migration were approved in 2014. Nepal experienced great earthquake 2014 and its effect on livelihoods and economic status during these periods. Mainly, Gorkha earthquake, Covid-19 pandemic, is the major reason for to decline of labor migration. After the Gorkha earthquake, 8964 people were died and 21952 people injured. People are got opportunity in construction work in Nepal so the trend of labor migration was slow down. Then, people started to seek opportunities around theirs's hometowns and elsewhere in the country. Likewise, the effect of COVID-19 also was a remarkable cause of decreasing of international labor migration from the country (Kikkawa et al., 2020).

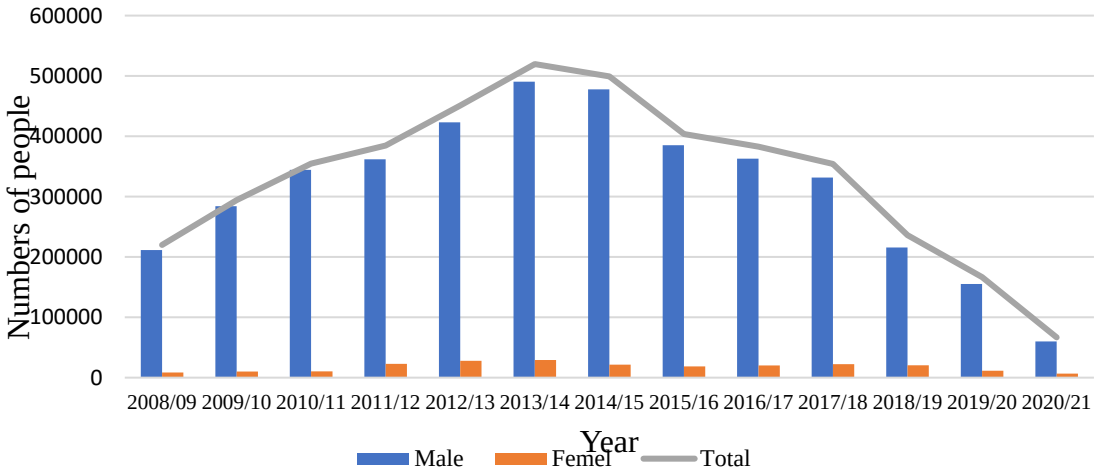

Figure 2. Labor visa approval by Government of Nepal during 2008/09-2020/021.

The number of Nepalese labor migrant was a decrease in this period but the government of Nepal opened new destination for working. There was limited working destination before 2017/18. The government of Nepal assigned the agreement for 132 countries for working permit after the 2018. Nepalese people can seek job and work opportunities in those countries listed by the government.

Comparatively male migrants are found higher than female. There is just 5% of Nepalese women have been working in foreign countries. However, in recent years, the Nepalese women are going to different country for working purposes. The Middle East is the main destination of women workers and they are involved in household works. It has reported that the household work is comparatively long working hours, physical abuse, and economic exploitation, which could be one of the factors behind the low volume of female outmigration (Martin, 2004; Shah & Menon, 1997).

3.2 Destinations of Nepali migrants

Nepalese labor has been made some specific working destinations across the world. The Middle East and Malaysia are the major working destination for Nepalese labors. However, Nepalese labor migration trends shows fluctuating, due to changes working policies, demands of labor in foreign country (Ministry of Nepal, 2020). Since 2008/09 most of the Nepalese labor worked in Malaysia, but the government of Malaysia changed their policy than the Nepalese migrants was started to decrease in Malaysia. In 2017/18, a total of 29.4% of Nepalese labor were worked in Malaysia, but after a year only 4.2% of Nepalese labor were visited for working. Here is a noticeable fluctuation in labor migration. In 2018/19, Malaysia rings out from top-five destination countries that provide job opportunities to Nepalese people as international labor. Mainly the changing policy on foreign workers was found the main reasons to decrease Nepalese labor in Malaysia. In 2017/18, predominantly four countries (Malaysia, Qatar, Saudi Arabia, and UAE) was made highest destination by Nepalese labor, where more than 87.1% Nepalese labor visited those countries (Figure 3). Federation International de Football Association (FIFA) decided to world cup 2022 in Qatar, the flow of workers increase in Qatar. More than one million Nepalese worker works in Qatar now. International labor migration from Nepal is concentrated in the Gulf Cooperation Council (GCC) and Malaysia.

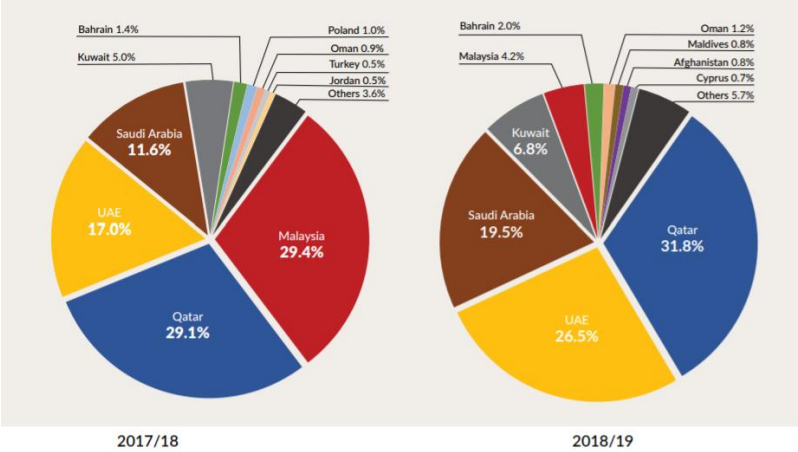

Figure 3. Destination country and visited Nepalese labor.

Nepal has long labor migration history but due to the lack of technical skills, and diversification, we depend on only some destination countries. Mainly, they are working as physical works. In a recent year government of Nepal directly talks and start to send semiskilled manpower to some countries like South Korea. United Kingdom, Mauritius, Maldives are purpose to send skilled workers through G2G contract. Nepalese people are started to go to other countries as skillful workers nowadays. Europe, North, and South America develop Asian countries, and Africa is the new working destination for Nepalese workers.

3.3 Major destination countries for labor migration (female)

Nepalese women are distributed almost all over the world as migrant labor. Most of them are non-skilled workers. Nepali manpower companies send a huge number of women workers in GCC and Malaysia as domestic workers. Cyprus, South Korea, and Israel are the most demanded country for Nepalese working women. The GCC and Malaysia cover more than 85% of women workers from Nepal (when??). The recent trend is a slight difference in the case of Nepalese women labor. There is noticeable diversity among the destination countries. Nepalese women worker started to go to other developed countries. However, there are very few shares compared to male labor migration. Overall migration pattern from Nepal is primarily driven by male.

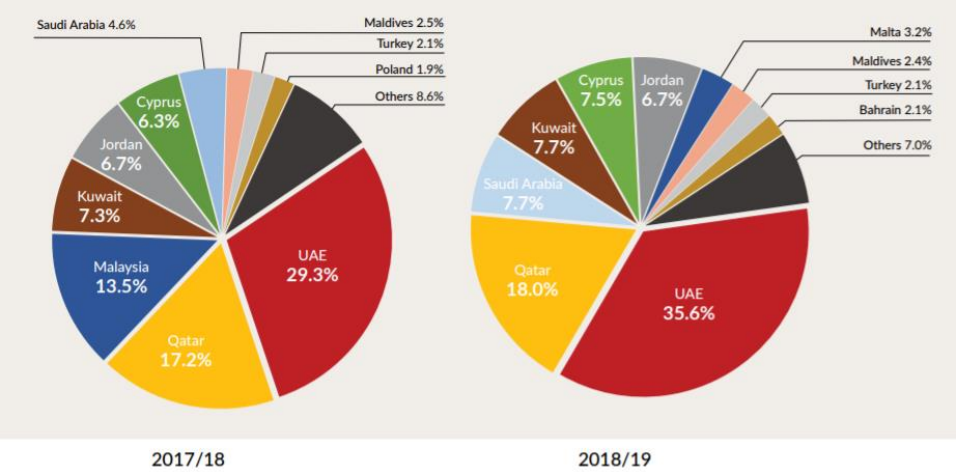

Figure 4. Major destination country for female labor.

Some decades ago Nepalese labor was oriented mainly to GCC country and Malaysia, but in recent years Nepalese labor distributed almost all over the world. In 2019, Nepal received more than 50,000 labor approvals from different countries. The government of Nepal

consensually efforts to geared towards developing bilateral cooperation with these countries that are benefited Nepalese workers to search job opportunities in a new destination. The searching for a new destination for working is increasing in recent years. It is continuing to increase in those countries which are a new destination for Nepalese migrant people. Nepal received labors approval from prominent countries but due to impact of COVID-19, the migration flow is very limited.

3.4 Spatial distribution of origins of migrants in Nepal

There is no equal ratio on labor migration. Sagarmatha and Madhesh province have the highest share of labor migration. In 2018/19, Sagarmatha and Madhesh province represents more than 50% of migrant to the various country for working. From Karnali and Sudurpashchim province, there are very few people were recorded for international labor migration. Largely, seasonal or log-term migrants from Karnali and Sudurpashim provinces used to go India. There are no official records of Nepalese migrants in Nepal. Likewise, in 2017/18, about 29% of people got visa approval (for whom??), while 24% originated from Sagarmatha province. Bagmati, Gandaki, and Lumbini provinces comprising between 12 to 17 percent of the total share give actual % for each province. Very few women were applied and got working visa for from Karnali and Sudurpaschim province.

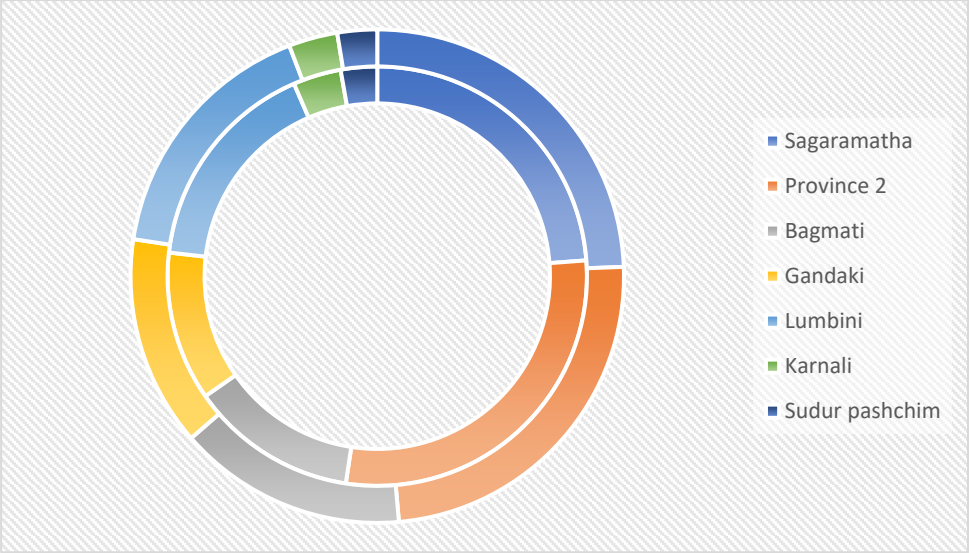

Figure 5. Distribution of migrants from various provinces of Nepal.

The regional migration of population particularly from the hills to Tarai region started first in the eastern parts of the country and the movement in the far western part only took place in the 1980s (Poertner et al., 2011b) ??? not clear. Several studies citation??? have been conducted in this field by different research institutions and scholars but most of these are concerned with an internal Hill to Tarai and rural to urban types of migration.

More than 90%immigrants are representing from the Hills and Mountain regions of Nepal (Sharma, 2009; Subedi, 1991). It is also notable that the population density in the border districts of India are far higher than those of the Tarai districts of Nepal. The eastern hills have experienced the highest number of out-migrants in the country (Khanal et al., 2015; Pandey, 2021). In the last decade, the migration of people from the hills of the far western region to Tarai has been very common. Similarly, population of city areas like Kathmandu, Pokhara, Bharatpur, Butwal, Lalitpur, Nepaljung, Dhangadi, and Mahendranagar have been steadily rising in recent years. Moreover, the population of those district headquarters have been rising every year.

3.5 Impact of labor migration in Nepal

T Migration has both positive and negative impacts on the utilization of natural resources (Guan et al., 2020). Due to migration, there are different economic consequences in both places of origin and destination (Hugo, 1995; Zachariah et al., 2001). When active populations migrate, they create a lack of labor force. Different types of social changes occur due to migration. When people from different castes, regions, and cultures migrate from one place to another, they exert changes in the social structures of both places of origin and destination. In city areas, the density of population is rising and so is environmental degradation. The percentage of barren lands are increasing in the rural areas of the Hill and Mountain regions (you can cite my paper, Khanal, Paudel). The occupation of people has changed, the number of people working in agriculture has decreased

You can discuss both positive and negative aspects such as GDP, remittance, migrations, education improvement, land/house abandonment, social degradation, etc.

4. Conclusion

This paper examined the labor migration of Nepal. The total migrants (male and female) are increasing in foreign works. The numbers labor is increasing trend compared to the past. In addition, the Government of Nepal also assigned to new countries for labor migration. People are starting to go to a new destination for labor work and a new trend is developing for international migration. There is both positive and negative impact of migration in Nepal. Nepal is highly depending on remittance for economic condition of the country. Nepal has observed the largely growing phenomena of an absent population over the census periods. Whereas the 2001 census recorded that there was an absent population of 762,181, which is increased to 1,921,494 absent people in 2011. Mention GDP here. Lack of employment in country, and poverty are the main reason for international labor migration.

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References

1. Balbo, M., & Marconi, G. (2006). International migration, diversity and urban governance in cities of the South. Habitat International, 30(3), 706–715. https://doi.org/10.1016/j.habitatint.2005.04.004
2. Bijak, Jakub. (2006). Forecasting international migration: selected theories, models, and methods. Central European Forum for Migration Research.
3. CBS, (2011). Population monograph of Nepal. (Vol. 1) https://mohp.gov.np/downloads/Population%20Monograph%20V01.pdf
4. Dako-Gyeke, M. (2016). Exploring the migration intentions of Ghanaian youth: A qualitative study. Journal of International Migration and Integration, 17(3), 723–744. https://doi.org/10.1007/s12134-015-0435-z
5. Gartaula, H. N. (2009). International migration and local development in Nepal.
6. Gautam, T. R. (2005). Causes and impact of migration: A sociological study of emigration from Kandebash, Baglung, Nepal.
7. Guan, J., Kirikkaleli, D., Bibi, A., & Zhang, W. (2020). Natural resources rents nexus with financial development in the presence of globalization: Is the “resource curse”

exist or myth? Resources Policy, 66. https://doi.org/10.1016/j.resourpol.2020.101641
8. Habti, D., & Elo, M. (2019). Rethinking self-initiated expatriation in international highly skilled migration (pp. 1–37). https://doi.org/10.1007/978-3-319-95056-3_1
9. Haggblade, S., Hazell, P., & Reardon, T. (2010). The rural non-farm economy: Prospects for growth and poverty reduction. world development, 38(10), 1429–1441. https://doi.org/10.1016/j.worlddev.2009.06.008
10. Hugo, G. (1995). International labor migration and the family: Some observations from Indonesia. In Asian and Pacific Migration Journal (Vol. 4, Issue 3).
11. ILO. (2020). ILO global estimates on international migrant workers results and methodology.
12. KC, B. K. (1998). Chapter 15, International migration in Nepal.
13. Kikkawa, T., Villafuerte, J., Gaspar, R., & Narayanan, B. (2020). COVID-19 Impact on international migration, remittances, and recipient households in developing Asia. https://doi.org/10.22617/BRF200219-2
14. Khanal, U., Alam, K., Khanal, R. C., & Regmi, P. P. (2015). Implication of out-migration in rural agriculture: A case study of Manapang village, Tanahn, Nepal. In source: The Journal of Developing Areas (Vol. 49, Issue 1).
15. Kharel, D. (2016). From lahures to global cooks: Network migration from the western hills of Nepal to Japan. Social Science Japan Journal, 19(2), 173–192. https://doi.org/10.1093/ssjj/jyw033
16. Lichter, D. T., Parisi, D., & Ambinakudige, S. (2020). The spatial integration of immigrants in Europe: A cross-national study. Population Research and Policy Review, 39(3), 465–491. https://doi.org/10.1007/s11113-019-09540-3
17. Ling, Z., & Liu, P. (2005). International migration in China: Linking it to development.
18. Magar, K. (2016). Causes and consequences of rural urban migration: A case study of phuyatappa vdc, Ilam in partial fulfillment of the requirements or the degree of master of arts (MA) in rural development.
19. Mannan, K. A. (2017). Bangladeshi migration to Italy: an analysis of motivational factors and process. International Journal of Migration and Development, 3(3). https://ssrn.com/abstract=3492201
20. Martin, S. F. (2004). Women and migration prepared by.
21. Ministry of Nepal, E. and S. S. (2020). Government of Nepal ministry of labour, Employment and social security Nepal labour migration report 2020.
22. Pandey, R. (2021). Male out-migration from the Himalaya: implications in gender roles and household food (in) security in the Kaligandaki basin, Nepal. Migration and Development, 10(3), 313–341. https://doi.org/10.1080/21632324.2019.1634313
23. Poertner, E., Junginger, M., & Müller-Böker, U. (2011a). Migration in far west Nepal intergenerational linkages between internal and international migration of rural-to-urban migrants. Critical Asian Studies, 43(1), 23–47. https://doi.org/10.1080/14672715.2011.537850
24. Pokharel, R. (2011). Politics and problematics of the definition and categorization of ethnicity in Nepal.
25. Rai, R., Zhang, Y., Paudel, B., Acharya, B. K., & Basnet, L. (2018). Land use and land cover dynamics and assessing the ecosystem service values in the trans-boundary Gandaki River basin, central himalayas. Sustainability (Switzerland), 10(9). https://doi.org/10.3390/su10093052
26. Rees, P., Bell, M., Kupiszewski, M., Kupiszewska, D., Ueffing, P., Bernard, A., Charles-Edwards, E., & Stillwell, J. (2017). The Impact of Internal Migration on

Population Redistribution: An international comparison. Population, Space and Place, 23(6). https://doi.org/10.1002/psp.2036
27. Seddon, D., Adhikari, J., & Gurung, G. (2002). Foreign labor migration and the remittance economy of Nepal. Critical Asian Studies, 34(1), 19–40. https://doi.org/10.1080/146727102760166581
28. Shah, N. M., & Menon, I. (1997). Violence against women migrant workers: Issues, data and partial solutions. In Asian and Pacific Migration Journal (Vol. 6, Issue 1).
29. Sharma, A., & Jose, A. M. (2020). Internal migration: Issues prevailing in the NCT (National Capital Territory) of Delhi. VEETHIKA-An International Interdisciplinary Research Journal, 6(3), 1–17. https://doi.org/10.48001/veethika.2020.06.03.001
30. Sharma, J. R. (2009). Practices of male labor migration from the hills of Nepal to India in development discourses: Which pathology? Gender, Technology and Development, 12(3), 303–323. https://doi.org/10.1177/097185240901200302
31. Sharma, S., Pandey, S., Pathak, D., & Sijapati-Basnett, B. (2014). State of migration in Nepal. www.ceslam.org
32. Singh, K. L. (2015). Emigration of Nepalese people and its impact. In Economic Journal of Development Issues (Vol. 19, Issue 20).
33. Subedi, B. (1991). Subedi sir. CNAS Journal, 18(1), 1–18.
34. Sunam, R. K., & McCarthy, J. F. (2016). Reconsidering the links between poverty, international labour migration, and agrarian change: critical insights from Nepal. Journal of Peasant Studies, 43(1), 39–63. https://doi.org/10.1080/03066150.2015.1041520
35. Sv Helgason, K. (2015). The economic and political costs of population displacement and their impact on the SDGs and multilateralism. https://www.un.org/development/desa/
36. Thieme, S., & Wyss, S. (2005). Migration patterns and remittance transfer in Nepal: A case study of sainik basti in western Nepal. International Migration, 43(5), 2005.
37. von Braun, J. (2007). Rural-urban linkages for growth, employment, and poverty reduction.
38. White, A. (2010). Young people and migration from contemporary Poland. Journal of Youth Studies, 13(5), 565–580. https://doi.org/10.1080/13676261.2010.487520
39. Zachariah, K. C., Mathew, E. T., & Rajan, S. I. (2001). Impact of migration on Kerala's economy and society 1. International Migration, 39(1), 2001.

Venture capital and regional innovation: mechanism, path and heterogeneity -- Based on empirical analysis of 29 Provinces in China

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Abstract. Under the background of knowledge economy, innovation has become the core element to promote regional development. Venture capital is an important factor affecting regional innovation, but the effect of venture capital on regional innovation is still controversial. This paper firstly systematically combs the mechanism of venture capital on regional innovation, proposes the theoretical framework and research hypothesis of venture capital and regional innovation, and then studies the nonlinear relationship between venture capital and regional innovation based on Chinese provincial data from 2011 to 2019. Finally, the spatial econometric model is used to measure the spatial spillover effect of venture capital on regional innovation. Research shows that: ①most of the province of venture capital and innovation output show significant relationship "U" curve, but the difference between regions, Shanghai, Jiangsu and other provinces in innovation and technology are developed, both show significant and complete "inverted U curve", in the less developed innovative technology in Guangxi and Yunnan provinces, the "inverted U" decline. ②The industry-university-research institute cooperation has a partial mediating effect, and venture capital can indirectly promote regional innovation development by enhancing the intensity of industry-university-research institute cooperation. ③Absorptive capacity and intellectual property protection have a moderating effect on the "U-shaped" relationship. A high level of absorptive capacity and intellectual property protection intensity can make the "U-shaped" curve tend to be flat, the inflection point move right, and promote the overall level of the "U-shaped" curve. ④The regression results of spatial econometric model confirm that there is a significant spatial agglomeration phenomenon of regional innovation output. The direct effect, indirect effect and total effect of venture capital on regional innovation show a "U-shaped" relationship, and the intra-provincial effect is significantly stronger than the inter-provincial effect. This study deepens the understanding of the relationship between venture capital and regional innovation in theory and provides an important theoretical basis for regional innovation decision-making in knowledge economy.

Key words: Venture capital; Regional innovation; Spatial econometric model; The "U" effect

1. Introduction

With the development of the knowledge economy, innovation has surpassed traditional economic production factors such as labor and capital, and has become the core factor in promoting regional development.The factors affecting regional innovation are complex, including the level of regional economic development, innovation foundation, industry-university-research linkages, technology spillover effects, etc.(Furman et al.,2002;Huang&Du,2014), as well as scientific and technological investment and the allocation efficiency of innovation resources(Lyu et al.,2015;Wu et al.,2011).However, the innovation process has huge risks. In the early stage of technological innovation, there are

characteristics of "large investment, high risk, and uncertain returns". Traditional financing channels are difficult to meet the needs of innovation. Venture capital is due to its innovative financing mechanism and risk sharing. mechanism that realizes the combination of financial capital and intellectual capital and plays a unique role in promoting regional innovation and economic growth (Duan&Chen,2021;Yao&Guo,2017).Studies have shown that venture capital is becoming one of the most active factors in my country's innovation and economic development(Meng et al.,2019).

The relationship between venture capital and innovation is close and complex. There has been a lot of research on the proposition "the impact of venture capital on innovation", but there is still debate on the relationship between venture capital and innovation.Most studies show that venture capital can effectively promote innovation in many aspects, such as financial support, corporate governance, and the provision of industrial resource channels(Croce et al., 2013;Hirukawa &Ueda,2011;Lerner,2000),specifically, it includes the "value added" effect and the "certification" effect.The effect of "value added" is reflected in alleviating the funding gap in the process of regional innovation, assisting innovators to build a broad information sharing system, providing technical support in a timely manner, and assisting in the establishment of an efficient management and operation mechanism.At the same time, the financial support of venture capital institutions to investee companies has a horizontal signal transmission function, which can attract other companies to follow suit and carry out R&D activities, thereby improving the technological innovation performance of the entire region and producing a "certification" effect.However, some scholars have found that the impact of venture capital on innovation is not very significant (Wang&Dang.2008; Wang&Wang,2011; Engel&Keilbach,2007), and sometimes there is even a negative correlation (Deng&Long,2013;Feng et al.,2016). By closely supervising enterprises, venture capital proposes strategies and goals different from those of enterprises, which may bring pressure and burden to enterprise innovation. With the increase of venture capital and regional competition, it is not conducive to the flow of innovation resources. In addition, Venture capital pays attention to the marketization and commercialization of enterprises. In the short-term with the participation of venture capital, enterprises can only focus on financial indicators, and pay insufficient attention to the long-term development of technological innovation activities.

Industry-university-research cooperation is considered to be one of the important ways for venture capital to influence regional innovation. Existing studies have shown that venture capital can promote industry-university-research cooperation by reducing risks, coordinating the relationship between industry, academia and research, and clarifying property rights(Wang,2018).At the same time, industry-university-research cooperation can promote the output of technological innovation through resource exchange, knowledge sharing and talent complementarity(Phelps,2010).Regional absorptive capacity is a key factor affecting innovation activities(Cohen&Levinthal,1990).A large number of studies have shown that the spillover effect of venture capital on regional innovation is closely related to the strength of regional absorptive capacity(Tao,2011;Andrea et al.,2012),regions with huge absorptive capacity can improve the local innovation level by making full use of the flow of information, knowledge and resources brought by venture capital, but regions with low absorptive capacity cannot convert rapidly increasing venture capital into sustained innovation output.In addition, appropriate intellectual property protection is conducive to the improvement of regional innovation performance(Fu&Yang,2019),for innovative enterprises, strengthening the strength of intellectual property protection can make enterprises more willing to disclose relevant R&D information and project prospects, reduce information asymmetry in R&D activities, and attract venture capital;for venture capitalists, strengthening the strength of intellectual property protection can reduce the risk of infringement of innovation achievements and improve the expected returns of investors(Xiao&Li,2022).

To sum up, scholars at home and abroad have explored the relationship between venture capital and regional innovation, but there are still disputes. We believe that the above differences are inevitable, because the impact of venture capital on innovation is difficult to generalize.This impact will vary due to the different stages of regional economic development, the intensity of regional industry-university-research cooperation, the overall absorption capacity of the region, and the strength of intellectual property protection.Unfortunately, few scholars have considered the role of the above factors in the entire transformation process of "venture capital-regional innovation".At the same time, venture capital may also have spillover effects in the process of promoting regional innovation, but the current discussion on the externality of venture capital mainly focuses on the enterprise level, and there are relatively few studies at the regional level."How does venture capital affect regional innovation in China? What is its internal mechanism?" "Is the innovation effect of venture capital in different economic regions heterogeneous?" "Does venture capital have a spatial spillover effect on innovation in neighboring regions?" above The answers to the questions will not only help the theoretical circle to deepen the understanding of the relationship between venture capital and regional innovation, but also help accelerate the integration of financial capital and technological innovation, and promote sustainable economic and social development.

In view of this, based on the relevant data of 29 provinces in China from 2011 to 2019, this research constructs a theoretical analysis framework of venture capital and regional innovation, analyzes the relationship between venture capital and China's regional innovation, and reveals the impact mechanism of venture capital on regional innovation,to examine whether there is a spatial spillover effect of venture capital in the process of promoting innovation from the regional level.It provides a new understanding for further clarifying the relationship between venture capital and regional innovation, and provides a basis for regional innovation decision-making.

2. Theoretical framework and research assumptions

This paper studies the impact of venture capital on regional innovation, and believes that venture capital can have positive and negative effects on regional innovation (Figure 1), and put forward the corresponding research hypotheses.

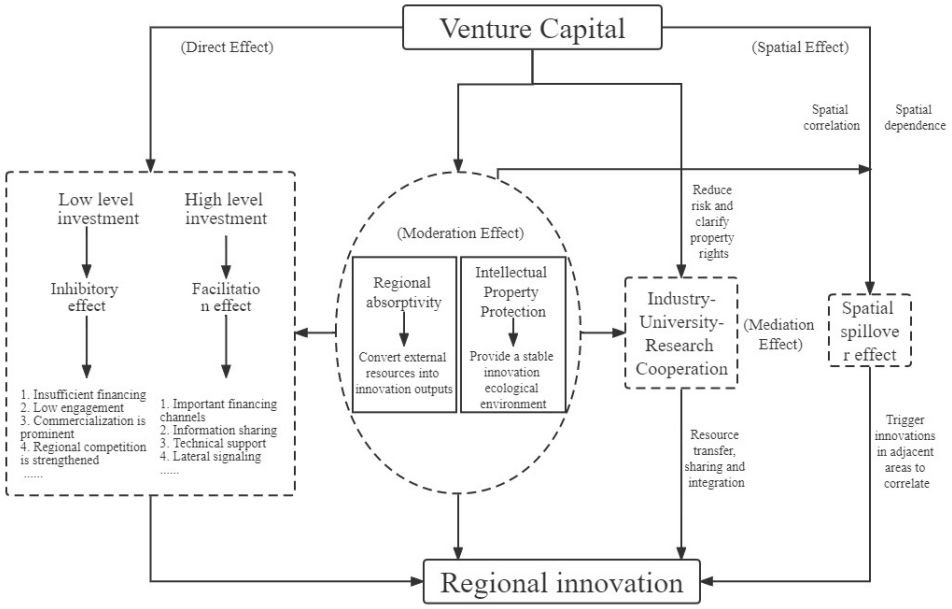

Fig. 1 Theoretical framework of venture capital and regional innovation

This paper argues that the positive and negative effects of venture capital on regional innovation can be divided into short-term effects and long-term effects(Xu et al.,2017).In the early stage of venture capital, the amount of investment is small, the investment ratio is low, it is difficult to effectively solve the financing problems of entrepreneurial enterprises, the management and supervision of enterprises are insufficient, technical support and information sharing are more restricted, and it is difficult to improve the innovation level of enterprises.In addition, venture capital uses its own industry and information advantages to seize innovative projects and ideas of investment objects, requiring rapid commercialization of enterprises, which restricts subsequent technological innovation. With the rapid development of venture capital, the scale of venture capital and the number of projects will undergo great changes, and venture capital has gradually become an important channel for start-ups to obtain financing(Tang&Chyi,2008).In this context, the "value-added" effect and "certification" effect of venture capital can play a positive role. Therefore, the inhibitory effect of venture capital on regional innovation can be realized in a short time, and the promotion effect has the characteristics of time lag(Faria& Barbosa,2014).

Hypothesis 1: There is a nonlinear relationship between venture capital and regional innovation. When venture capital is at a low level of development, not only does it not promote technological innovation, it may even inhibit innovation, but when venture capital flourishes, regional innovation output also increases.

The different stages of economic development in different regions may be the main reason for the differences in the relationship between venture capital and innovation between regions.There are obvious differences in the level of social development among provinces in my country. In areas with moderate or underdeveloped innovation levels, there is a lack of innovation mechanisms that are homogeneous with venture capital, and the relative advantages and comparative advantages of venture capital in promoting innovation output are more prominent; In the regions where enterprises have obvious advantages in terms of their own innovation capabilities and financial environment, the role of venture capital in innovation is easily replaced by other homogeneous innovation mechanisms.

Hypothesis 2: There is heterogeneity in the relationship between venture capital and regional innovation among regions.

The influence mechanism of venture capital on innovation has both direct influence and indirect influence through industry-university-research cooperation.In order to transform high-tech into real productivity, R&D investment must effectively integrate production resources, market resources and intellectual resources, and industry-university-research cooperation is an important channel for the transfer, sharing and integration of knowledge, technology and other innovative resources(Zhap&Wang,2013).Therefore, industry-university-research cooperation plays an important bridge role in the relationship between venture capital and regional innovation.In addition, absorptive capacity and the strength of intellectual property protection will also have an impact on the relationship between the two.The absorptive capacity of a region determines the extent to which external resources and knowledge can be transformed into innovations.Effective recognition and digestion of advanced knowledge and technology can help to enhance the role of venture capital in promoting regional innovation. Appropriate intellectual property protection can provide a stable innovation ecological environment for innovation entities and reduce the uncertainty of innovation entities'income., to stimulate the innovation enthusiasm of innovative subjects(Wu&Tang,2016).

Hypothesis 3: Industry-university-research cooperation plays an intermediary role in the relationship between venture capital and regional innovation; Absorptive capacity has a moderating role in the relationship between venture capital and regional innovation;

Intellectual property protection has a moderating role in the relationship between venture capital and regional innovation.

Venture capital has obvious spatial agglomeration characteristics(Wang et al.,2014), so there may be regional differences in the role of venture capital in promoting innovation in different regions.Regional resources do not exist in isolation. As a network of knowledge, technology and capital interaction, the venture capital market can achieve its spatial aggregation effect and spillover effect through the free flow of talents, capital and technology among neighboring provinces.Based on this, the innovation effect brought by the venture capital itself may have an impact on the innovation of the related regions on the basis of affecting the innovation level of the region.Compared with inter-provincial venture capital, the spillover effect of intra-provincial venture capital may be more significant.There are two main reasons: on the one hand, the province is the first to benefit from the financial support, industrial channels and management experience brought by venture capital;On the other hand, each innovation subject is more inclined to use the existing human, knowledge and technical resources to innovate locally.

Hypothesis 4: There is a spatial spillover effect of venture capital on regional innovation, and the impact of venture capital on innovation within a province is greater than that between provinces.

3. Data sources and research methods

3.1. Data source and description

(1) Explained variable. The explained variable in this paper is regional innovation output. At present, there is no consensus on the measurement of regional innovation output.The academic community mainly measures regional innovation output from the number of patent authorizations(Jiang,2014;Wang et al.,2018), the number of invention patent applications(Song&Zhao,2018), the output value of new products(Wang&Zhang,2013), the turnover of technology markets(Cai et al.,2010), and the number of papers published in core journals at home and abroad(Shen et al.,2017).However, a single indicator has limitations in reflecting the level of regional innovation output.This paper makes full use of the existing research(Li&Niu,2017;Zhang,2017), and builds a comprehensive evaluation index system of regional innovation output based on the main innovation subjects (high-tech enterprises, universities and research and development institutions) in the provincial innovation system (Table 1).High-tech enterprises are the main body of technological innovation. The number of invention patents authorized can reflect the scientific and technological influence of the enterprise and is an important output of scientific and technological achievements. The sales revenue of new products can reflect the ability of the enterprise to transform the results of innovation activities into business performance, which is important. Innovative economic output;Universities and R&D institutions are the main body of knowledge innovation. Scientific and technological works and scientific papers represent the establishment of new theories and the birth of new ideas, and are important indicators to measure the output of knowledge innovation achievements of universities and R&D institutions.At present, scholars widely use principal component analysis method, factor analysis method, entropy weight method, etc. to evaluate regional innovation capability, and a few scholars use simple weighted average method(Song&Du,2015).In contrast, principal component analysis and factor analysis have the problem of information loss, and the entropy weight method is suitable for the evaluation of similar indicators(Yu,2021).Since the nature of the innovation output indicators in this paper is similar, the entropy weight method is beneficial to give play to the advantages of the objective weighting evaluation method. Therefore, this paper uses the entropy weight method to determine the weight of each evaluation index and calculate the level of innovation output in China's provinces in each year.The specific measurement steps include data

standardization, information entropy determination, and weight calculation.Taking the logarithm (lnInno) and the square of the logarithm ($lnInno^2$) of the regional innovation output index as the core explanatory variables.The relevant data comes from the China Science and Technology Statistical Yearbook and the China Statistical Yearbook.

Table 1. Evaluation index system of regional innovation output

Target layer	Indicator layer	Weights
Regional innovation output	Invention patent applications	19.99%
	New product sales revenue of industrial enterprises above designated size	19.70%
	Universities publish scientific and technological works	8.23%
	Universities publish scientific papers	7.82%
	Research and development institutions publish scientific works	25.69%
	Research and development institutions publish scientific papers	18.56%

(2) Main explanatory variables: ①Core explanatory variables. The core explanatory variable of this paper is venture capital. Most of the existing literature sets up dummy variables for the presence or absence of venture capital to analyze the impact of venture capital on technological innovation of enterprises(Zhang et al.,2019).This paper analyzes the role of venture capital on regional innovation output from the mesoscopic level.The number of venture capital projects and the amount of venture capital are innovatively processed by the entropy weight method,and take the logarithmic form (lnVC) to represent the development of venture capital in each province.The calculated data comes from the Wind business database and the China Venture Capital Yearbook.②Moderating variables and mediating variables.Absorptive capacity should include the ability to receive, digest and imitate advanced technology,Referring to the measurement methods of Xiao and Xie(2016), the entropy weight method is used to deal with the expenditures of technology introduction, digestion and absorption, and technological transformation.The data comes from the China Science and Technology Statistical Yearbook, in logarithmic form (lnAc).The measurement of intellectual property protection (IPP) refers to Li et al(2014) and Jin et al.(2017), expressed as the proportion of the annual number of infringement cases in each province to the total number of infringement cases in each region by 2019.The data comes from China Statistical Yearbook and China Intellectual Property Protection Bureau.The measurement of the intermediary variable industry-university-research cooperation intensity (Tel) draws on the measures of Turk-Bicakci et al. (2005) and Zhuang et al.(2021).The degree of cooperation between universities and enterprises and between R&D institutions and enterprises is measured by the proportion of enterprise funds in the R&D funds of universities and R&D institutions. After standardization, the R&D investment scale of universities and R&D institutions is weighted and averaged to obtain the intensity of industry-university-research cooperation.The data comes from the China Science and Technology Statistical Yearbook.③Spatial weight matrix.In order to systematically examine the spatial correlation characteristics of regional innovation outputs, this paper draws on Shao's practice(2016) and constructs three spatial weight matrices, which are the nested weight matrix of geographic and economic distance (W1) and the geographic distance weight matrix (W2) and the economic distance weight matrix (W3).

(3) Control variables.Referring to the existing research results of venture capital and regional innovation(Wang,2021;Sui,2018;Chen et al.,2021;Qian&Fan,2021), the control variables selected in this paper mainly include the level of opening to the outside world (lnOpen), the advanced industrial structure (Str), the state of government support (lnGov), the level of education (Peo), and R&D capital. Input intensity (lnRD).The data comes from the database of the National Bureau of Statistics, China Statistical Yearbook of Science and

Technology and China Statistical Yearbook.In addition, in order to obtain balanced panel data of 29 provinces (excluding Tibet, Hainan, Hong Kong, Macao and Taiwan regions due to data acquisition reasons) for spatial econometric model analysis, the missing data of each individual indicator were supplemented by the average of the upper and lower items.In the end, 261 samples participated in the regression, and the period was from 2011 to 2019. The descriptive statistics of the relevant variables are shown in Table 2.

Table 2. Definition of variable names and descriptive statistics

Variable Name		Definition	Mean	Standard deviation	Minimum	Maximum
Explained variable	lnInno	The logarithm of regional innovation output	15.364	1.453	10.128	18.254
Core explanatory variables	lnVC	The logarithm of venture capital	9.014	2.099	0.715	14.654
	$lnVC^2$	Venture capital logarithm squared	85.647	38.514	0.511	214.747
Control variable	lnOpen	The logarithm of total imports and exports	6.264	2.017	0.478	9.901
	Str	Tertiary Industry/Secondary Industry	0.144	0.364	-0.640	1.655
	lnGov	The logarithm of science and technology expenditure in fiscal expenditure	4.307	1.002	1.324	7.064
	Peo	Average years of education in the workforce	10.125	1.086	8.139	14.116
	lnRD	The logarithm of the amount invested in R&D	14.806	1.239	11.660	17.249
Moderator	lnAc	The logarithm of absorptive capacity	14.188	1.236	11.047	16.628
	Ipp	Intellectual property protection	0.149	0.131	0	0.543
Mediating variable	Tel	The intensity of industry-university-research cooperation	0.004	0.740	-1.538	3.171

3.2 Research methods

According to the theoretical framework and research hypothesis, without considering the spatial spillover effect of venture capital, according to the research of Tian and Chen(2016), an econometric model (1) is constructed:

$$\ln Inno_{it} = \alpha_0 + \alpha_1 \ln VC_{it-1} + \alpha_2 \ln VC^2_{it-1} + \sum_{j=1}^{5} \beta_j Contro_{t-1} + \varepsilon_{it} \quad (1)$$

Among them, $Contro_{t-1}$ is the control variable, i represents the province, t represents the year, and ε_{it} is the error interference term. In order to avoid the endogeneity of the model, the explanatory variables and the control variables are all lagged by 1 period.

In view of the above analysis, in the process of venture capital affecting regional innovation output, it may directly affect regional innovation output, or it may affect regional innovation output through industry-university-research cooperation.Here,the function of industry-university-research cooperation is an intermediary variable. The mediation effect test is described by the following equation:

$$Y = cX + e_1$$

$$M = aX + e_2$$

$$Y = c'X + bM + e_3$$

Among them, X , Y and M represent the explanatory variable, the explained variable and the mediating variable, respectively.The total influence coefficient of X on Y is c ,the coefficient that X affects Y through the mediating variable M is ab ,the calculated mediation effect at this time is ab/c .

In order to test the mediating effect of industry-university-research cooperation, model (2) (3) is established:

$$Tel_{it-1} = \alpha_0 + \alpha_1 \ln VC_{it-1} + \alpha_2 \ln VC^2_{it-1} + \sum_{j=1}^{5} \beta_j Contro_{t-1} + \varepsilon_{it} \quad (2)$$

$$\ln Inno_{it} = \alpha_0 + \alpha_1 \ln VC_{it-1} + \alpha_2 \ln VC^2_{it-1} + \alpha_3 Tel_{it-1} + \sum_{j=1}^{5} \beta_j Contro_{t-1} + \varepsilon_{it} \quad (3)$$

To examine the moderating effects of absorptive capacity and intellectual property protection, model (4)(5) is established:

$$\begin{aligned} \ln Inno_{it} = {} & \alpha_0 + \alpha_1 \ln VC_{it-1} + \alpha_2 \ln VC^2_{it-1} + \alpha_3 \ln Ac_{it-1} + \alpha_4 \ln VC_{it-1} \times \ln Ac_{it-1} \\ & + \alpha_5 \ln VC^2_{it-1} \times \ln Ac_{it-1} + \sum_{j=1}^{5} \beta_j Contro_{it-1} + \varepsilon_{it} \end{aligned} \quad (4)$$

$$\begin{aligned} \ln Inno_{it} = {} & \alpha_0 + \alpha_1 \ln VC_{it-1} + \alpha_2 \ln VC^2_{it-1} + \alpha_3 Ipp_{it-1} + \alpha_4 \ln VC_{it-1} \times Ipp_{it-1} \\ & + \alpha_5 \ln VC^2_{it-1} \times Ipp_{it-1} + \sum_{j=1}^{5} \beta_j Contro_{it-1} + \varepsilon_{it} \end{aligned} \quad (5)$$

If the spatial correlation of innovation output in each province is considered, this paper needs to use SAR for research.The SAR model can not only analyze the spatial correlation of regional innovation output, but also estimate the direct effect, indirect effect and total effect separately.Drawing on the research of Liu et al.(2020), the econometric model (6) is constructed:

$$\ln Inno_{it} = \alpha_0 + rho \times w \times \ln Inno_{it} + \alpha_1 \ln VC_{it-1} + \alpha_2 \ln VC^2_{it-1} + \sum_{j=1}^{5} \beta_j Contro_{t-1} + \varepsilon_{it} \quad (6)$$

Where w is the weight matrix, rho is the spatial lag coefficient, if it is greater than 0, it means a positive spatial correlation; if it is less than 0, it means a negative spatial correlation.

In order to further identify the influencing factors of the proximity effect and explore the impact of spatial proximity venture capital on the innovation output of a specific province, the spatial Durbin model (SDM) (7) was constructed:

$$\begin{aligned} \ln Inno_{it} = {} & \alpha_0 + w \times \delta \times (\ln VC_{it-1} + \ln VC^2_{it-1} + \sum_{j=1}^{5} Contro_{it-1}) \\ & + \alpha_1 \ln VC_{it-1} + \alpha_2 \ln VC^2_{it-1} + \sum_{j=1}^{5} \beta_j Contro_{it-1} + \varepsilon_{it} \end{aligned} \quad (7)$$

Where δ is the vector of risk investment influence coefficients of neighboring provinces.

4. Empirical Analysis

4.1. Characteristics and facts of the relationship between venture capital and regional innovation

In order to explore the relationship between venture capital and regional innovation in each province, with venture capital as the horizontal axis and regional innovation output as the vertical axis, scatter plots and trend lines for 29 provinces were drawn (Table 3).The results show that the innovation output of 29 provinces roughly presents three types of "U-shaped", "inverted U-shaped" and no obvious relationship with the evolution trend of venture capital.

From the spatial distribution of the relationship between the two , there is a "U-shaped" relationship between venture capital and innovation output in most provinces, and most provinces are in a "U-shaped" upward trend.On the whole, the distribution of provinces with a "U-shaped" relationship is relatively scattered, and they are involved in the northwest and southwest regions, as well as in central and east China;The provinces with a "U-shaped" upward trend are concentrated in the inland areas of my country, and there are also a small amount in the northeast and eastern coastal areas;The provinces with a "U-shaped" downward trend are mainly distributed in Northeast China and Central China.It can be seen that, for most provinces in China, venture capital significantly promotes innovation output.However, because Chinese provinces are in different stages of economic development and the scale of venture capital absorbed varies greatly, the relationship between venture capital and innovation output is not the same in each province, and there is great spatial heterogeneity.In Shanghai, Jiangsu, Zhejiang, Guangdong and other eastern coastal provinces with large scale of venture capital and developed innovative technologies, the relationship between the two presents a significant and relatively complete "inverted U-shaped" curve, indicating that in the developed eastern coastal areas, venture capital has an important effect on innovation. Output is promoted first and then inhibited;In Guangxi, Yunnan and other border provinces with less venture capital and less developed technological innovation, venture capital and innovation output show a downward trend of "inverted U-shaped" curve, indicating that venture capital has a more obvious inhibitory effect on innovation output in underdeveloped areas;Inner Mongolia Autonomous Region and Ningxia Hui Autonomous Region have less correlation between venture capital and innovation output.

The reason for the above results may be that in Shanghai, Jiangsu and other eastern coastal provinces with advanced technology and advantageous geographical location, there are many innovative projects to choose from in the early stage of venture capital participation, so the success rate of project investment is high and the innovation output is high.However, as the degree of venture capital participation increases, its attention will shift from technology development to product sales and returns, causing competition between regions, resulting in a decline in the number of innovation outputs;In the border regions with less developed technologies such as Guangxi, Yunnan, Inner Mongolia, and Ningxia, venture capital is mainly used to support traditional industries, and the integration with emerging industries is not good. Therefore, the effect of venture capital in promoting regional innovation is not obvious or even has a restraining effect.Although the correlation between venture capital and innovation output varied across provinces, the correlation was positive in most provinces.

Table 3. Evolution trend and types of regional innovation output with the development of venture capital (2011—2019)

Type		Province	
U shape	U shape	Jiangxi Province（R^2=0.730）	$Y=0.329x^2-4.902x+33.148$
		Hubei Province（R^2=0.573）	$Y=0.163x^2-2.797x+28.008$
		Chongqing（R^2=0.603）	$Y=0.207x^2-3.449x+29.858$
		Xinjiang Uygur Autonomous Region（R^2=0.561）	$Y=0.196x^2-2.765x+23.065$
	U-shaped rise	Beijing（R^2=0.476）	$Y=0.039x^2-0.784x+19.773$
		Tianjin（R^2=0.469）	$Y=0.173x^2-0.004x+14.821$
		Hebei Province（R^2=0.769）	$Y=0.049x^2-0.455x+16.350$
		Shanxi Province（R^2=0.920）	$Y=0.530x^2-10.025x+61.754$
		Heilongjiang Province（R^2=0.489）	$Y=0.027x^2-0.271x+14.540$
		Anhui Province（R^2=0.750）	$Y=0.073x^2-0.877x+18.258$
		Fujian Province（R^2=0.305）	$Y=0.033x^2-0.511x+17.658$
		Shandong Province（R^2=0.859）	$Y=0.005x^2+0.180x+15.896$

		Hunan Province（R^2=0.455）	Y=0.138x^2-2.302x+25.799
		Sichuan Province（R^2=0.431）	Y=0.033x^2-0.579x+17.959
		Guizhou Province（R^2=0.574）	Y=0.032x^2-0.310x+14.330
		Shaanxi Province（R^2=0.455）	Y=0.057x^2-0.719x+17.267
		Gansu province（R^2=0.433）	Y=0.026x^2-0.625x+10.395
		Qinghai Province（R^2=0.742）	Y=0.017x^2+0.073x+10.191
	U-shaped drop	Jilin Province（R^2=0.753）	Y=0.057x^2-1.280x+8.439
		Henan Province（R^2=0.905）	Y=0.209x^2-3.692x+0.159
		Liaoning Province（R^2=0.463）	Y=0.007x^2-0.106x+16.097
Inverted U shape	Inverted U shape	Shanghai（R^2=0.540）	Y=-0.036x^2+0.902x+11.145
		Jiangsu Province（R^2=0.434）	Y=-0.233x^2+5.185x+11.091
		Zhejiang Province（R^2=0.899）	Y=-0.198x^2+4.781x+11.217
		Guangdong Province（R^2=0.472）	Y=-0.134x^2+2.998x+1.146
	Inverted U-shaped drop	Guangxi Zhuang Autonomous Region（R^2=0.511）	Y=-0.153x^2+2.113x+7.910
		Yunnan Province（R^2=0.692）	Y=-1.814x^2+21.100x-47.034
No apparent relationship		Inner Mongolia Autonomous Region Ningxia Hui Autonomous Region	

4.2. Test of the "U-shaped" relationship between venture capital and regional innovation

Firstly, the model (1) is regressed using panel data to preliminarily judge whether there is a curve effect between provincial venture capital and innovation output.The results in column (1) in Table 4 show that, using mixed panel (POLS) regression, none of the core explanatory variables passed the significance test, but the results in column (2) of fixed individual effects showed that the lnVC coefficient was significantly negative (-0.181), The lnVC2 coefficient is significantly positive (0.013), which preliminarily verifies that there is a "U-shaped" relationship between inter-provincial venture capital and innovation output.This paper draws on the more stringent criteria proposed by Haans et al.(2016) to further test the shape of the curve.Since the control variables do not affect the shape of the curve relationship(Tang&Xia,2019), model (1) can be simplified to formula ① when analyzing the shape of the curve.

$$\ln Inno = \alpha_0 + \alpha_1 \ln VC + \alpha_2 \ln VC^2 \qquad ①$$

The slope of the curve is significantly negative (-0.019) at the left end (0.715) of the value range of lnVC, and the right end (14.654) is significantly positive (3.131). Therefore, what this paper observes is a complete "U-shaped" curve.This result verifies the hypothesis 1 of this paper, that is, a possible logical relationship between venture capital and regional innovation output is that when venture capital is lower than a certain threshold (that is, the inflection point of this paper is 0.801), innovation output The result is a "crowding out" effect; only when the scale of venture capital exceeds a certain threshold (0.801), will a "crowding in" effect be formed on innovation output.On this basis, the time fixed effect is added, and the results in column (3) show that the relationship of the "U-shaped" curve is also significant, but the goodness of fit of the equation in column (3) is lower than that of the equation in column (2), which is different from the previous research. It is consistent with the conclusion that the time fixed effect is not obvious in the panel data.Other control variables: government support and R&D capital investment intensity both significantly positively affect regional innovation output, and the level of opening to the outside world significantly negatively affects regional innovation output. The advanced industrial structure and education level are not significant in this study.

Table 4. Regression results of the benchmark model

Variable	(1)POlS	(2)Fixed individual	(3)Two-way fixed
lnVC	-0.142	-0.181**	-0.204***
	(-1.50)	(-2.38)	(-2.62)
$lnVC^2$	0.009	0.013***	0.014***
	(1.64)	(2.93)	(3.13)
lnOpen	0.152***	-0.058*	-0.041
	(5.41)	(-1.16)	(-0.77)
Str	-0.567***	-0.067	-0.398
	(-4.11)	(-0.34)	(-1.33)
lnGov	0.364***	0.265***	0.279***
	(3.93)	(2.04)	(2.12)
Peo	-0.118**	0.085	-0.012
	(-2.16)	(0.73)	(-0.09)
lnRD	0.662***	0.251**	0.049**
	(8.23)	(1.34)	(0.22)
constant	4.84***	10.539***	14.323***
	(5.66)	(4.71)	(4.57)
Control individual	No	Yes	No
Control year	No	No	Yes
R^2	0.873	0.705	0.618
F value	249.250	14.517	7.301
N	261	261	261

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% confidence levels, respectively. The values in parentheses are t values, the same as in the table below.

4.3. Regional heterogeneity test of the relationship between venture capital and innovation output

The biggest feature of quantile regression is that it fits the independent variable based on the conditional distribution of the dependent variable, which can effectively avoid the bias caused by the small number of samples in traditional regression.This paper selects five representative quantiles (10%, 25%, 50%, 75%, 90%). It can be seen from Table 5 that below the 10% quantile, venture capital has no effect on innovation output. Significantly, above the 25% quantile, the coefficient of lnVC was significantly negative, and the coefficient of $lnVC^2$ was significantly positive, and with the increase of the quantile value, the absolute values of the coefficients of lnVC and $lnVC^2$ first increased and then decreased.This shows that the impact of venture capital on the middle part of the conditional distribution of innovation output is greater than its impact on the two ends.That is to say, increasing venture capital will benefit provinces with moderate innovation output, but it will have less impact on provinces with lower and higher innovation output.Specifically, for provinces with inactive innovation output (q=10%), there is no "U-shaped" curve effect of venture capital on innovation output;For provinces with moderately active innovation output (q=25%; q=50%; q=75%), venture capital has a significant "U-shaped" curve effect on innovation output;For provinces with extremely active innovation output (q=90%), there is no "U-shaped" curve effect of venture capital on innovation output.Through specific analysis of provinces within a specific quantile range, it is found that Inner Mongolia, Ningxia, Guangxi, Yunnan and other provinces are in the low quantile, Jiangxi, Shanxi, Henan and other provinces are in the middle quantile, and Guangdong, Shanghai and other provinces are in the high quantile The number of digits, which explains the difference in the relationship between venture capital and innovation output in different provinces in the characteristic fact.Hypothesis 2 passed the test.

Table 5 Quantile regression results of panel

	10%	25%	50%	75%	90%

lnVC	0.070	-0.030**	-0.037***	-0.159**	-0.073*
	(0.16)	(0.14)	(0.12)	(0.12)	(0.17)
$lnVC^2$	-0.003	0.001*	0.006**	0.016***	0.008*
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
lnOpen	0.134***	0.163***	0.121***	0.123***	0.101**
	(0.05)	(0.04)	(0.03)	(0.04)	(0.05)
Str	-0.793***	-0.645***	-0.694***	-0.446**	-0.683***
	(0.24)	(0.20)	(0.17)	(0.17)	(0.25)
lnGov	0.856***	0.679***	0.376***	0.153	-0.116
	(0.16)	(0.13)	(0.11)	(0.12)	(0.17)
Peo	-0.030	-0.084	-0.019	-0.132*	-0.179*
	(0.09)	(0.08)	(0.07)	(0.07)	(0.10)
lnRD	0.418***	0.463***	0.710***	0.838***	0.904***
	(0.14)	(0.12)	(0.10)	(0.10)	(0.15)
Constant	3.982***	5.352***	3.092***	3.977***	4.991***
	(1.48)	(1.22)	(1.05)	(1.07)	(1.54)
Observations	261	261	261	261	261

Note: "10%" represents the 10% quantile model, "25%" represents the 25% quantile model, "50%" represents the 50% quantile model, "75%" represents the 75% quantile model, "90%" represents the 90% quantile model.

4.4. Influence mechanism of venture capital on regional innovation output

From the previous analysis, we can see that the relationship between venture capital and innovation output has a significant "U-shaped" curve, and there is heterogeneity among different provinces.Then, what is the transmission path of the relationship between venture capital and innovation output? What are the adjustment factors?In order to answer these questions, this paper analyzes the impact mechanism of venture capital on regional innovation output through the mediating effect of industry-university-research cooperation level, the moderating effect of absorptive capacity and intellectual property protection.

4.4.1 The transmission path of the relationship between venture capital and innovation output

On the basis of clarifying the relationship between venture capital and innovation output and regional differences, this part will draw on the practices of Baron and Kenny(1986) and Wen(2004), and use industry-university-research cooperation as a mediating variable to test the impact of venture capital on innovation output.Table 6 lists the process of the mediation effect test, and the columns (1)(2)(3) are the regression results of the models (1)(2)(3) respectively.Combining the test results of the mediation effect in Table 6 and Table 7, it can be seen that, first, the "U-shaped" relationship between venture capital and regional innovation output is significant, and the argument is based on the mediation effect; secondly, the impact of venture capital on industry-university-research cooperation is tested in turn. and the influence of industry-university-research cooperation on regional innovation output, the coefficients of both are significant, indicating that the indirect effect is significant, and the direct effect of venture capital on regional innovation output is also significant; the coefficients of ab and c′ have the same sign, indicating that industry-university-research cooperation There is a partial mediation effect in the "U-shaped" relationship between venture capital and regional innovation output, and the proportion of mediation effect to the total effect is shown in Table 7.

Table 6. Regression results of mediating and moderating effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variable	Benchmark model	Mediation effect		Moderating effect 1		Moderating effect 2	

	lnInno	Tel	lnInno	lnInno	lnInno	lnInno	lnInno
lnVC	-0.181**	-0.127*	-0.171**	-0.179**	-	-0.179**	-0.175**
	(-2.38)	(-1.58)	(-2.24)	(-2.33)	0.306***	(-2.36)	(-2.13)
					(-3.03)		
$lnVC^2$	0.013***	0.019*	0.012***	0.013***	0.022***	0.013***	0.013***
	(2.93)	(1.57)	(2.75)	(2.87)	(3.90)	(2.89)	(2.79)
Tel			0.081*				
			(1.28)				
lnAc				1.226*	7.227		
				(0.13)	(0.77)		
lnAc*lnVC					0.135*		
					(1.86)		
$lnAc*lnVC^2$					-0.01***		
					(-2.84)		
Ipp						0.178**	0.013
						(0.67)	(0.05)
Ipp*lnVC							1.169*
							(1.83)
$Ipp*lnVC^2$							-0.096**
							(-2.06)
Control variable	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Control individual	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	10.539***	11.339***	9.626***	28.012	116.311	10.408***	10.156***
	(4.71)	(4.78)	(4.11)	(0.20)	(0.84)	(4.51)	(4.42)
R^2	0.705	0.301301	0.743	0.708	0.745	0.711	0.709
F value	14.517	8.886	12.945	12.648	12.581	12.728	10.933
N	261	261	261	261	261	261	261

Table 7 Mediation effect test results

	lnInno					
	c	c’	a	b	ab	Conclusion
lnVC	-0.181**	-0.171**	-0.127*	0.081*	-0.010	ab/c=0.057
	(-2.38)	(-2.24)	(-1.58)	(1.28)	All significantly	Partial mediation effect
$lnVC^2$	0.013***	0.012***	0.019*	0.081*	0.002	ab/c=0.118
	(2.93)	(2.75)	(1.57)	(1.28)	All significantly	Partial mediation effect

4.4.2 The moderating effect of the relationship between venture capital and regional innovation output

Combined with the previous theoretical analysis, this part empirically analyzes the possible moderating effects from the two aspects of absorptive capacity and intellectual property protection, in order to explore the reasons for the differences in the relationship between venture capital and regional innovation output between regions.

Columns (4) and (5) of Table 6 take absorptive capacity as a moderator variable, and add the interaction terms of absorptive capacity lnAc with venture capital lnVC and the square of venture capital lnVC2,the results in column (4) show that absorptive capacity is positively correlated with regional innovation output.The results in column (5) show that the coefficient of lnVC is significantly negative, the coefficient of lnVC2 is significantly positive, the coefficient of the interaction term of lnVC and lnAc is significantly positive, and the coefficient of the interaction term of lnVC2 and lnAc is significantly negative.It shows that absorptive capacity has a significant "U-shaped" moderating effect on the relationship between venture capital and regional innovation output.

Drawing on the analysis paradigm of Jia et al.(2018)and Zhu et al.(2018) on the moderating effect of "U-shaped" curve, model (4) is omitted from the control variables and simplified to formula ②,and the moderating effect of absorptive capacity is specifically analyzed from three aspects: shape, inflection point and overall level.

$$\ln Inno = \alpha_0 + \alpha_1 \ln VC + \alpha_2 \ln VC^2 + \alpha_3 \ln Ac + \alpha_4 \ln VC \times \ln Ac + \alpha_5 \ln VC^2 \times \ln Ac \quad ②$$

$$k = 2(\alpha_2 + \alpha_5 \ln Ac) \quad ③$$

First, the shape of the curve is judged, and the second derivative of the formula② is obtained to obtain the vertex curvature k③. The influence of the adjustment variable lnAc on the vertex curvature k of the "U-shaped" curve is manifested in the positive and negative of the coefficient α_5.If the coefficient α_5 is significantly positive, when the absorption capacity lnAc is larger, the curvature k is larger, and the curve is steeper; if the coefficient α_5 is significantly negative, when the absorption capacity lnAc is larger, the curvature k is smaller and the curve is smoother.

In the regression results in Table 6(5), α_5 is -0.01, which is significant at the 1% level, indicating that when the absorptive capacity is stronger, the curve relationship between venture capital and regional innovation output is smoother.

Secondly, judge the position of the inflection point, the inflection point formula is④,in order to study the influence of the change of the adjustment variable lnAc on lnVC*, the partial derivative of formula④can be obtained. If the partial derivative is greater than 0, the larger the adjustment variable lnAc and the larger the value of lnVC*, the curve inflection point will move to the right;Conversely, the inflection point of the curve will move to the left.By calculating the partial derivative of formula④, it can be found that the value of the partial derivative is 0.028[21], which is greater than 0.It shows that when lnAc is larger, the inflection point of the curve will move to the right, that is, the stronger the absorption capacity, the larger the amount of venture capital corresponding to the inflection point of the "U-shaped" curve of venture capital and innovation output.Take two special values of medium absorptive capacity (mean) and high absorptive capacity (mean + standard deviation) for specific verification.Under the premise of the adjustment variable setting, the inflection point under the medium absorption capacity is 6.704, and the inflection point under the higher absorption capacity level is 6.727, and the position of the inflection point is slightly shifted to the right.

$$\ln VC^* = \frac{-\alpha_1 - \alpha_4 \ln Ac}{2\alpha_2 + 2\alpha_5 \ln Ac} \quad ④$$

Finally, the overall level of the curve is judged, and the overall level of the curve is described by the size of the dependent variable when the independent variable of the model takes any value.In this paper, lnInno in provinces with strong absorptive capacity is denoted as $\ln Inno_{lnAcH}$, and lnInno in provinces with weak absorptive capacity is denoted as $\ln Inno_{lnAcL}$,If $\ln Inno_{lnAcH} - \ln Inno_{lnAcL}$ is always greater than 0, it means that a high level of absorptive capacity will improve the overall level of the relationship between venture capital and the regional innovation output curve.The calculation formula of lnInnolnAcH-$\ln Inno_{lnAcL}$ is shown in formula⑤.

$$\ln Inno_{\ln AcH} - \ln Inno_{\ln AcL} = (\alpha_4 \ln VC + \alpha_5 \ln VC^2 + \alpha_3)\ (\ln AcH - \ln AcL) \quad ⑤$$

Among them, $(\ln AcH - \ln AcL) > 0$, lnVC in the value range [0.715, 14.654] can make the function $f(\ln VC) = (\alpha_4 \ln VC + \alpha_5 \ln VC^2 + \alpha_3) > 0$ constant, that is, a high level of absorptive capacity will improve the overall level of the relationship between the risk investment and the regional innovation output curve.

[21] According to the partial derivative calculation formula: $(-0.306) \times (-0.01) - 0.022 \times 0.135 = 0.028$

The data in columns (6) and (7) in Table 6 are used to verify the moderating effect of intellectual property protection (Ipp).The results in column (6) show that intellectual property protection is positively correlated with regional innovation output.The results in column (5) show that the coefficient of lnVC is significantly negative, the coefficient of $lnVC^2$ is significantly positive, the coefficient of the interaction term of lnVC and lnAc is significantly positive, and the coefficient of the interaction term of $lnVC^2$ and lnAc is significantly negative.It shows that intellectual property protection has a significant "U-shaped" moderating effect on the relationship between venture capital and regional innovation output.Similarly, formula⑥⑦⑧⑨is established to analyze the moderating effect of intellectual property protection from three aspects: form, inflection point and overall level.

$$\ln Inno = \alpha_0 + \alpha_1 \ln VC + \alpha_2 \ln VC^2 + \alpha_3 Ipp + \alpha_4 \ln VC \times Ipp + \alpha_5 \ln VC^2 \times Ipp \quad ⑥$$

$$k = 2(\alpha_2 + \alpha_5 Ipp) \quad ⑦$$

$$\ln VC^* = \frac{-\alpha_1 - \alpha_4 Ipp}{2\alpha_2 + 2\alpha_5 Ipp} \quad ⑧$$

$$\ln Inno_{IppH} - \ln Inno_{IppL} = (\alpha_4 \ln VC + \alpha_5 \ln VC^2 + \alpha_3)(IppH - IppL) \quad ⑨$$

First, in the regression results in Table 6(7), α_5 is -0.096, which is significant at the level of 5%, indicating that the stronger the protection of intellectual property rights, the smoother the curve relationship between venture capital and regional innovation output;Secondly, the value of the partial derivative of formula⑧is about 0.002[22], which is greater than 0, indicating that when the Ipp is larger, the inflection point of the curve will move to the right,that is, the stronger the protection of intellectual property rights, the greater the amount of venture capital corresponding to the inflection point of the "U-shaped" curve of venture capital and innovation output;Finally, when $\ln Inno_{IppH} - \ln Inno_{IppL} > 0$ constant is established, the value range of lnVC is [0.715, 12.188], that is, when the venture capital is less than 12.188, high-quality intellectual property protection will improve the overall level of the relationship between venture capital and the regional innovation output curve.Based on this, Hypothesis 3 passed the test.

4.5. Spatial Spillover Effect Test of Venture Capital and Regional Innovation Output

The above analysis confirms that the venture capital and regional innovation output within the province show a significant "U-shaped" curve, and analyzes the impact mechanism of venture capital on regional innovation output.Based on the previous theoretical analysis and the construction of the spatial panel model, this part verifies the relationship between venture capital and regional innovation output between provinces.

4.5.1. Spatial Autocorrelation Test

This paper uses Moran's I index to test the geospatial correlation of regional innovation output.The variation range of Moran's I index is [-1,1], and the larger the absolute value, the stronger the spatial correlation.When Moran's I index value is in [0,1], it means that there is a positive correlation between geographic entities, and objects with similar attributes are clustered together;When Moran's I index value is [-1,0], it indicates that there is a negative correlation between geographic entities, and objects with different attributes are clustered together.

[22] According to the partial derivative calculation formula: $(-0.175)\times(-0.096)-0.013\times1.169=0.0016$

Figure 3 depicts the changes in Moran's I index of regional innovation output in China's provinces from 2011 to 2019.It can be seen that the index fluctuates between 0.219 and 0.274, and both passed the 1% significance probability test.It means that the regional innovation output of each province in China is obviously agglomerated, that is, the provinces with higher innovation output are adjacent to each other, and the provinces with relatively backward innovation output are also adjacent to each other.

Figure 4 shows the local Moran's I scatter plot of each province in 2019 under the nested weight matrix of geographic and economic distance.It can be seen from Figure 4 that the regional distribution of innovation output is not in a random state, but shows a relatively obvious geographical space aggregation state.Most of the provinces in the first quadrant are located in East China, North China and Central China. The specific provinces in this region and their surrounding provinces have high innovation output and have a strong positive spatial correlation. They are "hot spots" for innovation output.Correspondingly, the innovation capacity of the provinces in the third quadrant is weak, and the innovation output of specific provinces in the region and its surrounding provinces is at a low level, the spatial difference between the two is small, and there is also a strong positive spatial correlation.On the whole, Moran's I index can be used to preliminarily determine that there is a spatial aggregation effect in provincial entrepreneurial activities, and it is necessary to consider the spatial correlation.

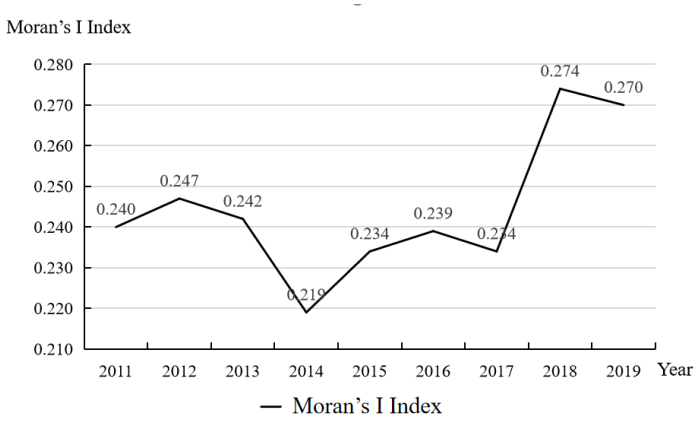

Fig.3 Moran's I index change of regional innovation output among provinces

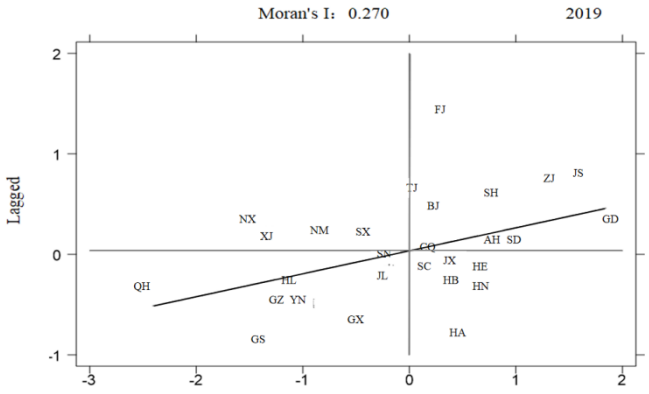

Fig. 4 Moran's I scatter plot of regional innovation output in 2019

4.5.2 Spatial spillover effect regression results

Judging from the test results of global and local spatial autocorrelation, regional innovation output has spatial correlation and should be studied by using a spatial econometric model.

This paper uses the SAR model to regress model (6) to verify the spatial correlation of provincial innovation output.In the regression results of the SAR model in Table 8, the lnVC coefficients are all significantly negative, and the $lnVC^2$ coefficients are all significantly positive, again verifying that inter-provincial venture capital and innovation output have a significant "U-shaped" curve relationship.The significant results of the correlation coefficients in the control variables are consistent with the benchmark model results in Table 4.In terms of spatial effects, the spatial correlation coefficients under the nested weight matrix (W1) and the geographic distance weight matrix (W2) were significantly positive, but when economic distance (W3) was used as the weight matrix, the spatial coefficient values were all negative.This shows that there is a significant positive spillover effect on innovation output in provinces that are geographically and economically adjacent or geographically similar.However, regional innovation output between provinces with similar economic distances has a certain competitive effect, resulting in a negative spatial spillover effect.The SAR model can not only verify the spatial correlation of innovation output between provinces, but also can no verify the spillover effects of intra-provincial venture capital (direct effect), inter-provincial venture capital (indirect effect), and overall venture capital (total effect) on innovation output can be estimated separately.Observing the effect decomposition results of the SAR model in Table 8, the direct effect and total effect of venture capital on innovation output in the region are both significant “U-shaped” curve relationships.In terms of indirect effects, inter-provincial venture capital also has a certain spatial spillover effect on innovation output, but the "U-shaped" curve is not significant.By comparing the absolute values of the direct effect and indirect effect coefficients, it can be seen that the intra-provincial effect is significantly stronger than the inter-provincial effect.This result validates Hypothesis 4 of this paper.

In order to verify whether the missing variables that affect the dependent variable have spatial correlations, or whether unobservable random shocks have spatial correlations, this paper uses a spatial error model (SEM) to verify whether the spatial correlations of variables are affected by error terms.From the lambda regression results of the SEM model in Table 8, it can be seen that the error impact on innovation output in neighboring regions will affect the innovation output in the region, and the direction of influence under different matrices is consistent with the SAR model.In addition, the "U-shaped" curve effect of venture capital on innovation output still exists.

On this basis, the spatial proximity effect is analyzed using the Spatial Doberman Model (SDM).The WX coefficient of the SDM model in Table 8 shows that the improvement of government support in neighboring provinces will significantly inhibit the innovation output of the province, and the strengthening of R&D capital investment in the neighboring provinces will significantly promote the innovation output of the province.Due to the coexistence of positive and negative proximity effects in the SDM model, the spatial coefficient (rho) failed the significance test.The effect decomposition results of the SDM model are highly consistent with the results obtained from the SAR model, which means that the results obtained in this paper are robust.

Table 8. Regression results of spatial spillovers between venture capital and regional innovation output

Variable	(1) SAR (W1)	(2) SAR (W2)	(3) SAR (W3)	(4) SEM (W1)	(5) SEM (W2)	(6) SEM (W3)	(7) SDM (W1)	(8) SDM (W2)	(9) SDM (W3)
Spatial (rho)	0.064 **	0.091 ***	-0.135 *				0.016	0.054	-0.127
	(0.69)	(0.95)	(-0.70)				(0.16)	(0.53)	(-0.58)

Spatial (lambda)				0.051 *** (0.51)	0.096 ** (0.95)	-0.257* (-1.22)			
lnVC	-0.182 *** (-2.58)	-0.183 *** (-2.61)	-0.178 *** (-2.53)	-0.182 *** (-2.58)	-0.185 *** (-2.62)	-0.171 ** (-2.43)	-0.197 *** (-2.78)	-0.191 *** (-2.72)	-0.198 *** (-2.82)
$lnVC^2$	0.013 *** (3.17)	0.013 *** (3.19)	0.013 *** (3.11)	0.013 *** (3.16)	0.013 *** (3.20)	0.012 *** (3.00)	0.014 *** (3.27)	0.014 *** (3.29)	0.014 *** (3.37)
lnOpen	-0.057 * (-1.21)	-0.057 * (-1.22)	-0.062 (-1.31)	-0.059 ** (-1.24)	-0.057 * (-1.23)	-0.057 (-1.23)	-0.041 * (-0.83)	-0.039 ** (-0.78)	-0.044 * (-0.91)
Str	-0.105 (-0.54)	-0.121 (-0.62)	-0.008 (-0.04)	--0.083 (-0.44)	-0.093 (-0.49)	-0.447 (-0.25)	-0.297 (-1.22)	-0.342 (-1.38)	-0.295 (-1.09)
lnGov	0.268 ** (2.22)	0.271 ** (2.25)	0.267 ** (2.21)	0.273 ** (2.25)	0.281 ** (2.33)	0.254 ** (2.10)	0.223 ** (1.84)	0.247 ** (2.04)	0.203 * (1.63)
Peo	0.083 (0.76)	0.074 (0.68)	0.093 (0.86)	0.092 (0.84)	0.088 (0.81)	0.077 (0.73)	0.033 (0.28)	0.059 (0.49)	0.006 (0.05)
lnRD	0.227 *** (1.29)	0.222 ** (1.27)	0.297 ** (1.60)	0.240 ** (1.38)	0.235 ** (1.36)	0.272 ** (1.57)	0.129 ** (0.64)	0.112 *** (0.56)	0.100 * (0.45)
WX									
W*lnVC							0.002 (0.02)	0.159 (0.83)	0.134 (0.41)
$W*lnVC^2$							0.001 (0.14)	-0.008 (-0.77)	-0.010 (-0.55)
W*lnOpen							0.062 (0.45)	-0.014 (-0.09)	0.059 (0.20)
W*Str							0.518 (1.27)	0.558 (1.19)	0.705 (1.18)
W*lnGov							-0.52 * (-1.77)	-0.588* (-1.88)	-0.855 (-1.00)
W*Peo							-0.100 (-0.44)	0.044 (0.20)	-0.292 (-0.75)
W*lnRD							0.782 * (1.77)	0.619 * (1.20)	1.616 * (1.30)
Direct									
lnVC	-0.180 ** (-2.48)	-0.181 *** (-2.50)	-0.176 ** (-2.43)				-0.195 *** (-2.67)	-0.188 *** (-2.60)	-0.199 *** (-2.75)
$lnVC^2$	0.013 *** (3.04)	0.013 *** (3.06)	0.013 *** (2.98)				0.013 *** (3.13)	0.013 *** (3.15)	0.014 *** (3.28)
Indirec									
lnVC	-0.014 * (-0.68)	-0.020 (-0.87)	0.016 (0.54)				-0.007 * (0.04)	-0.047 (-0.76)	0.131 (0.57)
$lnVC^2$	0.011 * (0.70)	0.009 * (0.90)	-0.001 (-0.57)				0.002 * (0.23)	0.007 (0.66)	-0.101 (-0.74)
Total									
lnVC	-0.194 ** (-2.38)	-0.201 ** (-2.38)	-0.160 ** (-2.15)				-0.201 ** (-1.13)	-0.412 * (-0.20)	-0.058 ** (-0.23)
$lnVC^2$	0.014 *** (2.88)	0.014 *** (2.87)	0.011 *** (2.53)				0.015 ** (1.62)	0.007 (0.61)	0.004 * (0.27)
Control individual	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

R^2	0.705	0.703	0.696	0.704	0.707	0.772	0.580	0.585	0.688
log-likelihood	-71.601	-71.387	-71.589	-71.706	-71.396	-71.061	-68.550	-67.940	-67.668
sigma2_e	0.101*** (11.42)	0.101*** (11.42)	0.101*** (11.42)	0.101*** (11.42)	0.101*** (11.41)	0.101*** (11.40)	0.099*** (11.41)	0.097*** (11.40)	0.098*** (11.)
N	261	261	261	261	261	261	261	261	261

5. Conclusion

This paper focuses on the relationship between venture capital and regional innovation.This paper discusses the heterogeneity and formation mechanism of the "U-shaped" curve effect between venture capital and regional innovation output,build a spatial econometric model to explore the spatial effect of inter-provincial venture capital on innovation output, and draw the following conclusions:

(1) According to the characteristic facts, the impact of venture capital on innovation output is heterogeneous in different provinces in my country.For most provinces in China, the initial stage of venture capital accumulation has no significant positive impact on regional innovation,when the stock of venture capital reaches a certain threshold, it will promote regional innovation, that is, there is a significant "U-shaped" relationship between venture capital and regional innovation;For Shanghai, Jiangsu and other eastern coastal provinces with large scale of venture capital and developed innovative technologies, venture capital first promotes and then inhibits innovation, showing a significant and relatively complete "inverted U-shaped" curve;For border provinces with less venture capital and less developed technological innovation, such as Guangxi and Yunnan, venture capital and innovation output show a downward trend of an "inverted U-shaped" curve, and venture capital has an obvious inhibitory effect on innovation output.

(2) According to the regression results of quantiles by region, it can be seen that the increase of venture capital has a relatively large benefit on the provinces in the middle level of innovation, but the impact on the provinces with low and high innovation output is relatively small.

(3) There are direct and indirect mechanisms for the impact mechanism of venture capital on regional innovation output.On the one hand, venture capital has a direct impact on regional innovation output;On the other hand, venture capital can indirectly promote innovation output by enhancing the intensity of industry-university-research cooperation.Among them, the intensity of industry-university-research cooperation acts as a key mediating variable, which is the realization path of the "U-shaped" relationship between venture capital and regional innovation output.

(4) The "U-shaped" relationship between venture capital and regional innovation output is positively regulated by absorptive capacity and intellectual property protection.The moderating effect of absorptive capacity and intellectual property protection is manifested in three aspects:A high level of absorptive capacity and intellectual property protection can make the “U-shaped” relationship between venture capital and regional innovation output more flat,the amount of venture capital corresponding to the inflection point of the "U-shaped" curve of venture capital and innovation output is larger,and make the overall level of regional innovation output higher.

(5) In terms of spatial effect, the results of nested weight matrix and geographic distance weight matrix show that the above "U-shaped" relationship has a significant spatial aggregation effect.The results of the economic distance matrix show that the provinces with similar economic levels are more likely to form a competitive effect, so that the spatial effect of venture capital and innovation output presents a scattered trend.On the whole, the direct

effect of venture capital on the "U-shaped" relationship of innovation output within a province is greater than the indirect effect between provinces.

References

1. Furman J L,Porter M E,Stern S.The Determinants of National Innovative Capacity[J]. Research Policy, 2002, 31(6):899-933.
2. Huang liang, Du debin. Theoretical evolution and reflection of innovation-oriented city research[J].Scientia Geographica Sinica,2014,34(7):773-779.
3. Lyu Lachang, Liang Zhengji, Huang Ru. A study on innovation linkages between major Cities in China[J].Scientia Geographica Sinica,2015,35(1):30-37.
4. Wu Xianhui, Wu Haiyan, Lu Qiang, et al.An empirical study on the influencing factors of China's regional innovation system[J].Science and technology progress and countermeasures,2011,28(7):26-31.
5. Duan Yongqian, Chen Jin.How does venture capital affect enterprise innovation?——Research review and prospect[J].Journal of Foreign Economics and Management, 2021,43(01):136-152.
6. Yao Li, Guo Yongji.Spillover effects of venture capital on regional technological innovation:Based on spatial panel model[J].Regional Financial Research,2017(08):16-21.
7. Meng Fanglin, Tian Zengrui, Jia Qiaoping, Zhao Yuanjun.Evolution and strategy of China's venture capital system under the background of "mass entrepreneurship and Innovation"[J].Macroeconomic Management,2019(06):30-36.
8. Croce A,Marti J,Murtinu S.The impact of venture capital on the productivity growth of European entrepreneurial firms:'Screening' or 'value added' effect?[J].Journal of Business Venturing, 2013, 28(4):489-510.
9. Hirukawa M,Ueda M.Venture capital and innovation:Which is first?[J].Pacific Economic Review.2011,16(4):421-465.
10. Lerner K J.Assessing the Contribution of Venture Capital to Innovation[J].The RAND Journal of Economics, 2000, 31(4):674-692.
11. Wang Lei, Dang Xinghua.R&D expenditure, venture capital and high-tech Industry development: An empirical study based on canonical correlation analysis in China[J].Research and development management, 2008,20(4):13-19.
12. Wang Jianmei, Wang Xiaoping.An empirical study of venture capital promoting Technological innovation in China[J].Science and technology progress and countermeasures.2011,28(8):24-27.
13. Engel D, Keilbach M. Firm-level implications of early stage venture capital investment—An empirical investigation[J]. Journal of Empirical Finance.2007, 14(2):150-167.
14. Deng Junrong, Long Rongrong.An empirical study on the effect of Venture capital on technological innovation in China[J].Research on Technology Economics and Management.2013(6):49-52.
15. Feng Zhaozhen, Wen Jun, Liu Qingyan.The Nonlinear Relationship between Venture capital and technological innovation: PSTR analysis based on provincial data[J].Industrial Economics Research, 2016,(02):32-42.
16. Wang yue.Research on venture capital embedded industry-university-research cooperation Model[J].Journal of Shanxi Agricultural Economics,2018,(3): 95-96.
17. Phelps C C.A longitudinal study of the influence of alliance network structure and composition on firm exploratory innovation[J]. Academy of Management Joumal,2010,53(4): 890-913.
18. Cohen W M,Levinthal D A.Absorptive capacity: A new perspective on learning and innovation[J].Administrative Science Quarterly,1990,35(1):128-154.

19. Tao Feng.Absorptive capacity, type of value chain and innovation performance: From the perspective of knowledge spillover of international Contract Manufacturing Alliance[J].China Industrial Economics,2011(01):140-150.
20. Andrea, Caragliu, &, et al. The impact of regional absorptive capacity on spatial knowledge spillovers: the Cohen and Levinthal model revisited[J].Applied Economics, 2012.
21. Fu X,Yang Q G.Exploring the cross-country gap in patenting: A Stochastic Frontier Approach[J].Research Policy, 2009, 38(7):1203-1213.
22. Xiao Zhenhong, Li Yan.Intellectual property protection, R&D investment and regional green innovation performance[J].Journal of Systems Management ,2022:1-15.
23. Xu Hao, Wan Difang, Xu Jin.Venture capital, regional innovation and innovation quality discrimination[J].Science research management,2017,38(08):27-35.
24. Tang M C,Chyi Y L.Legal environments,venture capital,and total factor productivity growth of Taiwanese industry[J].Contemporary economic policy,2008,26(3):468-481 .
25. Faria A P, Barbosa N. Does venture capital really foster innovation? [J]. Economics Letters, 2014, 122(2):129-131.
26. Zhao Yan, Wang Qi.An empirical study on the impact of the small world of alliance network on enterprise innovation -- Based on the analysis of Chinese communication equipment industry[J].China Soft Science,2013,(4):108-116.
27. Wu Chaopeng, Tang Di.Enforcement of Intellectual property Rights, technological innovation and Firm performance: Evidence from Chinese listed companies[J].Economic Research Journal,2016(11):125-139.
28. Wang Mingfeng, Wei Yehua, Qiu Juan.Spatial agglomeration and urban network of Venture capital activities in China[J].Journal of finance and economics,2014,40(04):117-131.
29. Jiang Tianying.Characteristics and causes of spatial differentiation of regional innovation output in Zhejiang Province[J].Geographical research,2014,33(10):1825-1836.
30. Wang Jingjing, Cheng Yu, Cao Xinxin.Spatial evolution and influencing factors of regional innovation output in Shandong Province[J].East China economic management,2018,32(11):14-21.
31. Song Xuguang, Zhao Yuhan.Spatial correlation and influencing factors of Regional innovation in China[J].Journal of quantitative and technical economics,2018,35(07):22-40.
32. Wang Peng, Zhang Jianbo.Foreign Direct Investment, government-industry-university-research cooperation and regional innovation output: An empirical study based on panel data of 13 provinces and cities in China[J].Economist,2013(01):58-66.
33. Cai Wei, Fu Xiang, Peng Jianhua.Evaluation and comparison of innovation performance in central region based on serial chain model[J].Financial theory & practice,2010,31(04):91-95.
34. Shen Hongting, Lu Yuqi, Shen Jinghong.Spatio-temporal coupling of provincial innovation input-innovation output-innovation benefit in China[J].Economic geography,2017,37(06):17-22+35.
35. Li Lin, Niu Tingyu.Structural evolution of regional innovation output spatial association network based on SNA[J].Economic geography,2017,37(09):19-25+61.
36. Zhang Aihua. Construction of Regional Innovation Evaluation Index System[J].Statistics & Decision,2017(24):51-54.
37. Song Yuegang,Du Jiang.Institutional change,OFDI reverse technology spillover and regional technological innovation[J].World Economy Studies,2015(09):60-73+128.

38. Yu Liping.Research on the nature of objective Weighting method and its application in science and technology Evaluation — — Taking academic journals as an example[J].Information Studies:Theory&Application,2021,44(02):50-56.
39. Zhang Xiru, Shen Rui, Lu Jiangyong.Venture capital research: Review and Outlook[J].Foreign economics and management,2019,41(04):58-70+138.
40. Xiao Liping, Xie Danyang.Foreign technology import and indigenous innovation Growth: Complementarity or substitution: from the perspective of heterogeneous absorptive capacity[J].China Industrial Economics,2016(09):75-92.
41. Li Mei, Yuan Xiaoyi, ZhangYi.Institutional environment and reverse technology spillover of FOREIGN direct investment[J].World Economic Research,2014(2):61-66.
42. Jin Qiaohua, Yan Taihua.Research on the relationship between independent R&D and regional innovation capability: Based on the dynamic threshold effect of Intellectual Property Protection[J].Science of science and management of science and technology,2017,38(02):148-157.
43. Brint S , Turk-Bicakci L.University-Industry Collaboration: Patterns of Growth for Low- and Middle-Level Performers[J]. Social Science Electronic Publishing.2005,(49):61-89.
44. Zhuang Yumin, Chu Qingqing.Financial agglomeration, industry-university-research cooperation and regional innovation[J].Finance and Trade Economics, 2021,42(11):68-84.
45. Shao Shuai, Li Xin, Cao Jianhua, Yang Lili.Economic policy options for haze pollution control in China: Based on the perspective of spatial spillover effects[J].Economic research journal,2016,51(09):73-88.
46. Wang Xinxin.Venture capital, R&D investment and Green technology innovation in China[J].Industrial Technical Economics, 2021,40(07):23-27.
47. Sui Bo.Venture capital, Spatial proximity and regional innovation[J].Qinghai Social Sciences,2018(02):109-117+124.
48. Chen Xin, Chen Demian, Ye Jiangfeng.Venture capital, spatial spillover and heterogeneous innovation[J].Management Review, 2021,33(04):102-112.
49. Qian Yan, Fan Cong.Venture capital, technological innovation and industrial structure upgrading[J].Journal of Soochow University (Philosophy and Social Sciences), 2021,42(01):107-116.
50. Tian Bifei, Chen Ziruo.The spatial spillover effect of FDI on Chinese entrepreneurship[J].China Industrial Economics,2016(08):40-57.
51. Liu Juan, Chen Min, Cao Jie.How OFDI affects Home-country entrepreneurship: Inhibitor or Booster?[J].World Economic Research,2020(07):105-119+137.
52. Haans R F J ,Pieters C,He Z L.Thinking about U: Theorizing and testing U-and inverted U-shaped relationships in strategy research[J].Strategic Management Journal,2016, 37(7):1177-1195.
53. Tang Yongjun, Xia Li.Environmental input, environmental information disclosure quality and enterprise value[J].Science and technology management research,2019,39(10):256-264.
54. Pan Xiongfeng, Pan Xianyou, Li Changyu.Research on the impact of Chinese government R&D funding on technological innovation[J].Journal of management engineering,2020,34(01):9-16.
55. Baron R M,Kenny D A.The Moderator Mediator Variable Distinction in Social Psychology Research:Conceptual,Strategic and Statistical Considerations[J].Journal of Personality & Social Psychology,1986,51(6):1173-1182.
56. Wen Zhonglin, Zhang Lei, Hou Jietai, et al.Mediation effect test program and its application[J].Acta Psychologica Sinica,2004(5):614-620.

57. Jia Huiying, Wang Zongjun, Cao Zuyi.R&D investment jumps and organizational performance: Moderating effects of environmental dynamics and absorptive capacity[J].Nankai management review,2018,21(03):130-141.
58. Zhu Dan, Zhou Shouhua.Strategic change, internal control and enterprise performance[J].Journal of Central University of Finance and Economics,2018(2):53-64.

Spatial Conflict and Influencing Factors of Ecological Protection and Sustainable Poverty Alleviation Capacities of Three-River-Source National Park

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Abstract. Using the coupling model and geographically weighted regression model, we investigate spatial conflicts and influencing factors of the ecological protection and sustainable poverty alleviation capacity of Three-River-Source National Park. Results show that the coupling coordination degree is 0.5270, which indicates reluctant coordination and the spatial conflict is obvious; the main influencing factors of the spatial conflict between the ecological protection and sustainable poverty alleviation capacities are the ecological governance ability of the government, the degree of resource dependence and per capita disposable income.

Keywords: spatial conflict, GWR, ecological protection, poverty alleviation, Three-River-Source National Park

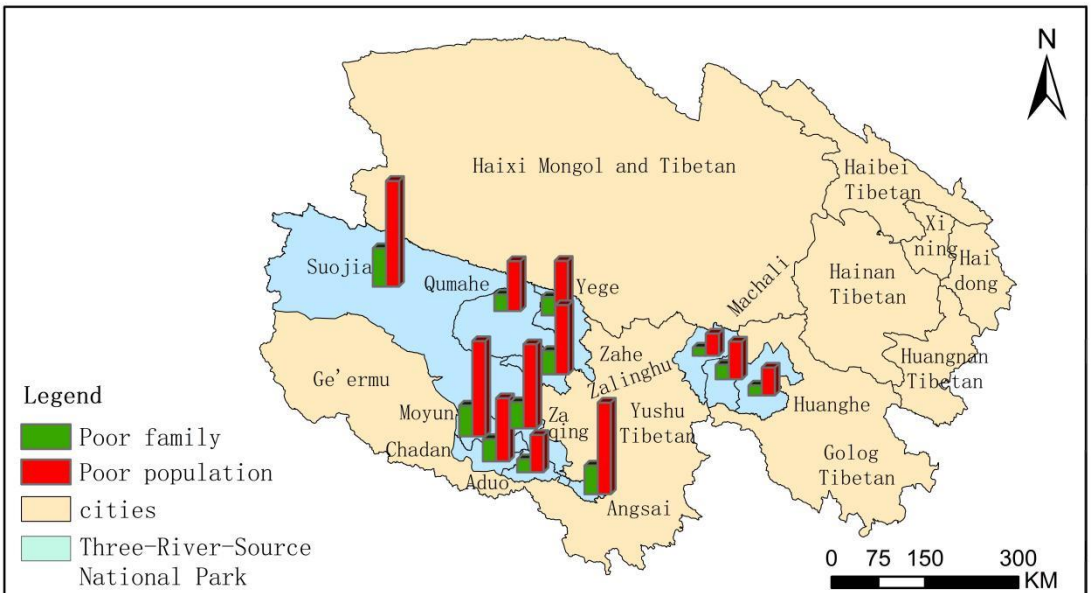
1. Aims and background

Under the background of comprehensively promoting the construction of ecological civilization and accurately poverty alleviation strategy, the establishment of national parks is a major measure for China to deepen the reform of environmental protection system and improve the level of ecological protection. As an underdeveloped province in Western China, Qinghai is not only the "source of three rivers" and "water tower of China", but also a once deeply poor area. During the 14th Five Year Plan period, Qinghai should not only build a highland of national even international ecological civilization, but also develop the economy with high quality, including permanently getting rid of poverty. The construction and operation of national parks is the carrier for Qinghai to achieve the above development goals. Three-River-Source National Park in Qinghai is one of the first national parks in China, which undertakes the task of coordinating development of ecological protection and sustainable poverty alleviation. Therefore, it is necessary to study the spatial conflict between ecological protection and sustainable poverty alleviation capacities (hereinafter referred to as SPAC) of local residents.

In recent years, scholar shave carried out relevant ecological protection studies on national parks, focusing on ecological protection, ecological compensation, ecological restoration, ecological red lines[1–4], and produced a series of achievements related to resource protection and utilisation, planning and integrated management, climate impacts, coordination of relevant stakeholders[5–9], the relationship between humans and complex natural systems in national parks[10–12]. At the same time, poverty capacity has always been a primary issue in poverty reduction research, involving capacity training, deprivation of rights, sustainable livelihoods, feasible capacity, multidimensional poverty, sustainable capacity, sustainable poverty alleviation[13–21]. In this process, the spatial conflict between ecological protection and the SPAC of local residents in national park has not attracted much attention in academic circles. So, this paper constructs an index system to evaluate the ecological protection and SPAC in Three-River-Source National Park, and analyse the spatial conflicts between the two functions and their influencing factors.

2. Research design

Three-River-Source National Park includes three river sources: the source of the Yangtze River, the source of the Yellow River and the source of the Lancang River, with a total area of 123100 square kilometers, and the park lies within 4 counties including Zhiduo County, Qumalai County, Maduo County and Zaduo County, as well as the jurisdiction area of Kekexili Nature Reserve. The park has a total population of 64000 in 53 villages (animal husbandry committees) in 12 townships (towns). By the end of 2018, 21000 people in Three-River-Source National Park had not yet been lifted out of poverty (Fig. 1).



county	town	poor family (households)	poor population (person)	county	town	poor family (households)	poor population (person)
Qumalai	Yege	524	1556	Zaduo	Aduo	634	1799
	Qumahe	470	1424		Angsai	372	1066
Zhiduo	Suojia	1093	3015		Chadan	816	2613
	Zahe	666	1978		Moyun	879	2721
Maduo	Huanghe	285	794		Zaqing	744	2400
	Machali	415	1076	total		7131	21074
	Zalinghu	233	632				

Note: According to the relevant data of the Three-River-Source National Park administration

Fig. 1. Distribution diagram of the populations living in poverty in Three-River-Source National Park in 2018

2.1. Research framework

The ecosystem service system and economic development system are the two main subsystems of Three-River-Source National Park, and these two systems are responsible for performing the ecological protection function of ecological production and the SPAC function of economic production, respectively. The two subsystems are interdependent, and they interact and influence each other; however, they are also in a dynamic process of constant conflict, constant coupling and long-term coexistence.

By maintaining the ecological balance, ecosystem service systems carry out the functions of enhancing ecological conservation, improving environmental quality, controlling soil erosion and maintaining ecological diversity. By providing development resources, economic development systems undertake the functions of ecological resource transformation, ecological value exploration, industrial structure transformation, and sustainable poverty alleviation. On the one hand, from the perspective of spatial conflict theory, under the

conditions of returning agricultural land (grazing) to forest (grass) and ecological migration, the function of ecological protection requires minimizing the development and destruction of ecological resources and fully providing ecological barriers. The function of economic development requires rationally using local resources to address the problem of sustainable livelihoods and poverty alleviation for local residents. Due to the scarcity and functional exclusion of resources, there is spatial conflict between the two functions in terms of resource utilization. On the other hand, from the perspective of sustainable development theory, ecological protection and sustainable poverty alleviation capacity have inherent coordination consistency. Strengthening ecological protection capacity, providing high-quality ecological products and effectively forming ecological resources are the ecological basis for sustainable development. At the same time, sustainable poverty alleviation requires eliminating direct dependence on ecological resources as much as possible and creating conditions for ecological protection through industrial transformation and modernization, improvements in the quality of residents, and expansion of income channels. The establishment of ecological management and protection positions and the development of the ecological economy can effectively alleviate spatial conflicts and achieve coordinated development (Fig. 2).

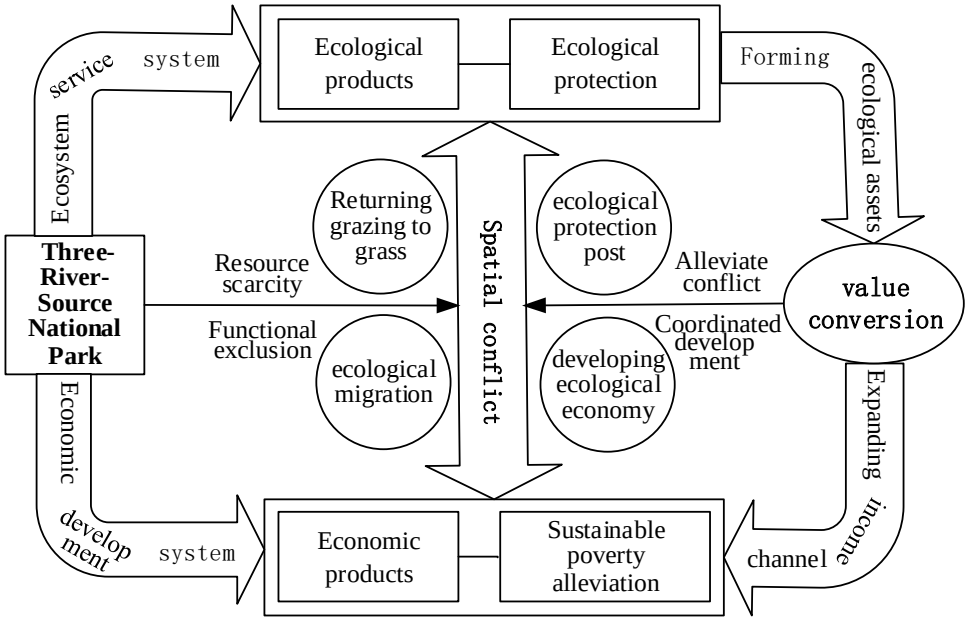


Fig. 2. Spatial conflict and coupling coordination mechanism of the ecological protection and SPAC of Three-River-Source National Park

Based on the above theoretical research framework, this paper analyzes the coupling coordination degree of the ecological protection and SPAC of Three-River-Source National Park, measures the spatial conflict level and influencing factors of these two functions, and constructs the coordination mechanism of the ecological protection and SPAC to provide a decision-making reference for promoting the innovation of the management system and mechanism of Three-River-Source National Park.

2.2. Index system

According to the core concept of developing Three-River-Source National Park and the overall goal of ecological civilization construction, the ecological protection index system of Three-River-Source National Park constructed in this paper covers the three dimensions of water and soil resource protection, biodiversity protection and green development and includes eight secondary indicators (including three indicators of water and soil resource protection, two indicators of biodiversity protection and three indicators of green development) and 21 tertiary indicators. Based on the theory of human capital[22], alleviation of poverty[23] and feasible ability[24], combined with the new requirements of Xi Jinping's "sustainable poverty

alleviation," in this paper, the constructed index system of the sustainable poverty alleviation capacity of the local residents in Three-River-Source National Park covers four dimensions: health security capacity, sustainable income growth capacity, asset accumulation capacity and competitive cooperation capacity, including 12 secondary indicators (including 3 indicators of health security capacity, 3 indicators of sustainable income growth capacity, 3 indicators of asset accumulation capacity and 3 indicators of competitive cooperation capacity) and 37 tertiary indicators (Table 1).

Table 1. Index System of the Ecological Protection and SPAC of Three-River-Source National Park

Category	First level indicators	Secondary indicators	Tertiary indicators	Definition of indicators	Entropy method weight (%)	Analytic hierarchy process weight	Combination weight (%)
Ecological protection capacity (64.35%)	Water and soil resources protection (14.86 %)	Water and soil conservation	Grassland vegetation	Reflects the protection	0.94	2.39	1.15
			Forest coverage rate	Reflects the level of	1.27	2.13	1.38
			Proportion of wetland	Reflects the level of	1.42	1.91	1.40
		Ecological restoration	Average coverage	Reflects the	1.20	2.12	1.31
			Vegetation coverage	Reflects the	1.27	2.02	1.32
			Land erosion area	Reflects the situation	2.55	1.94	2.55
		Environmental protection	Ecological	Reflects the	1.49	2.13	1.63
			Water quality of the	Reflects the water	1.27	1.90	1.23
			Growth rate of total	Reflects the growth of	3.33	1.68	2.89
	Biodiversity protecti	Plant protection	Number of wild plant populations (species)	Reflects the richness of plant population	3.09	8.42	13.38
		Animal protection	Number of wild animal populations (species)	Reflects the richness of animal population	3.13	8.57	13.81
	Green development (22.30 %)	Green industrial structure	Annual growth	Reflects the growth of	2.08	1.64	1.75
			Annual growth	Reflects the growth of	1.44	1.59	1.18
			Proportion of secondary and tertiary	Reflects the development of the	1.98	1.53	1.56
		Support of science and technology talent	Proportion of	Reflects the situation	1.94	1.40	1.39
			Number of patents	Reflects the status of	4.44	2.13	4.86
			Number of high school	Reflects educational	1.65	2.03	1.73
			Proportion of	Reflects the training of	0.89	1.89	0.86
		Green development guarantee	Ratio of ecological	Reflects the level of	6.17	2.22	7.06
			Per capita ecological compensation amount	Reflects the implementation of	1.08	1.92	1.07
			Proportion of public welfare positions in	Reflects the implementation of	0.92	1.81	0.86
Sustainable poverty alleviation capacity (35.65%)	Health security capability (10.21 %)	Physical and mental health ability	Proportion of healthy	Reflects the basic	1.56	2.77	2.22
			Proportion of mental	Reflects the level of	1.19	2.13	1.30
		Social security capacity	Satisfaction with	Reflects the level of	0.89	1.55	0.71
			Medical insurance	Reflects the level of	1.05	1.45	0.78
			Pension insurance	Reflects the level of	1.80	1.40	1.30
		Living environment	Agricultural	Reflects the production	1.73	0.91	0.82
			The supporting status	Reflects the sanitary	0.93	0.95	0.46
			Domestic sewage	Reflects the quality of living environment	3.02	0.84	1.30
			Harmless treatment		0.92	0.85	0.40
			Clean energy	Reflects the quality of	2.18	0.81	0.91
	Ability to		Proportion of labor force in family	Reflects the number of labor force	1.19	1.43	0.88
			Ratio of	Reflects the number of	1.44	1.41	1.05

increase income continuously (8.79%)	General	Average years of	Reflects the basic	0.99	1.25	0.63
	Mastery of labor skills	Proportion of people	Reflects the skills of	1.37	1.57	1.10
		Proportion of technical	Reflects the technical	1.46	1.30	0.98
		Proportion of people who can speak Chinese	Reflects the language communication ability	1.04	1.19	0.64
	Stability of income sources	Proportion of	Reflects the operating	2.02	1.46	1.52
		Number of household	Reflects the diversity of	1.37	1.30	0.92
		Distance to the county	Reflects regional	1.80	1.15	1.07
Asset accumulation ability(8.27%)	Status of family assets	Contracted area of grassland (mu)	Reflects the status of family grassland	3.75	0.95	1.84
		Number of cattle and	Reflects the status of	1.45	0.92	0.69
		Balance of household	Reflects the status of	0.97	0.88	0.44
		Valuation of existing	Reflects household	1.49	0.82	0.63
	Income from household assets	Proportion of land	Reflects the income of	2.11	1.45	1.58
		Proportion of idle land	Reflects the situation	0.97	1.12	0.56
		Proportion of idle	Reflects the situation	1.23	1.01	0.64
	Potential for increasing asset income	Proportion of credit loans in total	Reflects the credit loan situation	1.31	1.61	1.09
		Household income	Reflects the growth of	0.92	1.71	0.81
		Business enterprises	Reflects	1.86	0.93	0.89
Competition and cooperation ability (8.38%)	Competitive ability	Proportion of dividend	Reflects investment	1.42	0.91	0.67
		Number of village	Reflects resource	1.00	0.87	0.44
		Family financing ability	Reflects financial	2.09	0.89	0.95
	Cooperation ability	Number of participants	Reflects the ability of	2.05	1.23	1.30
		Proportion of social	Reflects business	2.16	1.17	1.31
		Enthusiasm to	Reflects the ability of	1.22	1.06	0.67
	Development potential	Consumption status of	Reflects social	1.35	1.64	1.14
		Leisure time of study	Reflects self-	1.13	1.75	1.02

Note: * is the reverse indicator.

2.3. Research methods

2.3.1. Weight determination method

This paper uses a combination of the objective weighting method and subjective weighting method to determine the weight of each index (Table 1) to avoid the possible errors caused by a single weighting method. The objective weighting method uses the entropy method to determine the weight value of each index. The subjective weighting method uses the analytic hierarchy process (AHP) to determine the weight of each index on the basis of hierarchical pairwise comparison scores of 10 targeted poverty alleviation experts and 10 managers of relevant departments in agriculture and rural areas. Then, the weights calculated by the above two methods are the combined weighting. Combination weighting formula is:

$$W_i = a_i b_i / \sum_{i=1}^{n} a_i b_i, i = 1,2,...,n \quad (1)$$

where Wi is the weight combination and ai and bi are the weights of the AHP and entropy methods, respectively[20].

2.3.2. Coupling model

"Coupling" was originally a physical concept, which refers to the phenomenon that two or more systems interact and influence each other[25]. Based on the research of Liao Chongbin (1999)[26], this paper first constructs a coupling degree model to analyze the degree of interaction between ecological protection capacity and sustainable poverty alleviation

capacity. *f1(t)* is the evaluation value of ecological protection capacity, *f2(t)* is the evaluation value of sustainable poverty alleviation capacity, and SC is the coupling degree.

$$SC = 2 * \sqrt{\frac{f_1(t) * f_2(t)}{[f_1(t) + f_2(t)]^2}} \quad (2)$$

Second, based on the coupling model, the coupling coordination degree model is constructed.

$$\begin{cases} SD = \sqrt{SC * ST} \\ ST = a * f_1(t) + b * f_2(t) \end{cases} \quad (3)$$

SD represents the degree of coupling coordination, *SC* represents the degree of coupling, and *a* and *b* represent the horizontal weight of ecological protection capacity and sustainable poverty alleviation capacity, respectively. This paper assumes that ecological protection and sustainable poverty alleviation are equally important, so the values of *a* and *b* are 0.5. Based on relevant research results[27–29], the classification standard of the coupling degree and coupling coordination degree is determined (Table 2).

Table 2. Classification of coupling degree and coupling coordination degree

SC value	Coupling degree	*SD* value	Coupling coordination degree	*SD* value	Coupling coordination degree
[0, 0.3)	Low-level coupling stage	[0, 0.1)	Extreme disorder	[0.5, 0.6)	Reluctant coordination
[0.3, 0.5)	Antagonistic stage	[0.1, 0.2)	Severe disorder	[0.6, 0.7)	Primary coordination
[0.5, 0.8)	Run-in stage	[0.2, 0.3)	Moderate disorder	[0.7, 0.8)	Intermediate coordination
[0.8, 1]	High-level coupling stage	[0.3, 0.4)	Mild disorder	[0.8, 0.9)	Good coordination
		[0.4, 0.5)	Verge of disorder	[0.9, 1]	High-quality coordination

2.3.3. Geographically weighted regression model

A geographically weighted regression model (GWR) introduces geographical location into regression parameters and uses the sample data information of adjacent observations to perform a local regression estimation to explain the impact of regional differences on variables [20]. The model is:

$$y_i = \beta_0(u_i, v_i) + \sum_{k=1}^{p} \beta_k(u_i, v_i) x_{ik} + \varepsilon_i, \quad i = 1,2,...,n \quad (4)$$

where (u_i, v_i) are the geographic coordinates of the *i*-th point, $\beta_0(u_i, v_i)$ is the regression constant of the *i*-th point, $\beta_k(u_i, v_i)$ is the regression parameter of the *k*-th variable of the *i*-th point, x_{ik} is the value of *xk* at point *i*, *p* is the number of independent variables at sample point *i*, and ε_i is the random error value at point *i*. The spatial weight matrix and local bandwidth are the two most important parameter settings. The spatial weight matrix is determined by the Gaussian function, and the optimal bandwidth is determined according to the AIC [20].

2.4. Data sources

The relevant ecological protection data for Three-River-Source National Park were obtained through the Ecological Monitoring Bulletin of Three-River-Source National Park in 2019, Bulletin of Three-River-Source National Park in 2019 and statistical yearbooks of relevant counties. The sustainable poverty alleviation capacity data were obtained from a field sampling survey. The sample is determined by the combination of simple random sampling and stratified sampling[30]. The expected error limit is ± 0.05%; the confidence interval is 95%; and the proportion of sample size in the total number is 0.5. After the calculation, there are 53

sample villages and 927 sample households in Three-River-Source National Park, and then, the total sample number is stratified into each township (Table 3).

Table 3. Sample distribution of sampling survey

Township	Total number of villages	Total number of households	Number of sampled villages	Number of sampled households	Township	Total number of villages	Total number of households	Number of sampled villages	Number of sampled households
Yege Township	3	524	3	68	Chadan Township	4	816	4	106
Qumahe Township	4	470	4	61	Moyun Township	4	879	4	114
Suogia Township	4	1093	4	142	Zhaqing Township	4	744	4	97
Zhahe Township	4	666	4	87	Huanghe Township	6	285	5	37
Aduo Township	4	634	4	83	Machali Town	8	415	7	54
Angsai Village	3	372	3	48	Zhaling Lake Township	5	233	4	30

Note: according to the relevant data of the Three-River-Source National Park administration

3. Results and analysis

3.1. Quantitative assessment of the ecological protection and SPAC of Three-River-Source National Park

Based on the standardized data and weight of each index of ecological protection capacity and sustainable poverty alleviation capacity, the ecological protection and SPAC of Three-River-Source National Park are quantitatively evaluated. The results show that the comprehensive evaluation value of the ecological protection of Three-River-Source National Park is 0.7178, and the comprehensive evaluation value of sustainable poverty alleviation capacity of the local residents is 0.4687.

3.2. Evaluation of the spatial conflict between the ecological protection capacity and sustainable poverty alleviation capacity of Three-River-Source National Park

3.2.1. Spatial conflict evaluation

This paper measures and evaluates the level of spatial conflict between the ecological protection capacity and the sustainable poverty alleviation capacity of Three-River-Source National Park through the coupling coordination degree. The coupling coordination degree indicates the overall coordination degree and spatial conflict between the ecological protection capacity and sustainable poverty alleviation capacity of Three-River-Source National Park. The greater the value, the stronger the coordination of spatial conflict. From the results, the coupling coordination degree of the ecological protection capacity and sustainable poverty alleviation capacity of Three-River-Source National Park is 0.5270, which indicates reluctant coordination, and the spatial conflict is obvious.

3.2.2. Spatial conflict and spatial differentiation

The coupling coordination degree of ecological protection capacity and sustainable poverty alleviation capacity of 12 townships in Three-River-Source National Park is calculated (Table 4).

Table 4. Status of spatial conflict between ecological protection capacity and sustainable poverty alleviation capacity in 12 townships.

Park	Township	Coupling coordination degree	Park	Township	Coupling coordination degree	Park	Township	Coupling coordination degree
Source region of Yangtze River	Suojia Township, Zhiduo County	0.5023	Source region of the Yellow River	Husanghe Township, Maduo County	0.4484	Source region of Lancang River	Chadan Township, Zaduo County	0.4110
	Zhahe Township, Zhiduo County	0.5022		Machali Town, Maduo County	0.4563		Zhaqing Township, Zaduo County	0.4018
	Yege Township, Qumalai County	0.3733		Zhaling Lake Township, Maduo County	0.4675		Aduo Township, Zaduo County	0.4036
	Qumahe Township, Qumalai County	0.3422		Moyun Township, Zaduo County	0.4198		Angsai Township, Zaduo County	0.3902

The mean values of the coupling coordination degree of the ecological protection capacity and sustainable poverty alleviation capacity of the source areas of the Yangtze River, the Yellow River and the Lancang River of the Three-River-source National Park are 0.4300, 0.4574 and 0.4053, respectively. Using the natural fracture method, the degree of coupling coordination between the ecological protection and SPAC of the 12 towns in the three parks is divided into two categories: a higher level (greater than 0.4198) and a lower level (less than or equal to 0.4198). Among the towns, in the source area of the Yangtze River, there are two villages and towns at a higher level and two at a lower level. There are three high-level towns in the source area of the Yellow River. There are five towns in Lancang River Park at a lower level. Fisher's exact test shows that the Fisher test value is 7.309, and the P value is 0.019. The spatial conflicts of the three parks are significantly different.

3.3. Analysis of the influencing factors of spatial conflict between the ecological protection capacity and sustainable poverty alleviation capacity in Three-River-Source National Park

3.3.1. Model construction and variable setting

When discussing the coordinated relationship between ecological protection and economic development, Hou Zengzhou, Zhang Rongtian and other researchers mainly considered the energy consumption of the regional GDP, the centralized treatment rate of urban domestic sewage, the forest coverage rate in built-up areas, the public budget expenditure for energy conservation and environmental protection, and the per capita net income of farmers and other factors[31–33]. Based on the above research results and combined with the actual situation, this paper establishes a regression model of the influencing factors of the coupling coordination degree between the ecological protection capacity and sustainable poverty alleviation capacity of Three-River-source National Park.

$$y=\beta_0+\beta_1 X_{Govern}+\beta_2 X_{Resoure+}\beta_3 X_{Income}+u \quad (5)$$

where y is the dependent variable, namely, the coupling coordination degree of ecological protection capacity and sustainable poverty alleviation capacity. X_{Govern}, $X_{Resoure}$, and X_{Income}, the three independent variables, represent the government's ecological governance capacity (*Govern*, represented by the proportion of ecological management and care workers in the population), the degree of resource dependence (*Resource*, expressed by the proportion of farmers' nonagricultural income in household operating income), and per capita disposable

income (*Income*, classified according to the natural fracture method, <=6505 is 1, >6505 and <=8161 is 2, and >8161 is 3), respectively; β_0 is a constant, and β_1, β_2 and β_3 are the coefficients of X_{Govern}, $X_{Resoure}$, and X_{Income}, respectively. u is the error term.

3.3.2. Geographically weighted regression results

First, ordinary least squares regression is used, and then, geographically weighted regression is used (kernel type selection fixed method, bandwidth selection AIC method, bandwidth 67.319 km, residual sum of squares 0.003, effective number 4.008, and Sigma 0.021). The results show that the three factors of resource dependence, the government's ecological governance capacity and per capita disposable income have a significant impact on the spatial conflict between the ecological protection capacity and sustainable poverty alleviation capacity of Three-River-source National Park at a level of more than 10%. The AIC value of the geographically weighted regression model is significantly lower, and R^2 is significantly higher than that of the least squares regression model, indicating that the geographically weighted regression model has a better fitting degree (Table 5).

Table 5. Results of ordinary least squares and geographically weighted regression

Dependent variable	Ordinary least squares regression model (OLS)				Geographically weighted regression model (GWR)					
	Independent variable	Coefficient	t	p	Average value	Maximum value	Minimum value	Upper quartile	Median value	Lower quartile
Coupling coordination	Constant term	0.428***	15.506	0.000	0.42815	0.42817	0.42812	0.42814	0.42815	0.42815
	Resource	0.065*	2.287	0.052	0.06464	0.06472	0.06458	0.06463	0.06465	0.06466
	Govern	0.103**	2.857	0.021	0.10282	0.10285	0.10278	0.10281	0.10281	0.10283
	Income	-0.037***	-3.627	0.007	-0.03740	-0.03738	-0.03742	-0.03740	-0.03740	-0.03740
Comparison of fitting degree	AIC=-37.598, R^2=0.787, ad-R^2=0.708, F=12.246*** VIF=1.094, DW=2.931, N=12				AIC=-39.646, R^2=0.0.821, ad-R^2=0.754					

Note: ***, ** and * are significant at the 1%, 5%, and 10% levels, respectively.

3.3.3. Analysis of the regression results

From the coefficient point of view, the coefficient of the government's ecological governance ability (Govern) is 0.065, indicating that the ecological governance measures taking into account ecological protection capacity and sustainable poverty alleviation capacity have a positive role in alleviating the spatial conflict between the two functions. The coefficient of resource dependence (Resour) is 0.103, indicating that the smaller the dependence on natural resources is, the weaker the spatial conflict between the ecological protection capacity and sustainable poverty alleviation capacity. The coefficient of per capita disposable income (income) is -0.037, indicating that per capita disposable income has a negative effect on the spatial conflict between the ecological protection capacity and sustainable poverty alleviation capacity; that is, the higher the income level is, the more obvious the spatial conflict between the two functions, reflecting the reality that the existing income of farmers and herdsmen in Three-River-Source National Park is still heavily dependent on resources.

4. Conclusions and policy recommendations

4.1. Conclusion

Based on the survey data collected for Three-River-Source National Park and its subordinate areas, this paper uses the coupling model to evaluate the ecological protection capacity and the sustainable poverty alleviation capacity of local herdsmen of Three-River-Source National Park and uses a geographically weighted regression model to analyze the spatial conflict between the two functions and their influencing factors. The following conclusions can be drawn:

(1) The ecological protection capacity of Three-River-Source National Park is good, and the sustainable poverty alleviation capacity of local residents is low. The overall level of the two is quite different. The coupling coordination between the two function is poor, and can be considered reluctant coordination. In addition, the spatial conflict is obvious.

(2) The spatial distribution of the coupling coordination degree between ecological protection capacity and sustainable poverty alleviation capacity is heterogeneous, and there are obvious differences among the source areas of the Yangtze River, the Yellow River and the Lancang River.

(3) The main influencing factors of the spatial conflict between ecological protection capacity and sustainable poverty alleviation capacity are the government's ecological governance capacity, degree of resource dependence and per capita disposable income. The first two factors have a positive promoting effect, while the last factor has a negative inhibiting effect.

4.2. Policy recommendations

In 2017, China established 10 national parks, including Three-River-Source National Park, and comprehensively carried out the national park system pilot, focusing on active implementation of overall plans, benefit coordination, construction models, community participation, benefit sharing, etc., and achieved phased results[34–37]. At the same time, China has also achieved the goal of "lifting all the people out of absolute poverty" under the existing poverty standard as a whole. However, from the perspective of specific areas of national parks, although significant achievements have been made in terms of ecological protection and alleviation of local residents' poverty, the problems related to the large differences in the development level of ecological protection and sustainable poverty alleviation, poor coupling and coordination between the two, and obvious spatial conflicts are still prominent. Accurately identifying and scientifically analyzing the spatial conflicts and influencing factors of ecological protection capacity and sustainable poverty alleviation capacity of national parks and then proposing targeted countermeasures and suggestions is a major issue that must be considered and effectively resolved after the national park system pilot is completed and the formal establishment of national parks occurs. Policy recommendations include the following:

(1) Adhere to the integration of the two goals of national park ecological protection and the sustainable poverty alleviation of local residents. The primary principle and general idea of national parks are ecological protection first. The main goal of parks is to strengthen the protection of the authenticity and integrity of the natural ecological system and form a new system and new mode of natural ecological system protection. However, at the same time, the economy of the areas where national parks are located is often no developed, and the life of the residents is relatively difficult. Most residents have just been lifted out of poverty. It is necessary to comprehensively improve their ability to sustainably alleviate poverty so that local residents can benefit from ecological protection and increase their income from the construction of national parks. Therefore, it is necessary to take into account ecological protection and sustainable poverty alleviation. Given the premise of protecting natural resources, the resources of national parks should be used moderately and limitedly to achieve the harmonious coexistence of humans and nature.

(2) Explore a win-win management method of national park ecological protection and the sustainable alleviation of local residents' poverty. The government's ecological governance ability is an important influencing factor of the spatial conflict between the ecological protection capacity and sustainable poverty alleviation capacity of Three-River-Source National Park. The core recommendation for governmental ecological governance is to form a win-win governance model in national parks that is conducive to ecological protection and sustainable income increases for local residents. Therefore, it is necessary to actively explore the potential for ecological management and protection positions, franchise projects, multiple ecological compensation mechanisms, community cooperation and protection, and social cogovernance and sharing to achieve the dual effect of ecological protection and residential poverty alleviation and to effectively improve the modernization level of ecological governance in national parks.

(3) Expand diversified value conversion channels from national park ecological resources to ecological assets. The degree of resource dependence is an important factor in the spatial conflict between ecological protection and sustainable poverty alleviation. Ending the direct dependence of local residents on ecological resources and implementing a value transformation from green water and green mountains to golden mountains and silver mountains is an important way for national parks to resolve the conflict between humans and land. Therefore, it is necessary to vigorously promote the transformation of the industrial structure led by the ecological economy, build a world-class salt lake industrial base, create a national clean energy industrial highland and an international ecotourism destination, and a place that receives exports in green organic agricultural and livestock products[38]. At the same time, it is necessary to accelerate the development of green financial products, develop a carbon trading market, expand the scale of the carbon sink trading market, and promote the value conversion of ecological resources in national parks.

References

1. Geldmann J，Barnes M，Coad L，et al. Effectiveness of terrestrial protected areas in reducing habitat loss and population declines[J]. Biological Conservation, 2013, 161(3): 230 - 238.
2. Wang Y, Bilsborrow R E , Zhang Q , et al. Effects of payment for ecosystem services and agricultural subsidy programs on rural household land use decisions in China: Synergy or trade - off?[J]. Land Use Policy, 2019, 81:785 - 801.
3. Benayas, J. M. R. , et al. , Enhancement of Biodiversity and Ecosystem Services by Ecological Restoration: A Meta - Analysis. Science (American Association for the Advancement of Science), 2009. 325(5944): 1121 - 1124.
4. Zhang Xuefei, Wang Chuansheng, Li Meng. Delimitation of ecological space and ecological protection red line in territorial spatial planning [J]. Geographic research, 2019, 38 (10): 2430-2446
5. Sax J L. Mountains without handrails: Reflections on the national parks[M]. University of Michigan Press, 2018.
6. Duzgunes E, Demirel O. Importance of visitor management in national park planning[J]. Journal of environmental protection and ecology, 2016, 17(2): 675-680.
7. Tomaskinova J, Tomaskin J. Integrated management of the National park Slovak Karst[J]. Journal of Environmental Protection and Ecology, 2013, 14(2): 664-674.
8. Shafer C L. From non - static vignettes to unprecedented change:The US National Park System, climate impacts and animal dispersal[J]. Environmental Science & Policy, 2014, 40: 26 - 35.
9. Nabokov P, Loendorf L. Restoring a Presence: American Indians and Yellowstone National Park[M]. University of Oklahoma Press, 2016.

10. Subakanya M, Tembo G, Richardson R. Land Use Planning and Wildlife - Inflicted Crop Damage in Zambia[J]. Environments, 2018, 5(10): 110.
11. Gu X, Li Q, Chand S. Factors influencing residents' access to and use of country parks in Shanghai, China[J]. Cities, 2020, 97: 102501.
12. A. R. NURDUBAYEVA: The Structure of Spatiality in Modern Architecture. J Balk Tribol Assoc, 27 (5), 725 (2021).
13. Schultz T W. Transforming traditional agriculture[M]. New Haven and. London: Yale University Press, 1964.
14. Sen A. Poverty and famines: an essay on entitlement and deprivation[M]. Oxford university press, 1982.
15. Scoones I. Sustainable rural livelihoods: a framework for analysis[J]. IDS Working Paper 72, Brighton: IDS, 1998.
16. Sen, A. Development as Freedom[M]. Oxford: Oxford University Press, 1999.
17. Yuan Liang, Zhang Guangqiang, Huo Xuexi. Impact of ecological compensation and livelihood capital on sustainable livelihood of residents: a case study of national key ecological function areas in Shaanxi Province [J]. Economic geography, 2017, 37 (10): 188-196
18. Ling Jingqiu. Sustainable poverty alleviation capacity: an analytical framework for China's Rural Poverty Governance in the new era [J]. Journal of Guangxi Normal University (PHILOSOPHY AND SOCIAL SCIENCES), 2018, 39 (02): 97 - 111
19. Sun Hanlin, Liu Xinzhi, Zhang Pengyao. Study on livelihood sustainability and dynamic risk of poverty-stricken households in poverty-stricken areas [J]. China population, resources and environment, 2019, 29 (02): 145-155
20. Hu Xiwu, Liu Xiaopeng, Huang Yue, Huang Lijun, Dong Mei. Spatial deprivation measurement and influencing factors of ecological immigrant villages in Ningxia [J]. Acta geographica Sinica, 2020, 75 (10): 2224-2240
21. Zhao Xu, Tang Feng, Zhang Pengtao, Hu Boyang, Xu Lei. Dynamic simulation and characteristic analysis of county production life ecological spatial conflict based on CLUE-S model [J]. Acta ecologica Sinica, 2019,39 (16): 5897-5908
22. Schultz, et al. Trans. On human capital investment [M]. Beijing: Beijing Institute of Economics Press, 1990
23. Amartya Sen, by Ren Yu, translated by Yu Zhen. Looking at development with freedom [M]. Beijing: China Renmin University Press, 2012
24. Amartya Sen, by Wen Xianyun, trans. What kind of equality [J]. World philosophy, 2002 (2): 61
25. Liu Yaobin, Li Rendong, song Xuefeng. Analysis on coupling degree of urbanization and ecological environment in China [J]. Journal of natural resources, 2005 (01): 105-112
26. Liao Chongbin. Quantitative evaluation and classification system of coordinated development of environment and economy: a case study of urban agglomeration in Pearl River Delta [J]. Tropical geography, 1999 (02): 3-5
27. Wang Yi, Ding Zhengshan, Yu Maojun, Shang Zhengyong, song Xiaoyu, Chang xiajie. Quantitative analysis of coordination relationship between modern service industry and urbanization based on coupling model: a case study of Changshu City in Jiangsu Province [J]. Geography research, 2015, 34 (01): 97-108
28. Xu Shuang, Hu yecui. Coupling coordination analysis of farmers' livelihood capital and livelihood stability: a case study of Jinqiao village resettlement area in Guangxi [J]. Economic geography, 2018, 38 (03): 142 - 148 + 164
29. Hu Xiwu, Huang Lei, Zhang Xiaoyi. Evaluation of coordination between economic development and ecological protection in Qinghai Province and analysis of influencing factors [J]. Qinghai Tibet Plateau forum, 2020 (04): 38-48

30. Hu Xiwu. Spatial deprivation and spatial optimization: the challenge and response of Ningxia ecological migration in the new era [M]. Beijing: Economic Daily Press, 2020
31. Hou Zengzhou. Evaluation of coordination degree between ecological environment and economic development in Dongying City, Shandong Province [J]. China population, resources and environment, 2011,21 (07): 157-161
32. Zhang Rongtian, Jiao Huafu. Analysis on coupling and coordinating relationship between economic development and ecological environment in Pan Yangtze River Delta [J]. Resources and environment of Yangtze River Basin, 2015,24 (05): 719-727
33. Gai Mei, Zhang Fuxiang. Coupling coordination analysis of regional carbon emission, economic development and environmental protection in Liaoning Province [J]. Geographic science, 2018,38 (05): 764-772
34. Zhang Haixia, Zhang Xuliang. Influencing factors and spatial diffusion of National Park model development in natural heritage sites [J]. Journal of natural resources, 2012 (4): 705 - 712
35. Xiang Baohui, Zeng Yuxi. Discussion on the construction and operation mechanism of ecotourism system in Three-River-Source National Park pilot area [J]. Resources science, 2017, 39 (01): 50-60
36. Zhang Haixia, Zhong Linsheng. Research on Institutional Logic and mode selection of national park management organization construction [J]. Resources science, 2017, 39 (01): 11-19
37. Tang Fanglin. Thoughts on the system construction of national parks with Chinese characteristics [J]. Forestry construction, 2018, 203 (05): 91 - 101
38. Xinhua news agency. Xi Jinping attended the deliberations of the Qinghai delegation, stressed: unswervingly take the road of high quality development and unswervingly promote the well-being of the people's livelihood [N]. People's Republic of China Central People's government, 2021.03.07. http://www.gov.cn /xinwen /2021-03/07/content_ 5591271.h

Crop management on swidden farming by Indigenous groups in mountainous of Nghe An province, Vietnam

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Abstract. Shifting cultivation, which is long-standing systems, practiced by most ethnic minority people in the mountainous regions of Asia including Vietnam. It is a traditional farming system for many indigenous groups and closely linked to their identity that based on geographical features. In Nghe An, although shifting farming has to be carried out under limited ecological and socio-economic conditions, they have innovated in crop selection and management and have achieved significant progress, especially in crop management development. This study focus on discovering indigenous experiences in shifting cultivation and crop management of local communities in Nghe An province. The surveys were conducted in 12 villages of 2 communes (Ta Ca and Muong Long belong to Ky Son district) by qualitative research tools, including participatory semi–structured interviews, questionnaires designed, and field observations. The results revealed that the community had accumulated the methods to select and preserve varieties, intercrop farming. We recommend that future policies should take advantage of crop management experiences, promote indigenous knowledge to increase sustainable agricultural values for the community; prioritize the socio-ecological resilience of mountainous landscapes and do not use use a one-size-fits-all strategy.

Key words: Shifting cultivation, Indigenous Groups, Crop management, mountainous of Nghe An province

1. Introduction

Shifting cultivation, or swidden farming, has been practiced by traditional societies for thousands of years, mostly in the humid tropics, and throughout its long history it has proven to be a dynamic and evolutionary system (G. Rasul and G. B. Thapa, 2003). There have been many studies of swidden cultivation that compare it with wet-rice cultivation (e.g. Padoch, 1985; Cramb, 1989; Conelly, 1992; Hunt, 2000; Mertz et al., 2009). However, while upland ecosystems have a lot of potential for development,they are very vulnerable, so there is a need for a holistic and environmentally friendly approach. A diverse range of adaptive fallow and tree-cropping systems have beendeveloped by local communities in their efforts to modify upland farming to meet evolving rural conditions (Fox, 2015). There have been reports of progress in crop diversification and management in some parts of the world, such as Amazonian Peru (Brookfield, 2015). In Vietnam, upland farming systems have a wide diversity of plant genetic resources (Tran, D. V. et al., 2015). The indigenous knowledge of ethnic minorities has enabled diversified systems of shifting cultivation to dominate mountainous areas of Nghe An province. These systems are generally suitable for sloping land conditions and are similar to those described by Rambo (1996) in his studies of the Tay ethnic group in Vietnam's northwestern mountains. However, the cultivation systems of Nghe An have a hot and moist environment and are focused on plant varieties capable of surviving in total dependence on the weather, where others may fail in these conditions.

The shifting cultivators of Nghe An have a long history of nomadic farming. They face an increasing population, limited ecological conditions, water supplies restricted to rainfall alone and challenging socio-economic conditions, but they have nevertheless been innovative in

their selection and management of crops, and havemade significant progress, particularly in the development of crop varieties. The domestication of rice over countless generations has been one of the most importantachievements of these mountain-dwelling ethnic groups. A lot of their rice varietieshave never been identified scientifically but exist only under their local names.

The study area

This study was conducted in Ta Ca commune and Muong Long commune, Ky Sơn district, Nghe An province (Figure 1). distance from the center of the district to Ta Ca commune is about more than 3 km while to Muong Long commune is about 50 km. Muong Long commune has a long international border with the Lao PDR. It has three ethnic groups: Thai, Mong and Kho mu.

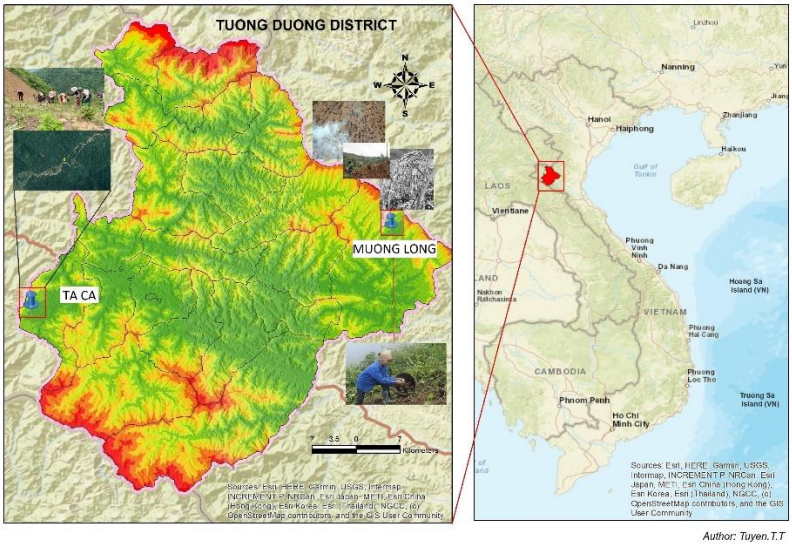

Figure 1: Location of the study area (Ta Ca commune and Muong Long commune, Ky Son district, Nghe An province, Vietnam)

The topography is strongly divided, with high mountains ranging between altitudes of about 1800 and 2500 meters above sea level. The average annual rainfall is from 2000 mm to 2200 mm. The soils are mainly ferrallisols, with humus on the mountains making for relatively thick soil. The forest in the area is dominated regenerated forest, with dominant small tree species and an understory of shrubs and herbs. One characteristic of this vegetation is its ability to recover quickly. Cultivated land is mostly reclaimed by the original farmer, after fallowing. In the past, the choice of plots to open for cultivation was governedby traditional laws, but the government has now granted ownership of the land to the farming families.

This study refutes the suggestion that shifting cultivation is a static practice and its practitioner's incapable of improving or intensifying their farming systems. Itsupports the notion that if left to their own devices, granted tenure over their land and given help on their terms, shifting cultivators will be every bit as innovative as their counterparts in modern agriculture.

2. Methods

2.1. Field observations

Observations were carried out simultaneously in two rice fields of each study village, one growing old (traditional) varieties and the second growing new varieties, at different times according to the seasonal calendar. The crops were thus observed atthe time of seed sowing in May and June, and later at harvest time in October. This provided information on the

development of the new varieties, why and how they were chosen, and planting, fertilizing, and harvesting for each plant. In this way, we could assess the flexibility and creativity of the farmers.

2.2. Sociological investigation

Twelve villages of Ta Ca commune and Muong Long commune, Ky Son district were involved in the study. Thirty individuals wereinterviewed from each village, making a total of 300 interviews. The gender and age structures of these groups were controlled. Each group of 30 was divided into 15 men and 15 women; their age was divided into three groups: 18 to 30 years old,30 to 60 and over 60. There were 10 respondents from each age group. In addition to gender and age, the interviewees were also chosen for their ethnic backgrounds. The 300 respondents were divided equally into three groups of 100 each for Kho mu,Mong and Thai people. Based on these criteria, individuals were otherwise chosen randomly. The division by gender and age groups was aimed at assessing indigenous knowledge according to gender and age. The selection of individuals forinformal and semi-structured interviews was not limited by numbers and focused on older people in the various communities because they were regarded as 'special people' holding 'special information'. The different ethnic groups had different approaches to crop management and these differences were used in assessing the economic effects of various cropping methods.

Using questionnaires designed for the purpose

A questionnaire can be a cost-effective research tool for use in data collection. However, several sequential steps should be followed in planning and designing a questionnaire, to ensure that the questions are handled consistently by all interviewers and that during the interview process the interviewer can answeror clarify respondents' queries. In the questionnaire for this study, the farmers were asked about traditional methods of seed selection (morphology, color, seed quality, etc.), the time of seed selection and the way the seeds were preserved for the following season. The farmers were also asked to compare different preservation methods that were considered at the time of selection and the way these methods might affect theproductivity of the crop.

Semi–structured interviews about discovering and selecting superior seeds

Because of the differences in age, gender and ethnicity in the survey, a semi-structured approach was adopted to develop interviewees' responses and obtain richer information. All methods were used to get closer to vital information on selection processes and preservation and storage of seeds so that each locality was able to plant the best varieties of crops.

3. Results

3.1. Salient practices in the selection and management of seeds

3.1.1. Collecting superior seeds

Rice is the most important food crop, directly feeding more people than any other crop in the uplands. In the past, the farmers saved their best rice fields to produce seed for the following season. However, the methods by which rice varieties are now selected have come from improved farming practices. Farmers have moved away from the system of using an entire field for seed stocks and have made painstakingand elaborate efforts to discover and select good seeds from many fields. They saythat good seeds are found on developing panicles that are about 40 to 50 cm long, and are weighed down with stocky, heavy grains (Figure 00-2). The panicles are harvested individually, dried in the sun, and taken back to the village.

Figure 2: Good rice-seed indicators: Panicles heavy with grain (left) compared with a field that can be overlooked for future seed stocks (right).

3.1.2. Breeding seeds

Breeding plays an important role in cultivation. Therefore, farmers are very interested in breeding, by helping nature to produce superior plants. In the past, they believed that 'seedlings belong to the mountain gods,' so that the grain from some fields was routinely saved for the next season. This method is still used by some households. However, they found that after a long period of cultivation, they collected many seeds of poor or inferior quality from their seed-production fields. At the same time, they noticed that other fields contained a lot of good seeds. Consequently, the selection of varieties for the next year's crop has been extended to other fields and the methods of selection have also changed.

Farmers have begun assessing the quality of developing crop plants at an early stage, and 87% of farmer respondents said they chose to assist the natural breedingof superior plants based on observations in their upland fields. The best plantsin their fields are marked from the flowering stage for maize and from panicle initiation for rice. In the case of maize, they watch for multiple branches on the male inflorescence at the apex of the plant's stem. The flower should be about 20 cm longand of a uniform color. They also note the direction of the cobs, or ears, as they develop (Figure 3).

They then monitor the ripening phase on each chosen plant. The important aspects are the texture and color of the grains, or kernels. When the grain is ripe and mature, a close watch is kept on how the hardness of the grain increases duringthe waxy state. The farmers also examine the color, viscosity and grain density of individual cobs and eventually select the best plants (Figure 00-4). When the maizeis ready to be harvested, the farmers cut the leaves around the selected cobs so thatthey receive the most sunshine. These cobs are left on the plants for about two weeksafter the rest of the crop is harvested.

Figure 3: Indicators of good seed for future maize crops: Multiple flowers (left) and flowers growing towards the sun (right).

Figure 4: Grain density (left) is one criterion by which farmers select seeds for future crops.

The process of selecting rice seeds based on the state of the developing panicleshas proven itself to be a more effective means of judging good quality plants. Seedrates, seed germination rates, plant growth rates and yields have all improved. Under the old, traditional system, the percentage of broken seeds was quite high. As shownin Table 00-1, the percentage of broken seeds has fallen and the germination rate has improved, along with a higher percentage of healthy plants. At present, rice seeds are planted at a rate of 08 to 11 seeds per dibble hole, and overall productivity has risen (**Figure 5**).

Figure 5: Seeds are planted at a rate of 8 or 11 per hole (left), and the germination rate has risen to 97%, with more than 90% of plants regarded as healthy (right).

Table 1. Effectiveness of innovative methods of seed selection in study villages.

Criteria	*Old method*	*New method (Innovation)*
Broken grain (%)	21.3	13.1
Germination rate (%)	83	97
Rate of healthy plants (%)	79.1	91.3

3.1.3. Protecting and storing seeds

Protecting and storing seeds for the following year's crop is a critical component ofseed treatment and plays a vital role in the study site's agriculture production. In addition to improved breeding techniques, the ways in which local people preserve their seed have been changing over time. Seed preservation is undertaken in a variety of ways to ensure both the quantity and quality of the seeds. The most effective of methods ensures that the seeds do not rot and are viable when planted for the next round of cropping. The focus on quality begins in the harvest, when harmful factors such as insect damage (termites, locusts, beetles, grubs, larvae, spiders, and so on) and excessive moisture are avoided.

Using field huts

One of the most popular means of protecting seeds from insect damage is to store them in a raised field hut, the design of which has been modified over time. Sometimes the seed huts have a keeper – a person to watch over the seed, but often they are simply unmanned.

Mong farmers make seed-storage huts with high floors, with an average floor area of about 4 m x 5 m. Smaller models may measure about 3 m x 4 m. The flooris between 2 m and

2.5 m above the ground – safe from animals and heavy rain. Thehuts are made with locally available materials, such as wood, bamboo, and rattan, and many of them have the appearance of a small house, with room for the rice, a place to rest, a fireplace, a pot of water,and room for laboring tools such as anaxe, a rake, a hoe and a dibble stick. In the past, seed-storage huts in the upland fields had no keeper, or human presence. To protect the seeds from the depredations of birds, Mong farmers often made scarecrows and created devices to generate noises tokeep the birds at bay. But the birds and termites still found ways to eat the seeds, so other ways had to be found toprotect them. The recent seed-storagehuts of the Mong people are muchmore substantial structures, even though they still go without a human presence. They are supported byfour strong columns and the walls are made of woven bamboo. Time invested in building stronger huts means the people worry less about the safety of their seeds. The heavy use of bamboo and leaves of other trees means the newhuts keep the seeds dry and safe. As for the crop itself, the rice and maize were traditionally stored in specially built houses on the swiddens or, at least, away from the villages. This had several disadvantages: people had to journey to the remote buildings and carry the grain home for consumption; the farming families were unable to keep a close watch on their grain supplies and there was a risk that wildfires could consume their staple foods. Nowadays, the family homes are more likely to house all their swidden products, or small houses are built near the houses and the grain is carried in for storage after harvest.

Storing the seed near the kitchen fire

Fire plays a vital role in the traditional culture of Thai, Mong and other ethnic groups. Within each house, the fireplace is not only for cooking and sitting together around the flames, but also for preserving important things like food, beliefs – and seeds. This is a popular way of preserving vital seed stocks in the study area. Everykitchen – or cooking area within each house – has shelves made from wooden sticks, that are usually about 2 m long, alongside or above the fireplace. Kitchen utensils are hung there. This is also a place for keeping seeds, often hung in dry bunches (Figure 00-10). There is nearly always a small open wood fire burning. After harvesting, the seeds and plant products are carried to the home and a beam is suspended near the fireplace, where the heat and smoke dry kernels and prevent the seed being invaded by bacteria, mold, insects and moisture. The kitchen fireplacenot only symbolizes the security of the home, but also protects the family's wealth, invested in the next crop.

Storing seed on the floor

Another method for storing seeds in the house is simply to leave them on the floor. Preservation is natural and without sophisticated technology. Usually, some fruits and vegetables are stored on the cool ground, which maintains sufficient moisture to keep taro corms ready to sprout. However, this method of storing seeds is open to attack right). Besides, the farmers have improved it by storing the seeds in bamboo bowls kept in a dark corner or constructing small platforms to hold the raw materials for their crops about half a meter above the floor (Figure 6).

Figure 6: Seeds for next year's crop, preserved in the heat and smoke of the fireplace in a Mong house.

3.2. The intercropping experiments

Swidden fields are usually covered by various plants. Over the past three decades, farmers in the study villages have been improving their performance in intercropping techniques.

3.2.1. 'Matched' crops in the fields

After the early trials, farmers improved their intercropping systems. They found which crops should be planted together and have reported considerable benefits from intercropping (Table 2). Today, taro is commonly grown, with high yields, but it is not intercropped with rice. Instead, rice is intercropped with a different variety of cucumber, one that does not creep, but crawls along the ground in higher elevations (Mong farmers). In addition, rice is intercropped with pumpkins and gourds at lower elevations (Thai, Khmu people). Maize is intercropped with beans. The beans are sown 50 days after the maize. Afterthe maize is harvested, the beans are still green for some months. They climb on the dried maize, covering and improving the soil, before their fruit is harvested. Usingthis procedure, following crops grow and develop well, they face less competition from weeds, and yields are higher.

Until recently, Thai people in the study villages planted monocrops of cassava. Thisled to severe soil erosion, so that after two or three years of cropping there was little soil remaining. Recently, they began planting peanuts along with the cassava and, asa result, the soil has been protected and soil fertility has increased, so this system has high economic efficiency.

Table 2. Farmers' comparisons of the effectiveness of intercropping and monocropping[23]

Aspect	*Intercropping*	*Monocropping*
Yields and income	Stable, high value Low, gender-balanced	Unstable, low prices, precariousLabor Low, gender-balanced
Food Security	Diverse, improved health	No diversity
Impact of the weather	Adaptable Stable yields Pests controlled	Difficult to adaptUnstable yields Pests and diseases
Greenhouse gas emissions	High biomass Longer cultivation cycle	Low biomass short cultivation cycle
Soil erosion System functions	Low impact Nitrogen-fixing species	High risk High inputs of NPK fertilizer
Ecological	Multi-functional, high biodiversity	Low functionality, low-biodiversity

[23] Results synthesized from participatory surveys conducted by researchers with the participation of Hmong and Thai communities in Ta Ca commune and Muong Long commune, Ky Son district, June - 2022.

3.2.2. Matching varieties to soil types

Before planting, the farmers choose a forest plot with the most suitable terrain. Based on long experience, they say that gullies with gentle or light slopes are the bestfor rice and maize. In this type of land there are few vines with thorny sprouts or rough spines. The soil is black, spongy, and moist, contains a lot of humus and is populated by earthworms. It is preferred for growing rice because it gives the highest productivity. As well as recognizing the favorable lie of the land and the color ofthe soil, the farmers plunge sharp knives about 30 cm into the ground. If soil adheres to the knife when it is withdrawn, it is deemed to be good soil.

Maize is the second most preferred crop, but the soil should be lighter and drierto grow good maize. Other plants that prefer the same soil conditions are planted together with the two main food crops. According to the study-site farmers, the change to finding the right soil type for each crop, rather than expecting crops to thrive on any patch of cleared forest land, has increased production efficiency and land use.

3.2.3. Using the signs of nature as crop-management indicators

The management of seasonal crops is often based on the annual cycle of fruit treesin the forest. Over many years of swidden farming, the Thai people in the study area have learned to recognize the stages of growth of upland rice. This knowledge has been written into proverbs, such as: 'July is the month that rice grows high; in Augustit is making panicles. The rice is in the foot of the buffalo in September, and it is broken if it is not harvested in October'. This indicates the need to work in the ricefields every month and the urgent necessity to tend to the changing needs of the crop, or it will be lost. This indigenous knowledge of seasonal management of rice crops by the Thai people of western Nghe An province not only reminds farmers of the seasonal calendar but also expresses the close relationship, deep understanding and harmony that exists between people and nature in mountainous areas.

3.2.4. Covering soil with dried vegetation

In the past, when fields were clearedof vegetation for new cultivation, farmers usually burnt all the plant residues. Dry branches left after burning were collected andburnt again, until there was no dry matter left on the field. What was left was fertilizing ash, but about 20 years ago, farmers began to regard the ash with some skepticism: although there was a lot of it left by the fires, after the first rain most of it had disappeared. This kind of awareness has helped farmers over recent decades to change their practices.

Nowadays, after sowing, farmers use dry matter to protect the seeds. Using the available organic matter, dried leaves, sticks and small branches are laid on the surface of the soil, with thicker patches covering newly sown seedbeds (Figure 00-6). This simple technique not only protects the seeds, but also protects and rehabilitates the soil. The dry matter reduces erosion by rain and wind and increases the porosity ofthe soil and its ability to absorb water. It therefore improves soil moisture, reduces surface run-off and evaporation, reduces weed growth, and increases the stability and structure of the soil surface. These effects increase the efficiency of fertilizer. Farmers reduce their investment in land preparation, weeding and fertilizer, while increasing the amount of organic matter and plant nutrients in the soil. The use of dry vegetation in this way creates good conditions for seed germination and strong root and plant growth. This new practice has increased and stabilized yields and thequality of sustainable crops. on a sloping field (left). It is regarded as one of the most important innovationsin the study villages and has become the basis for sustainable use and management.

Figure 6: Gathering dried vegetation (right) and using it to protect newly planted seeds

3. Conclusion and discussion

Shifting cultivation and its progress over the centuries is a long story. It has generated a wealth of knowledge among ethnic-minority communities that still depend upon it for their livelihoods. While this knowledge has accumulated over time and experience, it has been passed down in oral tradition from one generation to the next, to be used and passed on. However, its preservation has not been a matterof conservatism; it has been developed and improved in accordance with changing conditions. The cultures of ethnic minorities play an important role in biodiversity conservation (Sharma et al., 2006), and other aspects of their wisdom, gathered over generations of struggle in a difficult environment, seek to ensure economic, social, and environmental protection through an extraordinary closeness to nature. Such precious knowledge should be collected, improved upon, or coordinated with modern technology to apply to rural development programs or to develop new farming systems based on valuable experience. The depth of this experience extendsto seed selection, crop preservation, soil erosion control, soil selection, crop rotations and crop management associated with cultivating sloping land.

Research has revealed a wealth of indigenous knowledge related to seed and crop management, including seed selection and preservation. Ethnic groups involved inthis study have made innovative improvements to land selection, crop combinations and cultivation techniques to not only assure harvest quality but also to protect sloping land. All are based on traditional knowledge, and all have great value. However, the management of crops and cultivars in the study area is limited and the conditions, methods and means of harvesting and preserving agricultural products from slopingland remain quite simple and are less than safe. Farm products are stored in houses, dependingon the weather, so the quality of trade is poor and uncertain. In years of heavy rain, agricultural products rot or become moldy and the sun is unable to dry much of the finished products. Marketing is difficult because there is no place to preserve agricultural products properly and quality suffers as a result. Therefore, it is necessary to make use of the knowledge of these people, according to their languages, customs, and habits, and make reasonable improvements by combining their knowledge with advanced scientific and technical advice on agroforestry production. We could then expect that their native innovative thinking, together with the application of technical progress, would lead to positive advances now and in the future.

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References

1. Brookfield, H. (2015) ‘Shifting cultivators and the landscape: An essay through time’, in M. F. Cairns (ed.) *Shifting Cultivation and Environmental Change: Indigenous People, Agriculture and ForestConservation*, Earthscan from Routledge, London
2. Cairns, M. F. (ed.) (2007) *Voices from the Forest: Integrating Indigenous Knowledge into Sustainable Upland Farming*, Resources for the Future Press,Washington, DC

3. Cairns, M. F., Keitzar, S. and Yaden, T. A. (2007) 'Shifting forests in northeast India: Management of Alnus nepalensis as an improved fallow in Nagaland', in M. F. Cairns (ed.) *Voices from the Forest: Integrating Indigenous Knowledge into Sustainable Upland Farming*, Resources for the Future, Washington, DC, pp341-378
4. Cramb, R. A. (1989) 'The use and productivity of labour in shifting cultivation: An East Malaysian case study', *Agricultural Systems* 42, pp209-226
5. Fox, J. (2015) 'Foreword', in M. F. Cairns (ed.) *Shifting Cultivation and Environmental Change: Indigenous People*, Agriculture and Forest Conservation, Earthscan from Routledge, London.
6. G. Rasul and G. B. Thapa (2003), Shifting cultivation in the mountains of South and Southeast Asia: regional patterns and factors influencing the change, Land Degrad. Develop. 14: 495–508.
7. Hunt, R. C. (2000) 'Labor productivity and agricultural development: Boserup revisited', *Human Ecology* 28, pp251-277.
8. Mertz, O., Padoch, C., Fox, J., Cramb, R.A., Leisz, S. J., Lam, N.T. and Tran, D.V. (2009) 'Swidden change in Southeast Asia: Understanding causes and consequences', *Human Ecology* 37, pp259-264.
9. Padoch, C. (1985) 'Labor efficiency and intensity of land use in rice production: An example from Kalimantan', *Human Ecology* 13, pp271-287.
10. Rambo, A. T. (1996) 'The composite swiddening agroecosystem of the Tay ethnic minority of the northwestern mountains of Vietnam', in B.
11. Rerkasem (ed.) *Montane Mainland Southeast Asia in Transition*, Chiang Mai University, Chiang Mai, pp69-89.
12. Sharma, K. K., Jaiswal, A. K. and Kumar, K. K. (2006) 'Role of lac culture in biodiversity conservation: Issues at stake and conservation strategy', *Current Science* 91(7), pp894-898
13. Tran, D.V.,Vu,V. L. and Nguyen T. T. L. (2015) 'Plant genetic diversity in farming systems and poverty alleviation in Vietnam's Northern mountain region', in M. F. Cairns (ed.) *Shifting Cultivation and Environmental Change: Indigenous People, Agriculture and Forest Conservation*, Earthscan from Routledge, London

Diffusion of oriental language and culture: The temporal and spatial patterns evolutions and factors of Chinese and Korean language and culture institutes

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Abstract. Reflecting on oriental language and culture is receiving increasing attention in international exchange and language and culture institute is an important carrier of cross-cultural communication. This study examined the diffusion of oriental language and culture through analyzing the temporal and spatial patterns evolutions and their factors of the language and culture institutes of China and Korean—Confucius Institute and King Sejong Institute. The results indicate that most of the Confucius Institutes are established through the cooperation between domestic and foreign universities, and there are various cooperation types of the Sejong Institute. From its establishment to 2020, the number of Confucius Institutes has shown an "S-shaped growth", which can be divided into four stages. The number of King Sejong Schools has shown a "J-shaped growth", and the number of institutions was increasing rapidly. Meanwhile, the spatial pattern of Confucius Institutes and King Sejong Institute have both changed significantly. For oriental language and culture institutes, economical and geographical factors have become less important. On the other hand, these institutes serve the needs of national development and construction, playing the role of seeking common ground while reserving differences, bridging ideological differences, and seeking shared cultural consensus.

Key words: language and culture institute; oriental language and culture; Confucius Institute; King Sejong Institute

1. Introduction

With the promotion of globalization, the communication between eastern and western languages and cultures has become closer, but there has always been a phenomenon of information asymmetry. In the process of international cultural communication, compared with English, the dominant language and culture, oriental language and culture face a "cultural deficit" in cultural output. Promoting the communication of oriental languages and cultures, on the one hand, can enhance the influence of oriental languages and cultures and realize the development and innovation of languages and cultures; on the other hand, it is necessary to protect the diversity of civilizations, promote the dialogue between different civilizations and the diversified development of the world. International language and culture institutes, as carriers and cultural display places for cross-cultural communication, can expand the range and mode of language communication and are effective ways to enhance the influence of language and culture. Therefore, they have received more and more attention. Among eastern countries, China and South Korea were the first to set up international language and culture institutes in 2004 and 2007 respectively, which have formed a certain scale in terms of number and space. China and South Korea are geographically adjacent to each other and have similar historical and cultural backgrounds, but their national systems and cultural communication management systems are different. A comparative analysis of the spatial and temporal differentiation patterns and characteristics of factors of international language and culture

institutes in the two countries is conducive to revealing the path and characteristics of oriental language and culture transmission.

The existing literature has explored three issues associated with international language and culture institutes, specifically, the development and status quo of institutions (Wang, 2020; Wang ,2014; Taylor,1978), operation and management mode (Liu, 2020; Zhou, 2014; Rixon,2013), and the effect and influence of language and culture communication (Duan Yi 2018; Yu Miao 2010).A series of coping strategies from the aspects of regional development, cooperation mode, education and teaching should be taken for the better development of Confucius Institutes (Lin, 2019). Based on the annual reports of international language and culture institutes in six countries, an overall comparison of the main factors affecting the running status of international language promotion institutions has been made, and corresponding countermeasures and suggestions for the development characteristics of Confucius Institutes have been put forward (Liu, 2020).

Two or more major language and culture institutes in the world are selected for comparative analysis (Dong, 2015; Jiang, 2012; Gold K,2017; Li, 2016). Comparative analyses of the operation modes and decision-making mechanisms of the four language institutions (Cao, 2014) and the cultural promotion features of the Confucius Institute and Goethe Institute (Du, 2013) have been made. Rothwell's "5W" theory has been used in cross-cultural communication to compare the operation mode and decision-making mechanism of language and culture institutes in various countries. Through analyzing all links and components of cross-cultural communication, put forward development suggestions based on the composition of the communication chain (Chen, 2011).

The existing research scales of international language and culture institutes cover national (Han, 2013), regional (Li, 2017), continental (Yang, 2018) and global (East, 1982). Through analyzing the language and cultural communication effects of Confucius Institutes in Africa from the perspectives of the number of Chinese learners, national language policies, and attitudes of local college students, it has been proposed that the combination of language teaching and cultural communication should be strengthened to realize the transformation from quantity to quality (Yang, 2018). Confucius Institutes along "the Belt and Road" should make up for their shortcomings in spatial patterns according to local conditions in the future and transform into conjunctive development from the perspective of geography (Yu, 2019).

Regarding the methods used in research focusing on international language and culture institutes, qualitative analysis is the main research method, and literature materials, interviews and surveys are mostly used to summarize the model of language and culture institute. Quantitative analysis is rarely used, and the factors influencing the development of language and cultural institutions are mainly analyzed by mathematical statistics. Using principal component analysis, it has been concluded that the number distribution of Confucius Institutes in different countries is most influenced by the import and export volume of the country and related countries, followed by the population size, geographical proximity, or special policies of the host country (Cheng, 2016). A regression model has been used to analyze the conditions for the opening of Confucius Institutes, and the results showed that foreign direct investment, trade, geographical distance, level of development and whether it is an English-speaking country are important factors (Lien, 2014).

To sum up, most of the existing studies on international language and culture institutes focus on the development model and its factors of it from the perspectives of linguistics, education, management and other disciplines, and few studies are conducted from the perspective of geography. Based on the multi-source public data of international language and culture institutes in China and South Korea worldwide, this paper comprehensively uses spatial analysis methods and establishes a regression model to compare the spatial and

temporal patterns and influencing factors of Confucius Institute and King Sejong Institute, and on this basis discusses the characteristics and laws of the development of Oriental language and culture in international language and culture institutes. In order to provide a reference for the dissemination and communication of Oriental language and culture and the formulation of development strategies of relevant institutions.

2. Research methods

2.1 Data

The research data in this paper are mainly from the official websites of the Confucius Institute and King Sejong Institute and the official websites of the universities and other institutions that cooperate with them. The collected data include the number of Confucius Institutes and King Sejong Institute in the world, the geographical location of the cities where the language and culture institutes are located, the names and types of the cooperative institutions.Data processing includes data screening, coordinate reverse check and information completion.In addition, the supporting data includes the basic data and indicators of politics, economy, culture and other countries involved in the research.As of December 2020, there are 515 Confucius Institutes in 152 countries and 212 King Sejong Institutes in 71 countries. In addition, 66 Confucius Institutes closed in 10 countries from 2013 to 2020 are collected because there are a certain number of Confucius Institutes closed.

2.2 Analytical Methods

The study utilized spatial autocorrelation analysis to show the level of spatial autocorrelation of the number of international language and culture institutes in the world. Global Moran's reflects the overall autocorrelation level (Cai, 2016), and illustrates whether the distribution of the number of international language and culture institutes has spatial continuity and whether their development conforms to the law of expansion and diffusion. Local Moran's represents the spatial correlation between each region and its neighboring regions (Liu, 2019), which is used to reveal the spatial difference and significance of the number of language institutions in each country and its neighboring countries.

For factors of development of international language and culture institutes in four dimensions- economy, geography, politics, the method of stepwise regression was conducted to avoid unified dimension has the multicollinearity problem between multiple variables. According to the significance of regression square and test, independent variables are introduced one by one to ensure that each variable in the final regression model is significant, which can effectively solve the problem of multicollinearity among independent variables (He, 2011).

The cultural distance model used in this study is based on the "Huo model" (Qi,2014). Based on the score of six dimensions of power distance, individualism/collectivism, male/female degree, uncertainty avoidance, long-term/short-term orientation, self-indulgence and restraint, China and South Korea are selected as control countries respectively to calculate the cultural distance of sample countries: Institutional distance can be defined as the difference or similarity between countries in regulation, norms and cognitive institutional environment (Chen, 2014).According to the world Bank's world governance indicators published by the existing literature, the paper calculates the six indicators including speech and accountability, political stability and non-violence, government effectiveness, regulatory quality, legal rules and corruption control.

3. Cooperative school-running mode

According to the domestic cooperation organizations and foreign organizers of Confucius Institute and King Sejong Institute, the school running modes of Confucius Institute and King Sejong Institute are divided into different types (Tab. 1).The Confucius Institute is

a non-profit educational institution jointly established by China and foreign countries to promote Chinese language and culture to the world through Chinese language teaching.Confucius institute, which is based on colleges and universities, in domestic school-running mode according to different foreign undertaking institutions can be divided into the cooperation of colleges and universities at home and abroad, domestic and foreign social organizations in colleges and universities cooperation, domestic colleges and universities at home and abroad to cooperate with foreign governments and high school joint multinational cooperation in four categories, including domestic and foreign cooperation in running schools in colleges and universities pattern is the main mode of cooperation in running schools, accounting for 93.4%.At the same time, along with the development of the special purpose of Chinese teaching, 26 were set up as specialized worldwide Confucius institutes, including 12 business Confucius institutes, 6 Confucius institutes of traditional Chinese medicine, the Confucius institute of tourism, 2 Confucius institutes of science and technology and technological innovation, vocational education, international finance, dance and performance, friendly city each a Confucius institute, Most of these Confucius Institutes are run by universities at home and abroad with relevant academic backgrounds.

King Sejong Institute is a Korean language and culture school in the form of a social education institute, which was established to cater to multi-level Korean language education and learning purposes.The establishment can be divided into three types: independent, connected and cooperative, which are managed separately by a foreign local management organization, jointly managed by a domestic organization through a contract, and jointly managed by the Sejong Hak Foundation and a public organization. By 2020, King Sejong Institute can be divided into 9 modes according to the types of domestic cooperative organizations and foreign organizers. Among them, the largest number of institutions are operated independently by Korean cultural institutes/educational institutes in various countries, jointly operated by domestic and foreign universities, and independently operated by foreign universities.

Both Chinese and South Korean language and culture institutes take universities at home and abroad as important platforms for language and culture communication. King Sejong Institute has changed its operating body several times. Currently, it is jointly operated and managed by the Sejong Academy Foundation and several departments and institutions, and there are various types of domestic cooperative organizations. Before 2020, Confucius Institutes will be operated and managed by the National Office of Chinese Language Promotion Leading Group with strong government leadership. In 2020, a Sino-Foreign Language Cooperation and Exchange Center will be established, and Confucius Institutes will be handed over to The China International Chinese Language Education Foundation to gradually realize the strategic transformation of marketization and civilianization.

Tab.1 Types and proportions of Confucius Institutes and King Sejong Institutes

	Domestic cooperative institutions	Foreign organization	School-running mode
The Confucius institutes (Number:515)	Colleges and universities	Colleges and universities	Cooperation between Chinese and Foreign universities (93.4%)
		Social organizations	Cooperation between Chinese universities and foreign organizations (3.9%)
		Government agencies,	Cooperation between Chinese universities and foreign governments (2.3%)
		Universities associate with	Cooperation with multinational companies (0.4%)

		multinational companies	
King Sejong Institutes (Number：212)	No domestic cooperative organization	Colleges and universities	Independent operation of foreign universities (25.5%)
		Social organizations	Independent operation of foreign organizations (8.5%)
	Colleges and universities	Colleges and universities	Cooperation between Domestic and foreign universities (24.0%)
		Social organizations	Cooperation between Chinese universities and foreign organizations (1.9%)
	Embassies abroad	Colleges and universities	Cooperation between Embassies and foreign universities (3.8%)
		Independent operation of Korean embassies abroad (3.3%)	
	Community organizations, companies	Colleges and universities	Cooperation between Domestic organizations and companies and foreign universities (2.8%)
	Independent operation of Korean Cultural/Educational institutes abroad (28.8%)		
	Sejong Haekdang Foundation (1.4 %)		

4. Spatial and temporal differentiation characteristics

4.1 Temporal dynamics

The number and the start-up time of Confucius Institutes and King Sejong Institute in different continents were counted (Fig. 1), and the fitting degree R between the growth curve of Confucius Institutes and the cubic polynomial trend line^2=0.979, the fit is good, the number of institutions presents the characteristics of "S-shaped growth", the growth rate of the number of institutions increases first and then decreases, and the number of institutions in Europe, Asia and North America is the largest, which can be divided into four stages: (1)From 2004 to 2009, China's economic strength, international status and political influence increased rapidly, and the global demand and interest in Chinese language increased accordingly.The Confucius Institute project was promoted and developed rapidly in the early stage, and the number of institutions showed explosive growth, gradually forming a relatively equal feature with the largest number of institutions in Europe, Asia and North America.(2) From 2009 to 2013, the development of Confucius Institutes entered a stable period and maintained a uniform growth rate. The number of Confucius Institutes in Europe, Asia and North America increased rapidly, and so did the number of Confucius Institutes in Africa, South America and Oceania.(3) From 2013 to 2018, the growth rate gradually slowed down. Except for the significant increase in the number of Confucius Institutes in Africa, other continents were saturated. Since 2017, the number of Confucius Institutes in North America has decreased significantly, which is mainly related to the restrictive regulations of the United States and other countries on the opening of Confucius Institutes in universities.(4) From 2018 to 2020, due to the impact of the international political environment and COVID-19, some Confucius Institutes in North America and Europe were closed, while the number of Confucius Institutes in other continents was stable, and the number of Confucius Institutes in the world decreased slightly.

King Sejong Institute was founded a little later than Confucius Institutes, and its development speed and overall number are significantly lower than Confucius Institutes.It can be seen from the number growth curve that King Sejong Institute has a certain initial number of institutions, which is mainly caused by data processing. Some of these institutions were originally other Korean language teaching institutions, but they were not classified as King Sejong Institute until the establishment of King Sejong Institute. Since these institutions were established much earlier than King Sejong Institute, the establishment date of these institutions was recorded as 2007, when King Sejong Institute was established. The Number of King

Sejong Institute is still in the J-type growth stage. The number of King Sejong Institute grows slowly at the initial stage of its establishment, but the overall growth rate keeps an upward trend. From 2007 to 2012, the main body of operation of King Sejong Institute changed many times, and the development of the organization was unstable. Since the Sejong Foundation was officially designated as the main body of King Sejong Institute in 2013, the number has increased significantly. The development of King Sejong Institute has always been mainly in Asia, but its spread to other continents has been slow. More than half of the existing institutions are still located in Asia, and the rest of the continents, except Europe, account for less than 10%, showing an uneven distribution.

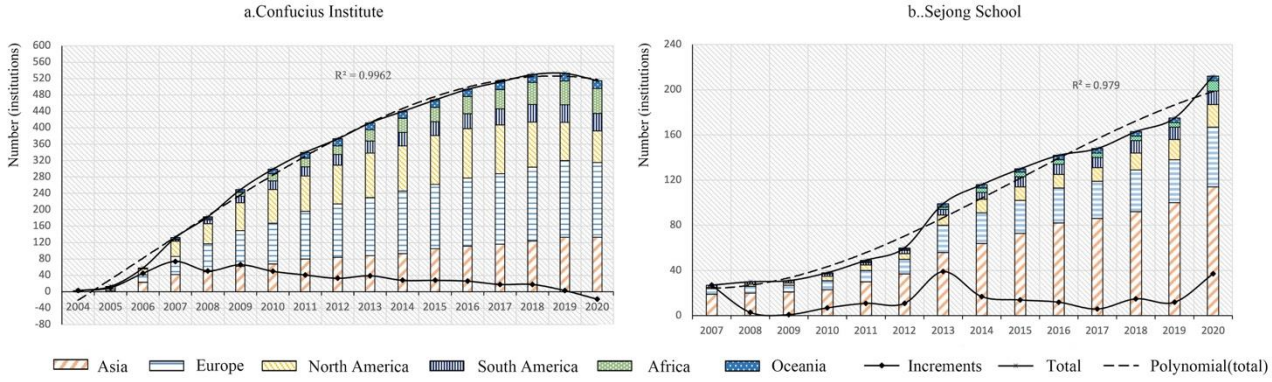

Fig.1 Temporal dynamics of the number of institutions

4.2 Spatial Distribution

4.2.1 Overall distribution pattern

In 2010, the Global Moran's I value of Confucius Institute and King Sejong Institute on the national scale were 0.11 and 0.10, respectively. In 2020, they were 0.11 and 0.41, respectively, with P values less than 0.05 and significant at the 95% level. Therefore, the spatial aggregation characteristics of Confucius Institutes are always weak, and the degree of spatial aggregation is basically unchanged, while the global spatial autocorrelation index of King Sejong Institute increases significantly from 2010 to 2020, and the degree of spatial aggregation is enhanced.

The global Moran index of King Sejong Institute has increased significantly, and the local spatial autocorrelation analysis of King Sejong Institute is further carried out (Fig.2). The development positioning of King Sejong Institute as "propagating centered on The Asian cultural circle" can be seen from LISA diagram. In Asia, the high number of institutions spread from East Asia, where South Korea is located, to Southeast Asia and South Asia. Both East Asia and Southeast Asia are the key regions for the global development of King Sejong Institutes. In addition, in 2020, King Sejong Institutes will add high-low areas in Europe, North America, and South America, and gradually become to a core-periphery structure. Turkey, the United States, and Brazil will have more institutions than their neighboring countries.

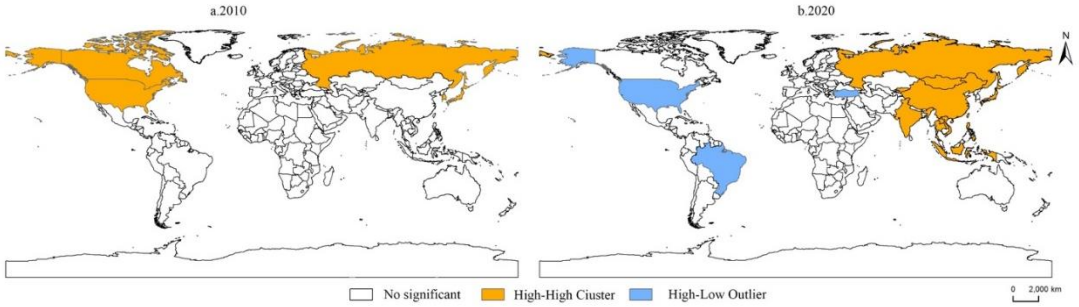

Fig.2 Correlation analysis of local space in King Sejong Institutes in 2010 and 2020

The spatial aggregation effect of Confucius Institutes is always weak, and the development of Confucius Institutes in a country can be substantively reflected by the number of institutions in each country [24], so the country is taken as the basic analysis unit, and the hierarchical statistical graph method is used to analyze its overall distribution pattern. In ArcGIS, the number of institutions is divided into five categories according to the natural breakpoint method (Figure 3). It can be seen that in 2010, Confucius Institutes covered most countries except African countries and formed core-periphery structures centered on France, Russia, South Korea and the United States in Europe, Asia and North America.To 2020, the development center of Confucius Institutes is adjusted, with the rising of the number of institutions along "the Belt and Road" and in many European countries, such as Germany, Britain, South America, Brazil. Besides, South Africa and Thailand become the new gathering center, with marked increases can be seen in the number of institutions in African countries. Overall, the distributions of Confucius Institutes in 6 continents tend to show core-periphery structures.

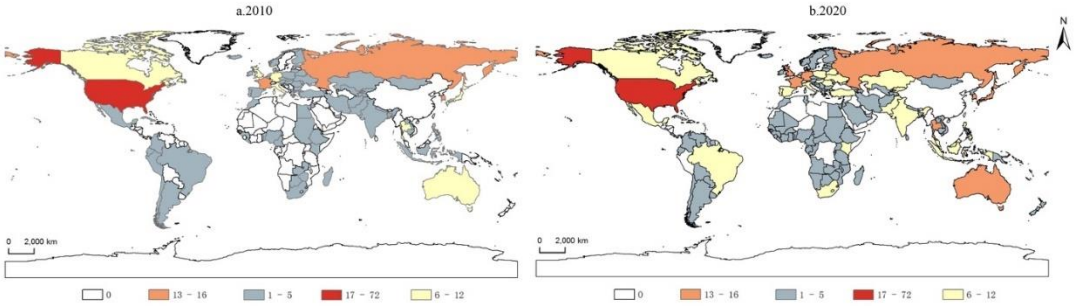

Fig.3 Spatial patterns of Confucius Institutes in 2010 and 2020

4.2.2 Distribution characteristics of key regions and countries

By further analyzing the key regions and countries of language and culture institutes at the urban scale, it can be found that more than 80% of Confucius Institutes and King Sejong Institutes are in a city alone. Cities with multiple languages and culture institutes are mostly capitals or economic and cultural centers of a country. The current development strategy of Confucius Institutes mainly focuses on Central Asian and Eastern European countries along “the Belt and Road”, as well as many African countries. King Sejong Institutes focus of development has shifted from East Asia to Southeast Asia, especially in Vietnam, Indonesia and Thailand, while expanding its coverage in Europe.Therefore, “the Belt and Road” region, Africa, Southeast Asia and Europe are selected as the typical regions for the analysis of Confucius Institutes and King Sejong Institutes respectively (Figure 4).The distribution direction of Confucius Institutes in countries along “the Belt and Road” is consistent with the trend of the Silk Road Economic Belt and the Maritime Silk Road, which shows that Confucius Institutes attach importance to responding to the National "the Belt and Road" initiative in terms of layout.At present, it is mainly in Southeast Asia and Eastern Europe, especially in Bangkok, Minsk, Moscow, Istanbul and other big cities.Most Of the Confucius Institutes in Africa are located in Sub-saharan Africa, and most of the cities they located are coastal and border cities. The Confucius Institutes in Africa distribute from northeast to southwest, and more of them located along the west coast of Africa. As the influence in political, social and economy of China rising rapidly in recent years, huge international market of China has led to the rapid growth of demand for Chinese in various countries with which China has close cooperation. King Sejong Institutes are mainly distributed in Vietnam, Indonesia, and Thailand in Southeast Asia, especially in Ho Chi Minh city and Hanoi city in Vietnam. King Sejong Institutes in Indonesia and Thailand are mainly located in Jakarta and Bangkok.

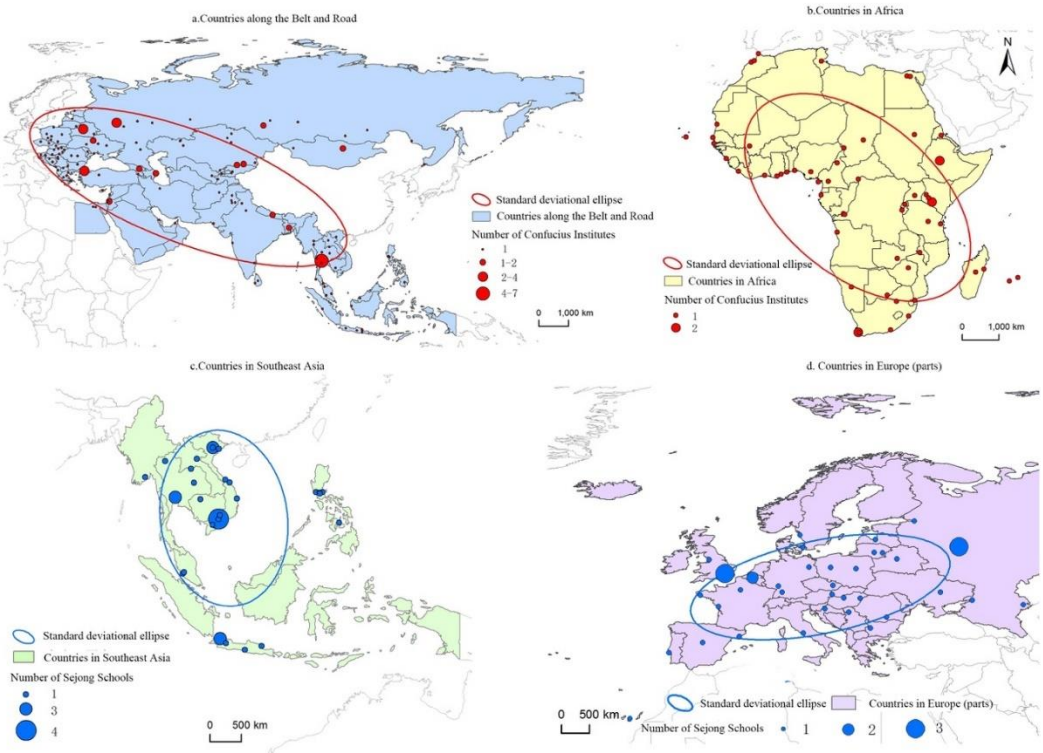

Fig.4 Layout patterns of Chinese and Korean language institutions in key regions

Confucius Institutes and King Sejong Institutes also show different distribution characteristics in key countries. The number of King Sejong Institutes is growing fastest in China and Vietnam, but the development patterns are different. The 28 King Sejong Institutes in China are evenly distributed in 25 cities, while the 15 King Sejong Institutes in Vietnam are mainly concentrated in Ho Chi Minh and Hanoi.From 2010 to 2020, the number of Confucius Institutes in the UK is the largest, and the UK also has the largest number of specialized Confucius Institutes in the world. There are many Confucius Institutes and King Sejong Institutes in the United States, but the Confucius Institutes are mainly located in New York, Houston, Atlanta and other cities on the East Coast of the United States, while the King Sejong Institutes are mainly in Los Angeles and other cities on the west coast. Both Confucius Institutes and King Sejong Institutes have developed in large numbers in Thailand, which is related to the fact that Chinese and Korean are the main foreign languages in public primary and secondary schools in Thailand, especially Chinese has become the second foreign language in Thailand after English.

5. Influencing factors

Based on the cross-sectional data of the number of international language and culture institutes in China and South Korea in 2010 and 2020, combined with the factors and indicators used in existing studies, the study selected dependent variables and independent variables to build a model for the number of institutions in key countries with many Confucius Institutes and King Sejong Institutes. By interpreting the parameters of each model, the factors of spatio-temporal paterns of international language and culture institutes between China and South Korea can be identified and compared.

The 10 countries with the largest number of Confucius Institutes and King Sejong Institutes respectively in 2010 and 2020 were selected, and 24 of them were obtained by deleting duplicates. By estimating the coefficient of each model, the factors of the number of Confucius Institutes and King Sejong Institutes and the total number of institutions are identified. The number of newly added and existing Confucius Institutes and King Sejong

Institutes in key countries from 2010 to 2020 is taken as the dependent variable, and the following four groups of independent variables are selected (Tab.2).

Tab.2 Indicator selection of econometric models

Indicators dimension	Index selection	Index meaning	Variable symbol
Economic factors	Gross domestic product	National economic aggregate	GDP
	Proportion of trade exports	Measure countries' economic extraversion	trade_output
Political factors	Freedom House's score on civil liberties and political power	National politics from the perspective of western countries	poli
	System of distance	The differences between the two countries in the rules, norms and cognition of the system	Poldis_chi, poldis_kor
Sociocultural factor	Cultural distance	Differences in cultural values between the two countries	Culdis_chi, culdis_kor
	Human development index	Measure the social and economic development of each country	HDI
Geographical and demographic factors	The distance between the two capitals	The direct distance between two countries	Chi_dis, kor_dis
	National population	Basic needs for language institutions	pop
	The number of overseas Chinese and Korean overseas Chinese	A critical demand for language institutions	People_chi, people_kor

Based on the existing number of Confucius Institutes and King Sejong Institutes in key countries in 2020 and the change in number of these institutes from 2010 to 2020, four regression models were established by the stepwise regression method. Multicollinearity test results show that as a result of the analysis of the national sample size is less, there is strong explanatory variables multicollinearity, choose the stepwise regression method to establish model, introduced one by one regressor is tested, and the existing filter to eliminate the cause of multicollinearity variables, eventually interpretating the most important variables in the model.Model fitting statistics show that the changes in numbers of Confucius institute and the King Sejong Institutes from 2010 to 2020 and 2020, the total use stepwise regression fit of the model is higher than directly establish regression model, to ultimately keep reducing the number of variables, and the correlation factor model adjusted increased significantly R^2 (Tab.3).

Comparing the model results between Confucius Institute and King Sejong Institute, it can be found that in terms of economic factors, the total number of Confucius Institutes has a significant positive correlation with the GDP of the host country, but the change in the number of Confucius Institutes has a significant negative correlation with GDP from 2010 to 2020, which reflects the strategic shift of the development of Confucius Institutes. China, as an underdeveloped country at the beginning, requires developed countries to recognize its culture. As China's economic strength and international status have been significantly enhanced, it has shifted to attaching more importance to the cultural exchanges between countries along "the Belt and Road" and African countries with close economic and political cooperation with China.There is a positive correlation between the total number of King Sejong Institutes and the proportion of trade exports. There are more national institutions with strong economic extroversion, but there is no significant correlation with the total economic volume of each country.

In terms of political factors, there is a positive correlation between the number of Confucius Institutes and the total number of King Sejong Institutes in each country and the

political distance between China and South Korea.In addition, the total number of King Sejong Institutes is positively correlated with the political status of each country from the western perspective, while the change in the number is negatively correlated with it.Embody the differences both in the system and political situation of the tendency for the further development of countries, suggests that Orient international language and culture institutes have in language and culture as the breakthrough point to reduce the mission of political system differences and disputes, seek common ground while putting aside differences in the international communication and exchanges, to close the ideological differences, seek the role of cultural sharing.

In terms of social and cultural factors, the total number of Confucius Institutes is positively correlated with the human development index, and there are more institutes in countries with higher social and economic development levels. The King Sejong Institutes is negatively related to the cultural distance, which show that King Sejong Institutes tend to construct instates with smaller cultural distance. Based on Asian culture spread outward, King Sejong Institutes ascend the national image, with the popularity of Korean about all things and positive attitude towards South Korea, which can stimulate the countries in the world to consumer products and culture.

In terms of geographical and demographic factors, the establishment of Confucius Institutes is not significantly affected by geographical and national population factors, while the total number of King Sejong Institutes is affected by geographical distance. More institutes are built in neighboring countries, and the number of institutes tends to be allocated according to the total population of the host country. In addition, the total number and number of Confucius Institutes and King Sejong Institutes in different countries are positively correlated with the number of overseas Chinese in the host countries, indicating that overseas Chinese are important service objects of international language and culture institutes.

Tab.3 Estimation results of econometric models

Explanatory variables	Model 1 Changes in the number of Confucius Institutes from 2010 to 2020	Model 2 Total number of Confucius Institutes in 2020	Model 3 Changes in the number of King Sejong Institutes from 2010 to 2020	Model 4 Total number of King Sejong Institutes in 2020
GDP	7.34 e-07***	2.28 e-06***		
trade_outpercent				10.515*
FDI_in_percent			1.504**	
FDI_out_percent	2.276**	1.898*		
poli			0.059**	0.147*
poldis_chi	2.329***			
poldis_kor				4.09349**
culdis_chi				
culdis_kor				1.279*
HDI		63.310**		
chi_dis				
kor_dis				6.779 e-05**
pop			3.98 e-09*	
people_chi	8.06 e-07**	1.40 e-06*		
people_kor			4.18 e-06***	1.020 e-05***
_cons	2.734	44.051	3.472	
Number of obs	19	19	22	22
R^2-adjusted	0.664	0.867	0.830	0.876

*Note: T statistics are in parentheses.*p< 0.1, < 0.05, < 0.01.**p***p*

6. Conclusions

Based on the construction data of Confucius Institutes and King Sejong Institutes in 2010 and 2020, this paper uses mathematical statistics, spatial analysis, and other methods to

describe the spatio-temporal evolution pattern of international language and culture institutes in China and South Korea and uses a regression model to explore the influencing factors of the number of Confucius Institutes and King Sejong Institutes in key countries.

The research indicated that the development of Confucius Institute and King Sejong Institute can be divided into different modes according to the types of domestic and foreign cooperation institutions. Among them, the domestic cooperation institutions of Confucius Institute are all universities, and the cooperation modes of domestic and foreign universities account for the highest proportion. A certain number of specialized Confucius Institutes have been set up based on the academic background of domestic and foreign universities. There are various types of domestic cooperative organizations of King Sejong Institutes, among which the independent operation of Korean cultural centers abroad, cooperation with domestic and foreign universities, and independent operation of foreign universities account for the highest proportion.

The analysis has identified that the number of Confucius Institutes shows the characteristics of "S-shaped growth", and it can be divided into four stages. After experiencing explosive growth, uniform growth and gradually slowing growth rate, the number of Confucius Institutes in all continents has basically reached saturation. King Sejong Institutes is still in the j-type growth stage, and its initial development is relatively slow. The number of institutions has increased significantly after the confirmation of the operating entity. At present, the institutional construction is mainly in Asia and is still in the rapid growth stage, and the number varies greatly among different continents.

From 2010 to 2020, the spatial agglomeration of Confucius Institutes has always been weak, and the structure of Confucius Institutes has changed from a core-periphery structure to a multi-core structure in every continent. The number of institutions along “the Belt and Road” has increased significantly, and the coverage of Confucius Institutes in African countries has increased. The degree of spatial aggregation of King Sejong Institutes has increased significantly, and the development center of King Sejong Institutes has expanded from East Asia to Southeast Asia. In Europe, North America and South America, the core-periphery characteristics have been gradually presented. In Turkey, the United States and Brazil, the number of institutions is high relative to the surrounding countries.The distribution direction of Confucius Institutes in countries along “the Belt and Road” is consistent with the trend of the Silk Road Economic Belt and the Maritime Silk Road, with Bangkok, Minsk, Moscow and Istanbul as the core cities with a large number of institutions.Most Of the Confucius Institutes in Africa are located in Sub-saharan Africa, and most of them have the characteristics of coastal and border areas. The distribution trend is from northeast to southwest, and there are more Confucius Institutes on the west coast. In Southeast Asia, King Sejong Institutes is concentrated in big cities in Vietnam, Indonesia and Thailand, while in Europe, it is distributed evenly in cities, with London, Moscow and Brussels as the focus.In addition, King Sejong Institutes are developing fastest in China and Vietnam, but they have different distribution characteristics.Both Confucius Institute and King Sejong Institutes have a large number of institutions in the United States, but they are located in different cities.

The Confucius institute and the King Sejong Institutes number are positively correlated with the number of overseas host countries, political distance. The number of Confucius institutes is negatively related to the country economy, social culture is related to the level of development. The number of King Sejong Institutes is positively related to country’s economic extroversion and positively related to the population; cultural distance is negatively related to the geographic distance. Both The Confucius Institute and The King Sejong Institute serve the needs of national development and overseas Chinese. The Confucius Institute tends to develop in developing countries with close cooperation with China, while the King Sejong Institutes are mostly built in The Asian cultural circle with similar geography and culture.

This paper takes the diffusion of Oriental language and culture in the world as the research object, takes Confucius Institute and King Sejong Institute as the carriers, makes a comparative analysis of the temporal change and spatial distribution characteristics of the two from the perspective of geography, and explores the main factors influencing the development and construction of Chinese and Korean international language and culture institutes in various countries on this basis. In order to provide a reference for the development of Oriental language and culture dissemination and international language and culture institutes. At present, Confucius Institute is in an important stage of development transformation and strategic adjustment. The cross-sectional data for 2010 and 2020 used in this paper can not fully reveal the transformation. In the future, continuous attention should be paid to their construction and development, and countermeasures should be put forward to address the challenges facing closure in some countries.In addition, we should pay attention to the international language and culture institutes in Japan, India and other eastern countries, and make a comparison with the international language and culture institutes in western countries, to better reveal the similarities and differences between the eastern and western language and culture dissemination.At the same time, the development of the network resources platform and epidemic factors promoted the international language to promote the development of network learning way, face-to-face learning, though still is the international language to promote the main way of teaching, but participates in the international language to promote online courses increased the number of online learning, the international language and culture institute is no longer just rely on an entity space platform, In the future, research on online courses and services provided by international language and culture institutes can be carried out.

References

1. Cai Bifan, Tao Zhuomin, Fang Yelin. 2016.A study on the temporal and spatial differences between inbound tourism and domestic tourism economy in mainland China .China Population, Resources and Environment, 26(S1):297-300.
2. Cao Diefeng.2014.Comparative Analysis of Operation Mode and Decision-Making Mechanism of Language Promotion Organizations in Various Countries.Journal of Social Sciences of Hunan Normal University, 43(01):141-147.
3. Chen Huaichao, Fan Jianhong, Niu Chonghuai.2014.Influence of Institutional Distance on Knowledge Transfer Effect of Chinese Multinational Corporations——The Moderating Effect of International Experience and Social Capital .Research in Science.32(04):593-603.
4. Cheng Mai, Liu Bocheng.2016.An Empirical Study on the Driving Factors of Confucius Institute Development . Education Academic Monthly (06): 31-38.
5. Chen Lei..2011.Interpretation of Confucius Institutes from the Perspective of Intercultural Communication. Nanjing Normal University
6. Confucius Institute Headquarters/Hanban. Confucius Institute Development Plan (2012-2020). Guangming Daily, 2013-02-28(7).
7. Ding Jinhua, Zhou Li.2021. Research on micro-update of tourism-oriented rural public space based on social network model: Taking Mingyuewan Village in Suzhou as an example. Modern Urban Research (12):48-55.
8. Donald Lien and Chang Hoon Oh. 2014.Determinants of the Confucius Institute establishment. Quarterly Review of Economics and Finance.54(3): 437-441
9. Dong Lu.2015. A Comparative Study of the Francophone Alliance and Confucius Institutes. Shenyang Normal University
10. Du Wei.2013. A comparative study on cultural promotion between the Confucius Institute and the Goethe Institute. Zhejiang University

11. Duan Yi.2008.Language-Culture International Promotion and Confucius Institute under the Framework of Hard Power-Soft Power Theory.Fudan Education Forum (02):48-51.
12. Eastment D J.1982.The Policies and Position of the British Council from the Outbreak of War to 1950. University of Leeds.
13. Han Mingjie.2013. The current situation and analysis of Chinese language dissemination in the Confucius Institute in Kyrgyzstan. Xinjiang Normal University
14. He Xiaoqun, Liu Wenqing. 2011.Applied Regression Analysis (Third Edition). Beijing: Renmin University of China Press
15. Jiang Xinxin.2012. A Comparative Study of Chinese and German Language Promotion Institutions. Northwest Normal University
16. Jin K. .2017.A Comparative Study on the Language and Culture Communication Strategies of the Confucius Institute in China and the Sejong Institute in Korea; Harbin Normal University
17. Li Baogui, Liu Jianing.2017. Opportunities and challenges faced by Confucius Institutes in cross-cultural communication under the background of the "One Belt, One Road" strategy. Journal of Xinjiang Normal University (Philosophy and Social Sciences Edition)38(04):148-155.
18. Li Qinzheng.2016. A Comparative Study of the Confucius Institute and the Russian Center. Liaoning Normal University.
19. Liu Jingjing, Wu Yinghui.2020. A comparative study on the educational status of Confucius Institutes and other international language communication institutions (2015-2017). Ethnic Education Research 31(06):126-134.
20. Liu Yang.2020. A Comparative Study on the Operation of Confucius Institutes and Four-Country Language and Culture Communication Institutions . Minzu University of China
21. Liu Ye, Wang Ruoyu, Xue Desheng, Zeng Yuan.2019. The spatial distribution pattern of China's high-skilled labor force and general labor force and its influencing factors. Geographical Research38(08): 1949-1964.
22. Lin Yishuo.2019. Research on the Spatiotemporal Distribution and Influence Mechanism of Confucius Institutes. Northwestern University
23. Qi Jianhong, Yang Li2014.Cultural distance and the choice of entry mode of Chinese enterprises' OFDI——Based on the micro data test of large enterprises.World Economic Research (06):55-61+88-89.
24. Rixon S. 2013.British Council survey of policy and practice in primary English language teaching worldwide.
25. Taylor P M. Cultural Diplomacy and the British Council: 1934-1939. British Journal of International Studies, 1978, 4(3): 244-265.
26. Wang Luman.2014. Current Situation and Development Trend of International Communication of Confucius Institutes. Hunan University.
27. Wang Xinyi.2020. A Comparative Study on the Constitution of Confucius Institutes and International Language and Culture Promotion Organizations. South China University of Technology.
28. Yu Linjuan, Huang Fojun, Zhu Shuangling, Nurbia Abdukyumu.2019. The development process of Confucius Institutes along the "Belt and Road"——Based on the Theory of Cultural Diffusion.Journal of Hubei University of Arts and Sciences40(10) :66-73.
29. Yu Miao.2010.The Mode and Effect of Chinese Language and Culture Promotion from the Confucius Institute.Journal of Wuhan University(Philosophy and Social Sciences Edition)63(06):952-957.

30. Yang Wei, Zhai Fengjie, Guo Hong, Su Juan. 2018.Research on the Effect of Language and Culture Communication of Confucius Institutes in Africa. West Asia and Africa(03):140-160.
31. Zhou Yansong.2014.Language and culture dissemination and model construction of Confucius Institutes of Traditional Chinese Medicine.World Journal of Integrative Medicine (11):1241-1242+1260.

Research on the integration of resource-based theory and transaction cost theory: Taking the relationship between OTA and traditional tourism enterprises as an example

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Abstract. As two classical theories in the field of strategic management, resource-based theory and transaction cost theory, the ultimate purpose is to analyze how enterprises obtain sustainable competitive advantage. Firstly, this paper combs the research progress and knowledge core of the two theories respectively, and points out that the starting point of resource-based theory is to realize the value of resources, while transaction cost theory pursues the cost saving of resource flow. These two theories can be effectively integrated when analyzing the competition and cooperation between enterprises. Further, taking the relationship between online travel service providers (OTAs) and traditional tourism enterprises as an example, this paper discusses the essence of their competition and cooperation, and points out that the key to building a sustainable competition and cooperation relationship between them is to formulate a reasonable value distribution model. This paper helps to further deepen the understanding of the relationship between resource-based theory and transaction cost theory, helps to understand the essence of the competition and cooperation relationship between online and offline tourism enterprises, and has some enlightenment for the research of organizational cooperation.

Key words: Resources; Transaction costs; OTA; Tourism enterprises

Introduction

The electronic distribution of travel information, prices, and availability has opened new channels by which people can reserve travel products. The most notable development is that reservations which used to come through travel agents is now being generated online by individual customers and corporate travel planners who are as likely to use online intermediaries as they are to contact travel agencies directly (Carroll & Siguaw, 2003; Miller, 2004). Traditionally, travel agents have played a key role in providing travel information and highly customized services to customers. Traditional agents can provide customized information by gathering and organizing information unique to their customers' travel needs. Clearly, an online travel agency's (abbreviation as OTA) capability to book all travel services in one transaction is an important feature to attract more potential customers interested in saving time and hassle. As a tourism intermediary organization, OTA connects tourists and traditional tourism enterprises, and together with traditional tourism enterprises forms a cooperation network to provide services for tourism. The two are both partners and competitors, showing a competitive and cooperative relationship (Yang & Zhao, 2020). Competition and cooperation relationship emphasizes that competition and cooperation exist simultaneously in the organizational network, and "cooperation and competition" are not mutually exclusive, but play a role and influence each other. Studies have found that OTA and traditional tourism enterprises show a competition and cooperation relationship. However, in recent years, the channel conflicts and disputes between OTA and traditional tourism enterprises have increased day by day. If handled improperly, it will lead to the disintegration of the potential mutually beneficial relationship between them, thus damaging the interests of tourists (Huang et al., 2019). Therefore, exploring the essence of competition and cooperation

between OTA and traditional tourism enterprises is of great significance to resolve the conflict between them and ensure the healthy development of tourism value chain.

Literature Review

1. Comparative analysis of resource-based theory and transaction cost theory

1.1. Resource based theory

The resource-based view (RBV) has been used to understand the sources of sustained competitive advantages (Zhu & Zhao,2011). It was first put forward by Professor Wernerfelt in 1984, which mainly discussed the usefulness of enterprises from the resource side rather than the product side; He believes that the source for enterprises to obtain competitive advantage is to obtain valuable resources, which are characterized by heterogeneity and impossible mobility (Wernerfelt, 1984). However, as a supplement to Professor Porter's view that enterprises obtain sustainable competitive advantage mainly through product market position, Professor Wernerfelt only looks at the same competition from the perspective of enterprise control resources, that is, the competition between enterprises about product market position can also be regarded as the competition of controlled resource position (Barney & Clark, 2007). Similarly, Rumelt put forward a strategic theory to explore the reasons for the existence of enterprises and the ability to obtain economic rents from the perspective of resources in 1984, and believed that enterprises are a model of multi-level governance, which is more effective in creating and grabbing economic rents than other forms of governance such as markets; It is pointed out that the essence of an enterprise is a bunch of productive resources, and the value of resources lies in their application according to the environment; At the same time, he also emphasized the establishment of "isolation mechanism" of enterprise resources. Consistent with Wernerfelt's cognition, Barney also believes (Barney, 1986) that resources with specific attributes are the source for enterprises to obtain sustainable competitive advantage, especially the strategic factor market, as a place for enterprises to purchase and sell the resources needed to implement their strategies, plays an important role in obtaining economic rents. In the strategic factor market, there are resources that cannot be developed within the enterprise and are urgently needed for competition. The development of these resources often requires proprietary knowledge and rich management capabilities or experience. Therefore, enterprises can only rely on external capabilities to solve their own resource constraints (Chatain, 2014). On the basis of Barney, Dierickx & Cool (1989) believe that key resources are accumulated rather than obtained in the strategic factor market, and the sustainability of enterprise assets depends on the substitutability and imitatability of assets.

In parallel with resource based theory, theories such as core competence, dynamic competence and knowledge base, represented by Prahalad, Teece, Grant and other scholars, have a wide impact on explaining the relationship between enterprise diversification and performance, strategic change in uncertain environments, enterprise innovation and so on. Prahalad & Bettis (1986) discussed the relationship between diversification mode and performance, and put forward a supplementary explanation of the relationship between the two, that is, whether the dominant logic matches the needs of diversification will affect enterprise performance. This is mainly because the dominant logic is a thinking set, a world outlook or the conceptualization of business and management tools, which serves the goals and decisions in business, And this invisible logical foundation is often difficult to imitate. Makadok (2001) believes that capabilities refer to the ability of enterprises to use resources by combining or using organizational processes without achieving the ultimate goal. However, the scope of enterprises' ability to use resources is too broad. Further, Prahalad & Hamel (1990) pointed out the importance of core competence for enterprises to obtain sustainable competitive advantage. Core competence refers to the collective learning ability of enterprises, especially the ability to coordinate diversified production skills and integrate multiple

technology flows. However, with the dynamic changes of the external environment, the resource base will be reconstructed, so the core competence also has a certain timeliness. Based on this, Teece *et al*. (1997) considered enterprise strategy from the dynamic perspective of capability, and believed that dynamic capabilities refer to the ability of enterprises to integrate, build and reconfigure internal and external capabilities to cope with the rapidly changing environment, reflecting the ability of an enterprise to obtain new competitive advantages under the given path dependence and market position. Knowledge is the basis of innovation. Analyzing the transferability mechanism of knowledge inside and outside the enterprise is of great significance for integrating professional knowledge. Taking special resources such as knowledge as the research perspective, a knowledge-based theory has been formed. Grant (1996) believes that enterprises can be conceptualized as a mechanism for integrating knowledge, and establishing a coordination mechanism for knowledge integration is the primary task to achieve good innovation performance, and points out four key mechanisms: Rules and directives, Sequencing, Routines, and Group problem solving and Decision making.

To sum up, we can see that the resource-based theory, enterprise capability theory and knowledge-based theory of enterprise strategic management have the same theoretical logic. Some scholars believe that the concept of enterprise capability and enterprise knowledge are the deepening of resource based theory (Tan, 2003). Barney and Clark (2007) also believe that resources, capabilities, talents and knowledge are the analysis of enterprise attribute characteristics. They are interchangeable and at the same level. At the same time, the theories based on these concepts have the same theoretical framework. Specifically, the resource-based theory mainly evolves in two directions: the first is the further discussion on resource selection, such as the discussion on the transfer attribute of knowledge, which has explicit and implicit characteristics, in the context of innovation, resulting in the knowledge-based theory. The second is the investigation of resource allocation, which mainly analyzes the implementation ability of resources. For example, the enterprise capability theory mainly discusses the impact of specific capabilities owned by different enterprises on competitive advantage under the condition of having the same resources. Further, the gene of the core competence theory is the dominant logic, and the key of the dynamic competence theory is the ability to cope with the dynamic uncertainty environment. In short, the resource attributes discussed in the early development of resource-based theory are relatively broad, and the theoretical defects are mainly reflected in the lack of consideration of situational factors and poor practical operability. The subsequent derivative theory is a further deepening of the theory. For example, enterprise capability theory is a further analysis of resources at the implementation level, knowledge-based theory is the deconstruction of knowledge, a special resource, and dynamic capability theory is formed by considering dynamic uncertain situational factors. Specifically, the evolution and specific relationship of different theories are shown in Figure 1.

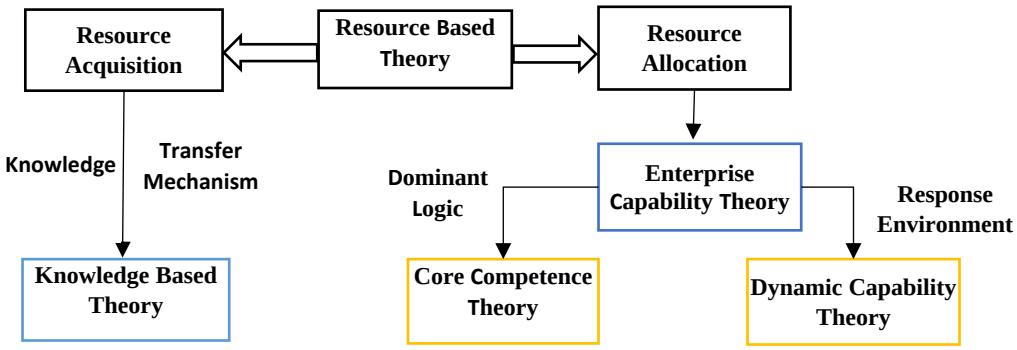

Figure 1. logic of resource-based theory

1.2. Transaction cost theory

The basic problem discussed in transaction cost theory (hereinafter referred to as TCT) is "should we produce or buy", that is, we should choose between "make" and "make or buy" (Williamson, 2002). Coase first explained the reasons for the existence of enterprises from the perspective of transaction costs in his classic paper "the essence of enterprises" in 1937, and believed that the market concerned by neoclassical economics has certain costs (negotiation, signing and other costs) in its operation, resulting in an organization with resources controlled by an authority (an "entrepreneur"). By coordinating and managing activities to allocate resources, transaction costs can be reduced, Therefore, it forms an alternative to the market that allocates resources by price mechanism (Bao,2018). Williamson (1998) believes that an enterprise is a governance structure, and its saving of transaction costs mainly depends on whether the transaction attribute matches this hierarchy governance structure. Specifically, because an enterprise cannot obtain the resources required for production alone or produce goods independently, it needs to sign trade or other types of agreements with other companies to generate transactions, and it is often advantageous to do so. Transactions occur when goods or services are transferred across organizational boundaries, often including conflict, relevance and order (Williamson, 2002). Therefore, when all transactions are regarded as a kind of contract, due to people's bounded rationality and opportunistic behavior, there is often a risk of default for transactions with asset specificity, and the contract is also incomplete, resulting in transaction costs. This kind of transaction cost is mainly manifested in the costs caused by the lack of coordination, refusal to cooperate and renegotiation between the two parties after signing the contract. In order to conclude a contract and maintain its long-term value, it is necessary to have a governance structure that can inject order, transfer conflicts and safeguard common interests after signing the contract.

The choice of governance structure often depends on the degree of asset specificity, transaction frequency and uncertainty. Transaction frequency refers to the number of transactions, which mainly affects the relative transaction cost; Uncertainty includes the uncertainty of accidental events, information asymmetry, prediction and behavior; The degree of asset specificity refers to the extent to which assets can be used for different purposes and used by different users without sacrificing production value (Shen & Zhang, 2013). Williamson (1985) identified four types of asset specificity: site specificity, physical specificity, human specificity and dedicated specificity. Site specificity refers to the highly non current assets reserved to save transportation and inventory costs. Physical specificity refers to the equipment and machinery specially used for this relationship. Human specificity refers to the education and training of human capital or other employees dedicated to this relationship. Specific specificity refers to major investments that are only made for this transaction and have no value outside this transaction. Transactions with high asset specificity, high transaction frequency and high uncertainty belong to a kind of relational contract, which

needs to be governed by hierarchy. Because asset specificity is widespread, it will restrict competition, so it is at the core of transaction governance analysis. In short, due to the existence of asset specificity, opportunistic behavior will occur as long as both parties to the transaction have specific assets, which will have a negative impact on the stability of the formed contract. Therefore, transactions must be managed, designed and implemented by institutional arrangements or contracts between companies. The form of governance structure is often described as existing in the range from the market price (purchase) at one end to the fully integrated (Manufacturing) company at the other end, that is, there is a spot market at one end, a fully integrated company at the other end, and various mixed models in the middle. Specifically, the basic logic of transaction cost theory is shown in Figure 2.

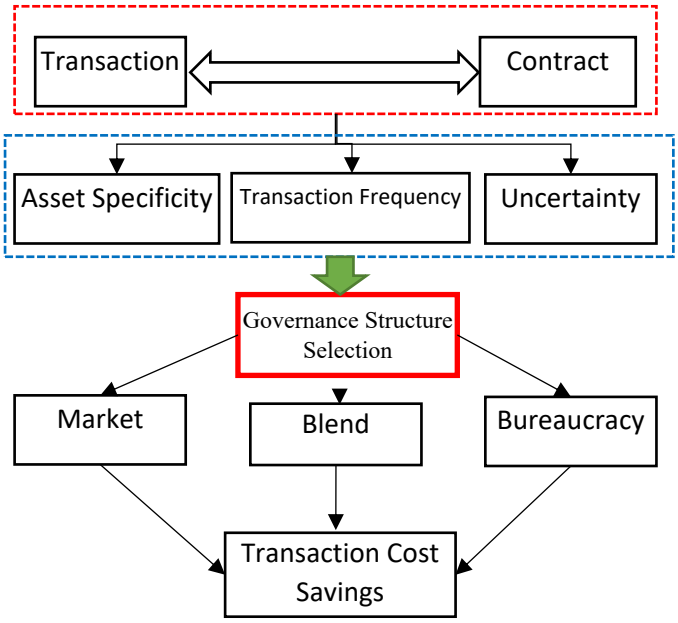

Figure 2 logic of transaction cost theory

Transaction cost theory initially focused on the dichotomy between "manufacturing" and "purchasing". However, recent research has focused on collaborative arrangements, called relationship governance or alliances. Relationship or alliance governance can be more beneficial and practical than other types of governance (such as market failure). In addition, transaction cost research has begun to explore how enterprises adjust their transactions to pursue multiple goals, which is also reflected in the fact that companies often allocate different goals to different organizational units.

1.3. Similarities and differences between the two theories

From the basic logic of resource-based theory and transaction cost theory, the difference between the two is mainly reflected in the different consideration of static income value and dynamic transaction cost of enterprise resources, but the ultimate goal is still to improve the sustainable competitive advantage of enterprises. The resource-based theory regards enterprises as an aggregation of resources. Enterprises obtain competitive advantages that competitors cannot imitate through the characteristics of valuable, scarce, incompletely imitatable, and usable by organizations; The transaction cost theory regards enterprises as the combination of various contracts. Enterprises mainly reduce the transaction costs in the process of resource utilization through effective control of transaction costs and various good institutional arrangements (Bao, 2018). It can be found that resource-based theory and transaction cost theory reflect the static value and dynamic value of resources respectively. The former mainly focuses on the benefits brought by the heterogeneity and illiquidity of internal resources, while the latter is based on how to reduce the increase of transaction costs

caused by the liquidity of resources. Therefore, using resource-based theory and transaction cost theory to analyze from the perspective of income and cost has become an effective analytical basis in the research of cross organizational cooperation (breaking through the boundary of a single enterprise). For example, Lu & Li (2006) believe that resource-based theory and transaction cost theory can complement and integrate in the research of Cross organization cooperation. It is indispensable to analyze the value creation of Cross organization cooperation from the two aspects of resource rent and cooperation cost. Zhang & Wang (2019) analyzed the R & D consortium from the perspective of resource-based theory and transaction cost theory, and believed that cooperative R & D can be analyzed from the perspective of value creation strategy of minimizing production costs and transaction costs, and implementing differentiation, with the ultimate purpose of establishing competitive advantage (profit).

In short, both theories are to analyze how to make enterprises obtain sustainable competitive advantage, and the research scope mainly focuses on a single enterprise, that is, to analyze the acquisition of resource rent or the saving of transaction costs. Therefore, when breaking through the boundary of a single enterprise, that is, the cooperation analysis between multiple organizations, we should discuss from two aspects: resource income and cooperation cost, which can draw a more objective conclusion. Madhok & Tallman (1998) believe that the transaction costs generated in the process of resource exchange are interdependent with the nature of the resources to be traded. The reason is that valuable assets are embedded in a larger and endogenous institutional environment, forming a system of resource relations. Therefore, combining transaction cost theory and resource-based theory, we can get more powerful insights in the formation, management and instability analysis of cooperation.

2. Analysis of the relationship between OTA and traditional tourism enterprises

2.1. Definition and characteristics of traditional tourism enterprises and OTA

Traditional tourism enterprises refer to tourism enterprises that use traditional technical means, adopt traditional management concepts, and provide traditional tourism products and services, including traditional travel agencies, accommodation enterprises, transportation enterprises, scenic spot enterprises, tourism commodity enterprises, etc. Traditional tourism enterprises mainly provide conventional tourism products and services, which are mainly reflected in the six elements of tourism. Based on the resource-based view, traditional tourism enterprises are composed of "resources + capabilities", and the types of resources are composed of tourism resources, asset investment, human resources, technology, information, etc. while the ability elements include the integration ability of internal and external resources, which requires enterprises to have decision-making power, support power and execution power. The characteristics of traditional tourism enterprises are: narrow business scope, conservative management, single profit model, weak human resources, slow technological renewal, and low added value of products and services.

OTA refers to a tourism start-up enterprise that provides tourism information sharing and search, tourism product reservation and other services to tourists through the Internet for the purpose of making profits. Sheng (2019) believes that OTA is an intermediary that provides online consultation, comment, reservation and other services based on the Internet platform. It can provide tourists with a cheap and efficient package of tourism solutions mainly by integrating existing tourism products and information and reducing transaction costs. OTA will not own any offline entities such as hotels, but has a lot of hotel information, price comparisons, discounts and reviews to attract tourists Chang *et al.*, (2018) . Yin *et al.*, (2019) believed that OTA rose in the United States in the 1990s and quickly gained the global tourism market mainly through the improvement of information technology foundation and business model. Unlike offline channels, online tourism channels, as a powerful platform, can provide

tourists with a variety of tourism related information search services to facilitate their purchase of products or services. Although traditional tourism enterprises have also built direct selling websites, because OTA integrates all tourism services, it can provide online users with a full range of travel packages, such as one-time air tickets, hotels, car rental, scenic spot tickets and other services, and tourists' clothing, food, housing, transportation and play are integrated into a unified channel, thus maximizing the savings of travel time and transaction costs. In addition, OTA is more beautiful and smooth in the page setup and transaction process of tourism websites, which can often maximize the attention resources of tourists. Therefore, due to its technological advantages, OTA has more competitive advantages than traditional tourism enterprises in the Internet channel. Traditional tourism enterprises value assets while modern tourism enterprises value assets less.

2.2. Evolution of dynamic relationship between OTA and traditional tourism & hotel enterprises

2.2.1. The relationship between OTA and traditional tourism enterprises

The progress of new technology, especially information technology, has fundamentally changed the supply chain of tourism (Zhang *et al.*, 2009). In the 1990s, OTA quickly occupied an important share in the global tourism market with its information technology infrastructure and business model (Yin *et al.*, 2019), and also became an important part of the tourism supply chain. The appearance of platform enables tourists to browse the information of tourism products directly by clicking the mouse and other operations, understand the price and inventory of travel product suppliers in real time, and realize the online reservation and purchase of tourism products, so as to integrate scattered tourism resources and provide tourists with a set of customized services, which greatly improves the consumption utility of tourists. However, the OTA platform still cannot open traditional tourism enterprises, and traditional tourism enterprises also need OTAs. On the one hand, OTA platform can find the service pain points in the tourism industry, which is mainly driven by technological progress, but its service foundation is still based on the resources owned by traditional tourism enterprises. On the other hand, due to the limitations of their own dominant logic, traditional tourism enterprises need to use OTA to realize the effective allocation of resources, so as to obtain greater rental income. Although the cooperation between traditional tourism enterprises and OTAs can realize the optimal allocation of resources to a certain extent, due to the cooperation that breaks through organizational boundaries, there are extensive transaction costs, resulting in frequent conflicts of interest. Due to the dynamic changes of capabilities, conflicts of interest tend to be amplified, mainly due to the scarcity of resources. Therefore, from this perspective, traditional tourism enterprises and OTA show a competitive and cooperative relationship.

2.2.2 The relationship between OTA and hotel enterprises

OTAs and hotels cooperate and compete with each other simultaneously in multichannel environments. OTA websites help to introduce new customers to hotels, and hotels provide information to enrich OTA websites. However, because OTAs force hotels to provide deep discounts and charge a hefty commission for each referred customer, hotel managers hope that returning customers book their future visits directly through hotel websites instead of OTA websites. Thus, hotels offer valuable packages to attract customers to use hotel booking services. The two channels cooperate to introduce new customers to hotels, but compete with each other for returning customers. With the development of e-commerce, business practices have gradually turned away from purely online channels to the integration of online and offline channels, termed the O2O mode. Online and offline channels can cooperate with each other to attract new customers, yet they may also compete with each other for returning customers. Hotels are highly dependent on OTAs to increase the hotel's occupancy rate and have limited

bargaining power over booking fees charged by OTAs. Thus, hotels have intensified their online presence through web direct sales to compete with OTAs. This has resulted in channel conflicts and disputes between hotels and OTAs became increasingly public in recent years (Law *et al.*, 2015; Lee *et al.*, 2013; Yang & Leung, 2018).

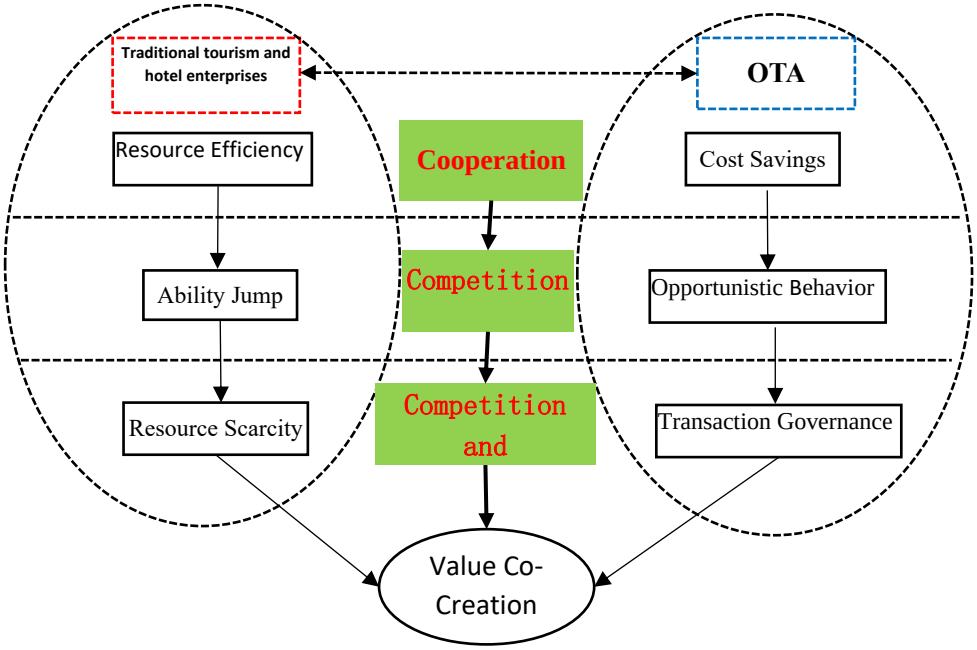

Figure 3 Dynamic evolution of the relationship between traditional tourism & hotel

Conclusion

The rapid development of Internet technology has broken the inherent interests formed by the dominant logic of traditional tourism enterprises and hotel enterprises, that is, with the popularization and application of Internet technology, consumers will more often book services in advance through online APPs, which makes OTAs participate in the distribution of resource value of traditional tourism enterprises and Hotel enterprises, and on the one hand, activates the rigid resource value of traditional tourism enterprises, On the other hand, it also needs to pay a certain commission fee to OTA. However, as OTA is embedded in the traditional tourism and hotel value chain and gradually takes a dominant position in the distribution channels of tourism products, its value conflicts with traditional tourism enterprises and hotel enterprises are also gradually increasing. Therefore, how to develop the strategic relationship between OTA and traditional tourism enterprises and hotel enterprises is of great significance for the sustainable development of tourism value chain. This paper discusses the competition and cooperation relationship between OTA and traditional tourism enterprises and hotel enterprises, which is embodied in the maximization of resource value and the minimization of transaction costs. For the construction of tourism value chain, it also means that the competition between OTA and traditional tourism enterprises and hotel enterprises lies in the competition for resource value, while the cooperation is reflected in the reduction of transaction costs. Therefore, to build a reasonable value distribution model, we can increase the cooperation between OTA and traditional tourism enterprises and hotel enterprises, so as to form value co creation, reduce the occurrence of behaviors that damage tourists, and ensure the effective operation of the tourism value chain. For example, there is an online and offline multi-channel sales model for hotel rooms, which can coordinate with OTA and design the best reservation of guest rooms on an official website, so as to complete the reasonable value distribution with OTA and maximize the value of resources in this way.

In addition, the relationship between OTA and traditional tourism enterprises should be understood from two aspects: cooperation and competition. From the perspective of cooperation, OTA's service quality helps introduce new customers to traditional tourism enterprises. After customers visited traditional tourism enterprises, their experience of traditional tourism enterprise services increased their intention to re book hotels through OTA . From the perspective of competition, customers' perception of OTA website service quality and their willingness to book traditional tourism enterprise services through OTA websites have a substitution effect on their willingness to book services through traditional tourism enterprise websites. Traditional tourism enterprises and hotel enterprises can attract repeat customers by improving the perceived value of their reservation services, while OTA can compete for repeat customers by improving the service quality of the website.

References

1. Barney, J. B. (1986). Strategic factor markets: Expectations, luck, and business strategy. *Management science*, *32*(10), 1231-1241.
2. Barney, J. B., & Clark, D. N. (2007). *Resource-based theory: Creating and sustaining competitive advantage*. OUP Oxford.
3. Carroll, B., & Siguaw, J. (2003). The evolution of electronic distribution: Effects on hotels and intermediaries. *Cornell Hotel and Restaurant Administration Quarterly*, *44*(4), 38-50.
4. Chang, Y. W., Hsu, P. Y., & Yang, Q. M. (2018). Integration of online and offline channels: a view of O2O commerce. *Internet Research*.
5. Chang, Y. W., Hsu, P. Y., & Lan, Y. C. (2019). Cooperation and competition between online travel agencies and hotels. *Tourism Management*, *71*, 187-196.
6. Chatain, O. (2014). How do strategic factor markets respond to rivalry in the product market?. *Strategic Management Journal*, *35*(13), 1952-1971.
7. Dierickx, I., & Cool, K. (1989). Asset stock accumulation and sustainability of competitive advantage. *Management science*, *35*(12), 1504-1511.
8. Grant, R. M. (1996). Toward a knowledge-based theory of the firm. *Strategic management journal*, *17*(S2), 109-122.
9. Huang Yin, C., Goh, E., & Law, R. (2019). Developing inter-organizational relationships with online travel agencies (OTAs) and the hotel industry. *Journal of Travel & Tourism Marketing*, *36*(4), 428-442.
10. Kim, D. J., Kim, W. G., & Han, J. S. (2007). A perceptual mapping of online travel agencies and preference attributes. *Tourism management*, *28*(2), 591-603.
11. *Law, R., Leung, R., Lo, A., Leung, D., & Fong, L. H. N. (2015). Distribution channel in hospitality and tourism: Revisiting disintermediation from the perspectives of hotels and travel agencies. International Journal of Contemporary Hospitality Management, 27(3), 431-452.*
12. *Lee, H. A., Denizci Guillet, B., & Law, R. (2013). An examination of the relationship between online travel agents and hotels: A case study of Choice Hotels International and Expedia. com. Cornell Hospitality Quarterly, 54(1), 95-107.*
13. Madhok, A., & Tallman, S. B. (1998). Resources, transactions and rents: Managing value through interfirm collaborative relationships. *Organization science*, *9*(3), 326-339.
14. Makadok, R. (2001). Toward a synthesis of the resource-based and dynamic-capability views of rent creation. *Strategic management journal*, *22*(5), 387-401.
15. Miller, B. (2004). Building e-loyalty of lodging brands: avoiding brand erosion. *Journal of Travel & Tourism Marketing*, *17*(2/3), 133-142.
16. Prahaland, C. K., & Hamel, G. (1990). The core competence of the corporation.
17. Prahalad, C. K., & Bettis, R. A. (1986). The dominant logic: A new linkage between diversity and performance. *Strategic management journal*, *7*(6), 485-501.

18. Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic management journal*, *18*(7), 509-533.
19. Wernerfelt, B. (1984). A resource-based view of the firm. *Strategic management journal*, *5*(2), 171-180.
20. Williamson, O. (1985). Williamson OE The Economic Institutions of Capitalism.
21. Williamson, O. E. (1998). The institutions of governance. *The American Economic Review*, *88*(2), 75-79.
22. Williamson, O. E. (2002). The theory of the firm as governance structure: from choice to contract. *Journal of economic perspectives*, *16*(3), 171-195.
23. Yang, Y., & Leung, X. Y. (2018). A better last-minute hotel deal via app? Cross-channel price disparities between HotelTonight and OTAs. *Tourism Management*, *68*, 198-209.
24. Zhu, Z., & Zhao, J. (2011). The sources of e-business competitive advantages between travel agencies and online travel service firms in China. *International Journal of Information Systems and Change Management*, *5*(2), 160-179.
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Research on the Spatial-temporal Coupling Mechanism of Economic Resilience and High-quality Economic Development in the Urban Agglomeration in the Middle Reaches of the Yangtze River

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Abstract. Exploring the coupling and coordination mechanism of economic resilience and high-quality development might help make economies more resilient to external shocks and promote more sustainable economic growth. In order to analyze the spatial and temporal patterns, synergistic relationships, and coupling mechanisms of economic resilience and high-quality economic development in the urban agglomeration in the middle reaches of the Yangtze River from 2010 to 2019, this paper employs the entropy value method, coupled coordination model, and geographic detector. The results show that: (1) overall, the economic resilience and high-quality economic development of the urban agglomeration in the middle reaches of the Yangtze River show an increasing trend, and the spatial clustering characteristics of Wuhan, Changsha, and Nanchang as the core are significant; (2) the coupling and coordination of regional economic resilience and high-quality economic development is increasing, indicating a "center-edge" pattern with Wuhan, Changsha, and Nanchang at the core; (3) economic recovery > resistance > evolution in the driving role of coupling coordination degree, among the five subsystems of economic quality development, innovation, and inclusiveness integrated driving coupling coordination degree, coordination, green, and open subsystem driving role is not significant; the interaction of each factor shows complementary enhancement effect and double factor enhancement effect.

Key words: the urban agglomeration in the middle reaches of the Yangtze River; economic resilience; high-quality economic development; coupling mechanism

1. Introduction

The 19th Communist Party of China National Congress declared that China's economy has shifted to the stage of high-quality development, and the 2018 Central Economic Work Conference proposed specific requirements for achieving high-quality economic development, indicating the direction of high-quality economic development in China. The connotation of high-quality economic development in the new period is a shift from "total expansion" to "structural optimization", from "growth speed" to "quality of development", and from "whether there is" to "good." [1]. At the same time, the world is experiencing an increase in insecurity and uncertainty, and achieving high-quality development in the new era by strengthening economic resilience and resolving potential large-scale emergencies has become the top priority. However, the relationship between economic resilience and economic high quality is still in its infancy, and more research is needed to determine how economic resilience can contribute to economic high-quality development. As a result, in the current complex and changing international and domestic situation, it is critical to conduct research on the relationship between "resilience" and "high-quality" development, and to build a policy system that is conducive to enhancing economic resilience and promoting high-quality development on this basis. It is extremely important in practice.

There are few research findings, both domestic and international, on how to quantify the relationship between economic resilience and high-quality development. Foreign scholars' research does not focus on high-quality economic development, but rather on the evolution

mechanism of resilient regions[2-5], regional economic resilience assessment[6-9], and resilient regional development practice[10-13]. Domestic scholars have begun to pay attention in recent years, with Sun Hui and Yuan Weipeng[14]taking the western region as a research object and demonstrating that economic resilience has a significant contribution to high-quality economic development in the short term, while the two have a causal link in the long term; Guan Changling and Zhang Jitong[15]taking the Yangtze River Delta region as an example and discovering that economic resilience can contribute to high-quality economic development. Overall, the preceding studies use panel models to examine the role of economic resilience in promoting high-quality development, but they lack in-depth analysis of the mechanism and driving factors of the coupling and coordination of the two, making it impossible to optimize the coupling and coordination of the two in a targeted manner. As a result, further empirical research is required.

The study of the coupling mechanism between economic resilience and high-quality development is of great significance to promote coordinated regional development [16-17]. The deadline is February 2022 "As one of the important strategies to support the development of the urban agglomeration in the middle reaches of the Yangtze River as "an important growth pole of national high-quality development," the " *implementation plan for the development of the urban agglomerations in the middle reaches of the Yangtze River during the 14th Five-Year Plan* " proposed to "comprehensively enhance the resilience of urban development and risk prevention and control capability." This is one of the critical strategies for assisting the development of the urban agglomeration in the middle reaches of the Yangtze River "an important growth pole for high-quality national development.

A resilient economic system is essential for comprehensive high-quality economic development, and improving economic resilience emphasizes the economic system's ability to cope with external shocks by regulating itself and to achieve a better state by forging new development paths. As a result, using panel data from 28 prefecture-level cities in the urban agglomeration in the middle reaches of the Yangtze River from 2010 to 2019, this paper analyzes the coupling and coordination relationship between the two using the entropy value method, coupling and coordination model, and geographic detector to provide a reference for the path selection and policy formulation of high-quality economic development in the urban agglomeration in the middle reaches of the Yangtze River in the central region. The study of the economic development of urban agglomerations in the central region is complementary.

2. Materials and methods

2.1 Methods

2.2.1. Entropy method

In this paper, we first standardized the original data, then assigned weights using the entropy method, and finally use the multi-objective weighted summation method to calculate the comprehensive evaluation value of economic resilience and the level of high-quality economic development of 28 prefecture-level cities in the urban agglomeration in the middle reaches of the Yangtze River, as shown below.

$$P_{hi} = \sum_{j=1}^{z} Y_{hij} \times W_j \quad (1)$$

Where P_{hi} is the composite score of economic resilience and economic quality development level, Y_{hij} and W_j are the indicators and their respective weights after standardization.

2.2.2. Coupling coordination degree model

Because of its applicability, the concept of "coupling" as a physical concept is used in a variety of research fields [18]. The coupling phenomenon is the interaction and influence of two or more systems, and it is often characterized by the coupling degree (C) [19]. The coupling degree model is improved, and the coupling coordination degree model (D) is built to reflect whether the elements have a good co-development relationship. The phrase is as follows.

$$C = \left[\frac{Y_1 \times Y_2}{[(Y_1 + Y_2)/2]^2}\right]^{\frac{1}{2}} \quad (2)$$

$$D = \sqrt{C \times T} \quad T = \alpha Y_1 + \beta Y_2 \quad (3)$$

The α and β in the formula are generally taken as 0.5[20-21], and Y_1 and Y_2 are the comprehensive indices of economic resilience and high-quality economic development, respectively. This paper drew on the research results of Ma Yaofeng and other scholars[22-23] and used the "0.1 cut-off point method" to classify them into 10 levels.

Tab 1. Classification of coupling coordination levels

Value of D	Degree	Value of D	Degree
0.0000—0.1000	Extreme incoordination	0.5001—0.6000	Reluctant coordination
0.1001—0.2000	Severe incoordination	0.6001—0.7000	Primary coordination
0.2001—0.3000	Intermediate incoordination	0.7001—0.8000	Intermediate coordination
0.3001—0.4000	Mild incoordination	0.8001—0.9000	Favorable coordination
0.4001—0.5000	Basic incoordination	0.9001—1.0000	Quality coordination

2.2.3. Geographical detectors

The geographical detector is a statistical method for detecting spatial heterogeneity in geographical things and elucidating their driving factors [24]. With the following equation, this method is used in this paper to investigate the driving factors that influence the degree of coupled coordination between economic resilience and high-quality development.

$$q = 1 - \frac{\sum_{h=1}^{L} N_h \sigma_h^2}{N\sigma^2} = 1 - \frac{SSW}{SST} \ (h = 1,2,3 \ldots L) \quad (4)$$

Where q ranges from [0-1], and the greater the value, the greater the explanatory power of the driver for the coupling and coordination of economic resilience and high-quality development; Each indicator factor's stratification is represented by h. N_h and N are the sample sizes for stratum h and the entire region, respectively; σ_h^2 and σ^2 are the variances for stratum h and the entire region, respectively.

2.2 Model building

2.2.1 Study area and data source

The urban agglomeration in the middle reaches of the Yangtze River is a regional center composed of three major metropolitan areas, namely Wuhan urban agglomeration, Changzhutan urban agglomeration, and Poyang Lake urban agglomeration, with a scope that includes 28 prefecture-level cities in Hubei, Hunan, and Jiangxi provinces. In this paper, Fuzhou City and Ji'an City of Jiangxi Province as a whole are included in the scope of the study, including 28 prefecture-level cities in Hubei, Hunan, and Jiangxi provinces, based on the planning scope of the Yangtze River Midstream Urban Agglomeration Development Plan and considering the completeness of data. Panel data from 28 prefecture-level cities in the urban agglomeration in the middle reaches of the Yangtze River were used as sample data

from 2010 to 2019, and the data were obtained from the 2011-2020 China Urban Statistical Yearbook, the Statistical Yearbook of each province and city, and the statistical bulletin, and missing data were made up using the mean method or interpolation method.

2.2.2 Construction of the indicator system

Under the economic complex system's synergy, resilience, and high-quality interact to promote the economy's synergistic and sustainable evolutionary development. As a result, there are two layers of system synergy in this study's evaluation of the relationship between economic resilience and high-quality economic development: The first layer is the synergistic development of the resilient system and the high-quality development system, which comprise the sustainable economic development; the second layer is the respective synergistic system of the resilient system and the high-quality development system. The second layer is a synergistic system comprised of resilient and high-quality development systems.

Briguglio et al[6]built a national economic resilience index evaluation system with 86 countries (regions) as research objects for measuring economic resilience; Oxborrow et al[7] analyzed the Middle East's economic resilience using interviews and questionnaires. From 2006 to 2015, Mingdou Zhang and Xiaoqing Feng[8]measured the economic toughness of 30 Chinese provinces using four indicators such as fiscal revenue and the amount of actual foreign capital used; Equality Zhang[9]established an indicator system to compare the economic toughness of China and other countries in two aspects: market efficiency and government efficiency. Economic resilience influencing factors now include industrial structure, urbanization, social capital, cultural factors, and so on. The conventional wisdom holds that industrial structure is the most important factor influencing economic resilience[25-26]. Economic resilience is defined in this paper as an inherent property of the system that is reflected by a combination of resistance that can maintain its stability after a shock, recovery that can return to its original growth posture, and evolution that can transform and develop by relying on its endowments. Furthermore, the evaluation system of economic resilience is based on three dimensions of resistance, recovery, and evolution [27]. As shown in Table 2, the development of specific indicators is based on relevant studies by Xin Qi et al[28] and Ding et al[29]. The Herfindahl- Hirschman Index (HHI) measures industrial structural diversity; the higher the HHI index, the lower the industrial diversity, as calculated below.

$$HHI = \sum_{i=1}^{N} \left(\frac{X_i}{X}\right)^2 = \sum_{i=1}^{N} S_i^2$$

Where N=3, X_i, X, and S_i represent the output value of industry I regional GDP, and the proportion of industry I output value to regional GDP, respectively.

Tab.2 Comprehensive evaluation index system of economic resilience

Target	Guideline	Indicators	Explanation of indicators
Level of economic resilience development	Resistance	GDP(+)	GDP (billion yuan)
		Urban Per Capita Disposable Income (+)	Per capita disposable income of urban residents (yuan)
		Savings Balance of Urban and Rural residents (+)	Savings balance of urban and rural residents (billion yuan)
		HHI(-)	Herfindahl- Hirschman Index
		Actual level of foreign capital utilization (-)	Actual utilization of foreign capital (billion yuan)
		Urban registered unemployment rate (-)	Regional unemployment rate level (%)
	Recovery	Fiscal self-sufficiency level (+)	Local fiscal revenue / local fiscal expenditure (%)
		Local fiscal expenditure (+)	Local government resource deployment capacity (billion yuan)

		Total retail sales of social consumer goods (+)	Regional market size (billion yuan)
	Evolution	Urbanization rate (+)	Urban resident population/total resident population (%)
		Financial education expenditure intensity (+)	Local fiscal expenditure on education/local fiscal expenditure (%)
		Number of patents granted per 10,000 people (+)	Number of patents granted/total resident population (items/million)
		Scientific research investment intensity (+)	R&D expenditure/regional GDP (%)

Note: In the table, "+" indicates that the indicator is positive and "-" indicates that the indicator is negative, as in Table 2.

The total factor productivity of the economy is frequently used to measure high-quality economic development [30-31]. However, single indicator measurement, such as total factor productivity, has limitations and cannot provide objective and comprehensive evaluation results. As a result, an increasing number of academics are developing a comprehensive index system to assess high-quality economic development. Ma Ru et al[32] assessed the level of regional high-quality development across five dimensions: supply, demand, efficiency, operation, and openness. Li Jinchang et al[33] developed an evaluation system that considers five factors: economic vitality, innovation efficiency, green development, people's lives, and social harmony. Liu Rui et al [34] assessed Northeast China's economic development from the standpoint of the new development concept. This paper draws on relevant studies[35-36] to construct an evaluation index system for the high-quality economic development of the urban agglomeration in the middle reaches of the Yangtze River based on the new development concept, as shown in Table 3.

Tab.3. Comprehensive evaluation index system of high-quality economic development

Target	Guideline	Indicators	Explanation of indicators
Level of High-quality Economic Development	Innovative Development	patents applications granted(+)	Total number of patents granted (items)
		Investment in R&D personnel (+)	Total number of R&D personnel (10,000)
		Fiscal expenditure intensity on science and technology (+)	Local fiscal expenditure on science and technology / local fiscal expenditure (%)
	Coordinated Development	Industrial structure rationalization index（-）	Industry Theil index
		Index of advanced industrial structure (+)	Proportion of output value of primary industry×1+Proportion of output value of secondary industry×2+Proportion of output value of tertiary industry×3
		Urban-rural income ratio (-)	Per capita disposable income of urban residents/per capita disposable income of rural residents
		Urban-rural consumption ratio (-)	Per capita consumption expenditure of urban residents/per capita consumption expenditure of rural residents
	Green Development	Greening coverage of built-up areas (+)	Greening coverage rate of built-up areas (%)
		Wastewater emissions per unit GDP (-)	Total wastewater discharge/GDP (million tons/billion yuan)
		Emission of waste gas per unit of GDP (-)	Industrial SO2 emissions/GDP (tons/billion yuan)
		General solid waste comprehensive utilization rate (-)	General industrial solid waste comprehensive utilization / (general solid waste generation + comprehensive

			utilization of previous years storage) (%)
	Open Development	Foreign trade dependence (+)	Total imports and exports / regional GDP (%)
		Intensity of foreign capital utilization (+)	Amount of actual utilization of foreign capital / regional GDP (%)
		Trade balance (+)	Export volume - import volume (billion yuan)
	Inclusive Development	Number of general colleges and universities (+)	Number of general colleges and universities (%)
		Number of hospital beds per 10,000 people (+)	Number of hospital beds/total resident population (sheets/million)
		Number of urban basic pension insurance participants (+)	Number of urban basic pension insurance participants (10,000 people)

3. Results

3.1. Comprehensive evaluation of time and space

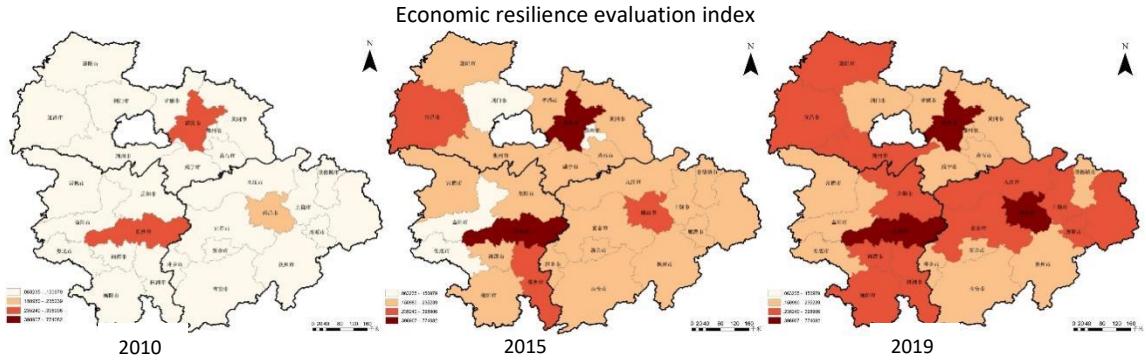
From 2010 to 2019, the entropy value method is used to calculate the scores of economic resilience and high-quality economic development of 28 prefecture-level cities in the urban agglomeration in the middle reaches of the Yangtze River, and the ArcGIS software is used to divide the evaluation index into four levels (from low to high, low-value area, low-value area, high-value area, and high-value area), and to plot the economic resilience and high-quality economic development. Figure 1 depicts the spatio-temporal pattern of the city group's high-quality level and economic resilience in the middle reaches of the Yangtze River to reflect the characteristics of the temporal evolution and spatial divergence of the overall economic resilience level and the high-quality economic development level of the urban agglomeration.

From 2010 to 2019, the percentage of cities with economic toughness in the medium-high value zone or higher increased from 7.14% to 50%, and economic toughness increased significantly. In particular, the average level of economic toughness in 2015 increased by 78.88% when compared to 2010. Hubei, Hunan, and Jiangxi provinces have been actively cooperating since the signing of the "Framework Agreement on Strategic Cooperation to Accelerate the Construction of Urban Agglomerations in the Middle Reach of the Yangtze River" in early 2012, and have signed the *Wuhan Consensus*, the *Changsha Declaration*, and the *Nanchang Action*. This has resulted in widespread agreement in many areas, including transportation, tourism, economic development, and infrastructure construction, and has strengthened extensive cooperation from the government to the social level. With a slower growth rate, the average economic resilience level in 2019 is 36.30 percent higher than in 2015. The State Council formally approved the Development Plan for the Midstream Yangtze River Urban Agglomeration in March 2015, which has been instrumental in increasing economic resilience and has played a significant role in promoting the overall average value to the medium-high value level in 2017. The distribution of Wuhan, Changsha, and Nanchang characterizes the economic resilience of the he urban agglomeration in the middle reaches of the Yangtze River. This is related not only to Jiangxi Province's natural conditions, but also to strategic initiatives undertaken by its government departments, such as the integration of Nanchang and Jiujiang.

From 2010 to 2019, the percentage of cities with economic toughness reaching the medium-high value zone and above has increased from 7.14% to 50%, and economic toughness has increased significantly. Specifically, the average economic toughness level in 2015 increased by 78.88% compared to 2010. Since the signing of the "Framework Agreement on Strategic Cooperation to Accelerate the Construction of Urban Agglomerations in the Middle Reach of Yangtze River" by Hubei, Hunan, and Jiangxi provinces in early 2012, they have been actively cooperating and have signed the Wuhan Consensus, the Changsha

Declaration, and the Nanchang Action. This has led to a broad consensus in many aspects such as transportation, tourism, economic development, and infrastructure construction, and has continued to strengthen extensive cooperation from the government to the social level. The average economic resilience level in 2019 is 36.30% higher than that in 2015, with a slower growth rate. In March 2015, the State Council formally approved the Development Plan for the Midstream Yangtze River Urban Agglomeration, which has been instrumental in enhancing the economic resilience level and has played a huge role in promoting the overall average value to reach the medium-high value level in 2017. Spatially, the economic resilience of the urban agglomeration in the middle reaches of the Yangtze River is characterized by the distribution of Wuhan, Changsha, and Nanchang. This is not only related to the natural conditions of Jiangxi Province but also closely related to the strategic initiatives taken by its government departments, such as the integration of Nanchang and Jiujiang.

From 2010 to 2019, in the urban agglomeration in the middle reaches of the Yangtze River, the percentage of cities in the low-value zone of economic high-quality development level decreased from 85.71 percent to 25 percent, and the cities in the medium-high value and above were Wuhan, Changsha, and Nanchang, and the level of economic high-quality development was generally improved. Between 2010 and 2015, the urban agglomeration in the middle reaches of the Yangtze River's economic resilience increased, as did the level of high-quality economic development. Despite the impact of the 2008 international financial crisis on the economic development of Hubei, Hunan, and Jiangxi provinces, the state's series of plans shifted investment to the central and western regions, bringing more development opportunities to the region and promoting urban economic growth. From 2015 to 2019, the level of high-quality economic development in the urban agglomeration in the middle reaches of the Yangtze River remained stable. Hubei, Hunan, and Jiangxi provinces have been implementing an innovation and rise strategy with supply-side structural reform as the main line to drive high-quality economic development since the 18th National Congress. The level of economic quality development and economic resilience in the urban agglomeration in the middle reaches of the Yangtze River is similar in terms of spatial distribution, exhibiting the spatial distribution characteristics of Wuhan, Changsha, and Nanchang. Simultaneously, a large number of low-value or low-value areas are located in their vicinity, which is due to the provincial capital cities' siphoning effect on the high-quality factors of the surrounding cities due to their advantageous conditions, forming depressions around them. In comparison, the level of high-quality economic development in the Yangtze River urban agglomeration lags economic resilience. The economic system, as well as environmental protection and social security, are all considered when determining the level of high-quality economic development. The urban agglomeration in the middle reaches of the Yangtze River is rich in arable land, water resources, and mineral resources, which has resulted in the full development of related resource-based industries, the increasing concentration of key industrial bases, and the gradual expansion of development scale over the last decade or so.



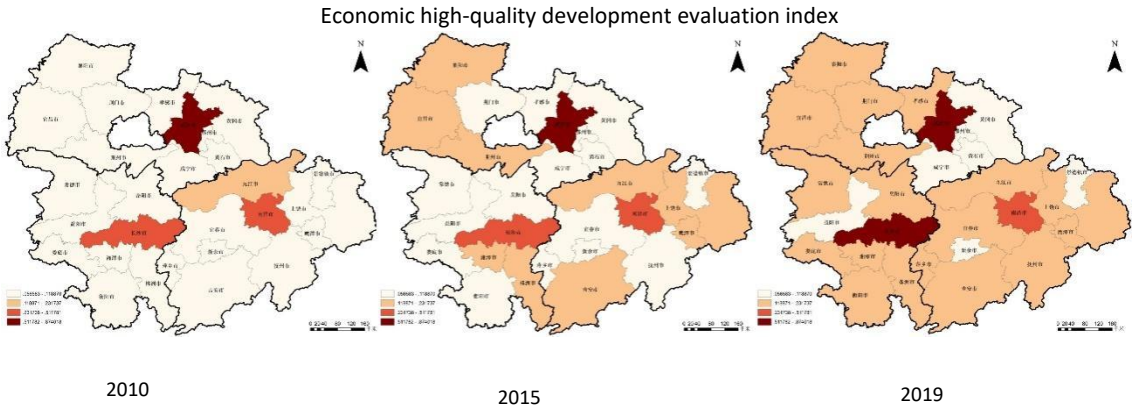


Fig.1. Spatio-temporal evolution of economic resilience and high-quality development in the urban agglomeration in the middle reaches of the Yangtze River

3.2. Coupling relationship analysis

3.2.1. Time-series variation of the coupling relationship

Figure 2 depicts the coupling and coordination of the urban agglomeration in the middle reaches of the Yangtze River as a whole and each sub-city group's economic resilience and high-quality economic development. The urban agglomeration in the middle reaches of the Yangtze River has the fastest growing coupling and coordination level, reaching near disorder in 2015; the coupling and coordination level of Wuhan Urban Agglomeration is essentially synchronized with the Yangtze River Central River Urban Agglomeration as a whole, ranging from 0.33-0.46; and the coupling and coordination level of Poyang Lake Urban Agglomeration is relatively low, ranging from 0.31-0.44. The degree of coupling and coordination between economic resilience and high-quality economic development in the urban agglomeration in the middle reaches of the Yangtze River is increasing year by year, indicating that the synergy between them is improving. The overall mean value rises from 0.33 in 2010 to 0.46 in 2019, approaching dissonance, and there is still room for improvement.

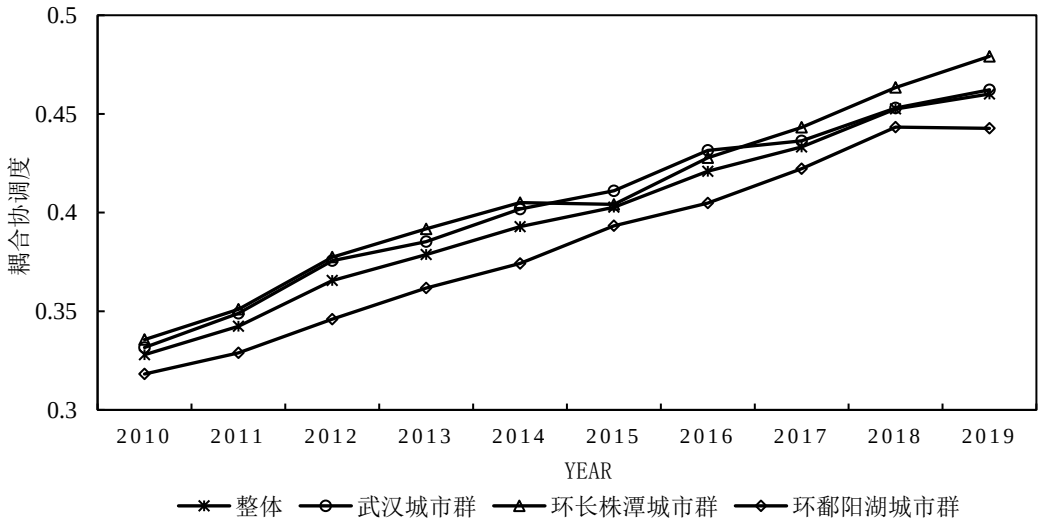


Fig.2. Temporal evolution of the coupling coordination degree between economic resilience and high-quality economic development in the urban agglomeration in the middle reaches of the Yangtze River

Table 4 shows the coupling coordination between economic resilience and economic quality development level of 28 prefecture-level cities in some years. By 2015, the coupling coordination values of 28 prefecture-level cities were all greater than 0.2, indicating moderate dissonance or higher; 22 cities, including Wuhan, Changsha, and Nanchang, had improved their coupling coordination levels. By 2019, the coupling coordination values of 28 prefecture-level cities are all greater than 0.3, indicating mild dissonance or higher; among them, Zhuzhou is barely coordinated, while Wuhan, Changsha, and Nanchang have coupling coordination levels of primary coordination or higher. Wuhan and Changsha, as new first-tier cities, perform better in terms of development awareness, action force, and attractiveness of city scale, talents, policies, and capital, demonstrating the great development potential of new first-tier cities; Nanchang, as the provincial capital city, performs slightly worse, but in recent years, it has gathered resources and optimized industrial structure, effectively promoting the coupling coordination of economic resilience and high-tech development.

Tab.4. The coupling coordination degree between economic resilience and high-quality economic development in the urban agglomeration in the middle reaches of the Yangtze River from 2010 to 2019

City	2010Year	2015Year	2019Year	City	2010Year	2015Year	2019Year
Wuhan	0.636	0.775	0.906	**Yueyang**	0.295	0.362	0.437
Huangshi	0.312	0.376	0.403	**Changde**	0.298	0.378	0.422
Yichang	0.334	0.446	0.498	**Yiyang**	0.254	0.318	0.388
Xiangyang	0.339	0.432	0.490	**Loudi**	0.266	0.306	0.389
Ezhou	0.299	0.315	0.334	**Nanchang**	0.478	0.563	0.655
Jingmen	0.263	0.336	0.400	**Jingdezhen**	0.298	0.349	0.383
Xiaogan	0.272	0.361	0.411	**Pingxiang**	0.278	0.348	0.423
Jingzhou	0.310	0.380	0.431	**Jiujiang**	0.337	0.408	0.457
Huanggang	0.276	0.352	0.389	**Xinyu**	0.338	0.368	0.396
Xianning	0.270	0.332	0.354	**Yingtan**	0.314	0.401	0.431
Changsha	0.552	0.664	0.782	**Ji'an**	0.285	0.382	0.414
Zhuzhou	0.354	0.442	0.513	**Yichun**	0.260	0.372	0.433
Xiangtan	0.339	0.388	0.453	**Fuzhou**	0.274	0.357	0.402
Hengyang	0.322	0.371	0.445	**Shangrao**	0.317	0.381	0.430

3.2.1. Spatial variation of the coupling relationship

Overall, the spatial pattern centered on Wuhan, Changsha, and Nanchang indicates that the coupling and coordination of economic resilience and high-quality economic development is better in the urban agglomeration in the middle reaches of the Yangtze River. As illustrated in Figure 3, in 2010, the coupling and coordination of economic resilience and high-quality economic development were more prominent in Wuhan, Changsha, and Nanchang, while cities with moderate and mild disorders surrounded their periphery. Wuhan, Changsha, and Nanchang's coupling and coordination were still significantly better than other cities in 2015, but all cities with moderate disorders in their periphery had changed to mild disorders and increased to 20. In 2019, 65% of the cities with mild disorders are upgraded to near disorders, and the coupled coordination of urban economic resilience and high-quality economic development is further optimized.

The spatial development pattern within each sub-urban agglomeration is closely related to the province's development strategy, with Wuhan, Yichang, Xiangyang, and other cities in the Wuhan Urban Agglomeration having higher coupling and coordination degrees and improving faster, roughly in line with Hubei Province's regional development strategy of "one main and two vice"; in the urban agglomeration around Changzhutan, Changzhutan area, Yueyang, and Hengyang having higher coupling and coordination.

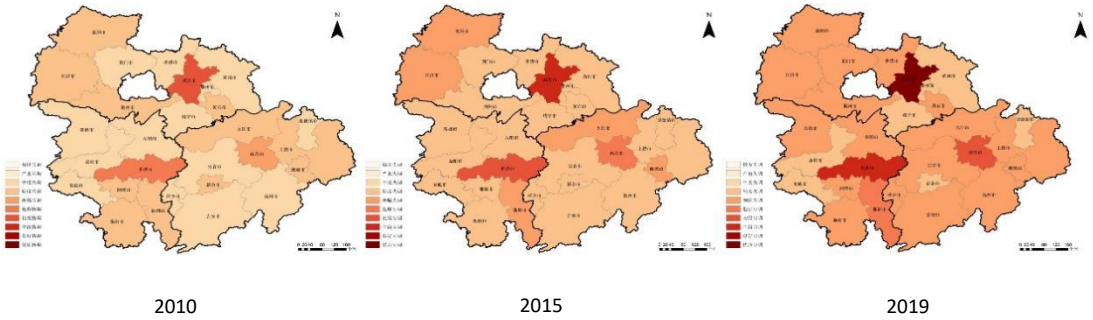


Fig.3. Spatio-temporal evolution of the coupling coordination degree between economic resilience and high-quality economic development in the urban agglomeration in the middle reaches of the Yangtze River

3.3. Driving mechanism and coupling mechanism

3.3.1. Driving mechanism of coupling coordination

Economic resilience and high-quality development are complex giant systems involving multiple subsystems, and in order to deeply study and judge the shortcomings of regional economic development in the urban agglomeration in the middle reaches of the Yangtze River, the magnitude of the driving force of relevant indicators acting on the coupling coordination degree, as well as its evolution process, are detected using geographic probes, and the top ten indicators ranked by influence q-value are identified.

According to the findings of the analysis, the spatially divergent explanatory power of each indicator for the degree of coupling and coordination of economic resilience and high-quality economic development was greater than 0.5 in 2010. The q-value of the indicator of the number of urban basic pension insurance participants in the inclusive subsystem was greater than 0.9, and the q-values of the indicators of general colleges and universities and hospital beds per 10,000 people were also greater than 0.8. Although their q-values fell slightly between 2015 and 2019, they still maintained a high level overall, indicating that pension insurance is a key factor influencing the coupling and coordination level of economic resilience and high-quality development. The study by Zou Hong and Wang Luyin et al[37-38] also found that pension insurance fund expenditure and coverage can significantly stimulate urban residents' consumption, and perfect social security brings better expectations. Investment in R&D personnel has a significant driving effect on the coupling and coordination of the two systems in the innovation subsystem, and shows a trend of gradual increase, indicating that this indicator not only plays a significant role in promoting the transformation and quality of economic development, but also helps to enhance economic resilience, so that the economic system can renew itself and evolve after disturbances, and improve the overall coupling. In comparison, the coordination, green, and open subsystems contribute relatively little to the coupling coordination degree, and only the industrial advanced indicator in the coordination subsystem has a more significant driving effect on the coupling coordination degree in 2010.

The explanatory power of the indicator of total retail sales of social consumer goods on the coupling coordination degree in the economic recovery subsystem is greater than 0.9 in 2010, and slightly lowers in 2015 and 2019. Increases in government fiscal spending between 2010 and 2015 can effectively stimulate residents' consumption, which has a greater contribution to improving the coupling coordination degree. It can be seen that greater resilience can disperse and transfer shock impact, improve system coupling coordination, and then ensure the orderly promotion of high-quality economic development and achieve sustainable economic development. In the economic resilience resistance subsystem, indicators such as gross regional product and the savings balance of urban and rural residents

have a strong positive driving effect on the coupling coordination degree, and gross regional product and per capita disposable income have a stronger contribution in 2019. As a negative indicator, the q-value of actual utilization of foreign capital is generally increasing and reached above 0.9 in 2015, indicating that since the "Belt and Road" strategy was proposed, the provinces of Hubei, Hunan, and Jiangxi have introduced a series of measures and implemented a series of actions in response to the national strategy, and have continuously strengthened their cooperation with countries along the route. Open development, as an important influencing factor of high-quality economic development, has a strong explanatory power on the coupling and coordination of the two systems. However, how to reduce external dependence on capital, strengthen reverse innovation transfer, and then increase economic resilience in the context of the "double cycle" is a major issue that must be addressed in the process of participating in cross-border capital flows. The contribution of the number of patents granted per 10,000 people to the subsystem of economic resilience evolution has been steadily increasing, as a result of provincial governments' implementation of the rise of innovation strategy in recent years. Innovation in science and technology is changing the input mix of factors and guiding the transformation and upgrading of industries, consolidating the coupling coordination by optimizing the development degree of both.

Through interaction detection, it is found that the detection factors in 2010, 2015 and 2019 show a two-factor enhancement or nonlinear enhancement after interaction, indicating that the formation of the spatio-temporal divergence pattern of coupled and coordinated economic resilience and high-quality economic development in the middle reaches of Yangtze River urban agglomeration is the result of multi-factor interaction and synergy. As a result, the author believes that the construction of a composite development strategy in the collaborative development of the urban agglomeration in the middle reaches of the Yangtze River can help improve the level of coupling and coordination between economic resilience and high-quality economic development, and then enhance the level of regional sustainable development. Exchange and cooperation, as well as further opening up.

Tab 5. Results of driving factors of the coupling coordination degree between economic resilience and high-quality economic development

2010Year		2015Year		2019Year	
Driving factors	***q***	**Driving factors**	***q***	**Driving factors**	***q***
Number of urban basic pension insurance participants	0.917	Investment in R&D personnel	0.923	Actual utilization of foreign capital	0.899
Total retail sales of social consumer goods	0.903	Number of urban basic pension insurance participants	0.913	Per capita disposable income	0.897
Industrial structure advanced index	0.891	Actual utilization of foreign capital	0.902	Gross Regional Product	0.897
Actual utilization of foreign capital	0.875	Total retail sales of social consumer goods	0.890	Industrial Structure HHI	0.896
Number of general colleges and universities	0.872	Savings balance of urban and rural residents	0.886	Number of patents granted per 10,000 people	0.895
Investment in R&D personnel	0.868	Local fiscal expenditure	0.859	Investment in R&D personnel	0.891
Number of hospital beds per 10,000 people	0.814	Number of general colleges and universities	0.840	Number of general colleges and universities	0.858
Regional GDP	0.810	Number of patents granted for 10,000 people	0.839	Number of urban basic pension insurance participants	0.857
Savings balance of urban and rural residents	0.795	Financial self-sufficiency level	0.837	Total retail sales of social consumer goods	0.843
Local fiscal expenditure	0.792	Regional GDP	0.831	Urbanization Rate	0.838

3.3.2 Coupling coordination mechanism

Economic resilience, according to the analysis, is the foundation and prerequisite for high-quality economic development, and high-quality economic development is the result and performance of economic resilience. On the one hand, increased economic resilience will promote high-quality urban economic development. The economic resilience system, as a subsystem of the economic development system, plays an important supporting role. The improvement of economic resistance, recovery, and evolution will undoubtedly optimize the industrial structure, science, and technology innovation development, reducing pollution emissions, boosting high-quality development, and boosting the economic system's sustainable development. The number of patents granted per 10,000 people in Wuhan City, for example, increased from 12.14 in 2010 to 43.33 in 2019, and the upgrade of the evolution of economic resilience represents a series of changes in industrial structure and ecological environment, which profoundly affects the change of coupling coordination from primary to high-quality coordinated development. The number of patents granted per 10,000 people in Ezhou fell from 14.64 in 2010 to 6.64 in 2019, indicating that the coupling coordination degree is still mildly dysfunctional in 2019.

High-quality economic development, on the other hand, will have a positive impact on economic resilience. To achieve good development in an environment of innovation, coordination, green, openness, and inclusiveness, the economic system's sustainability is enhanced; and this sustainability also provides the opportunity to transform and enhance the resilient system, and economic resilience will be significantly improved. Furthermore, when medical health and education degrees are guaranteed, it can better release the consumption potential, promote the social economy's steady forward movement, achieve high-quality economic growth, and optimize and improve the economic resilience system. For example, in Wuhan, a sub-provincial city, the number of urban basic pension insurance participants increased from 3,095,800 in 2010 to 4,823,000 in 2019, higher than in 27 other cities with a more complete inclusive subsystem and residents with higher consumption capacity. Because general prefecture-level cities like Yingtan have fewer urban basic pension insurance participants than the other 27 cities, Wuhan has a much higher coupling coordination than Yingtan.

This demonstrates that this coupling mechanism exists not only in provincial capitals, but also in cities at the general prefecture level. Economic resilience and high-quality economic development are mutually reinforcing, providing a strong impetus for the sustainable development of urban economic systems in order to achieve higher quality, more efficient, more equitable, and more sustainable economic development.

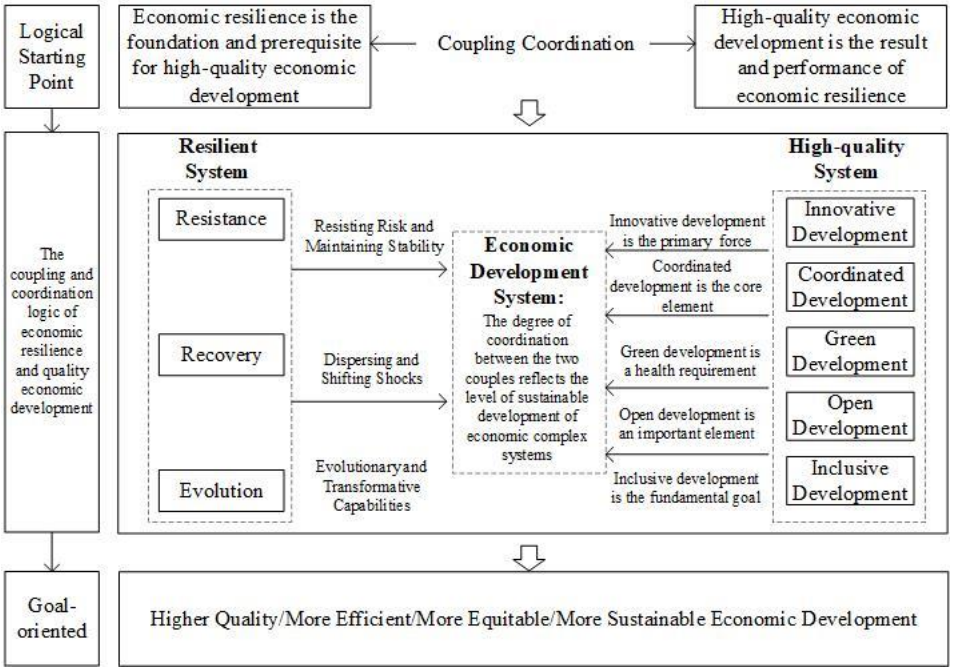


Fig 4. Synergistics system of economic resilience and high-quality development

4. Conclusion and discussion

The following conclusions are drawn from using the entropy method to measure the 28 prefecture-level cities in the urban agglomeration in the middle reaches of the Yangtze River from 2010 to 2019. (1) The economic resilience and level of high-quality economic development of the Yangtze River urban agglomeration as a whole have improved, and the spatial economic resilience and level of high-quality economic development demonstrate the characteristics of Wuhan, Changsha, and Nanchang, which have a strong siphon effect on neighboring cities. (2) The coupling and coordination between economic resilience and high-quality economic development is steadily increasing, but remains primarily in a state of dissonance, with large development potential; spatially, it exhibits a "polycentric" spatial distribution pattern, with Wuhan, Changsha, and Nanchang at the core, and a large number of cities in a state of dissonance distributed around them. (3) Economic resilience resistance > recovery > evolution in the driving role of coupled coordination. Among the five major subsystems of economic quality development, innovation, and inclusiveness comprehensive driving coupling and coordination, green and open subsystem driving role is not significant; the interaction of each factor shows complementary enhancement effect and double factor enhancement effect, and each factor develops synergistically in order to constitute sustainability. As a result, targeted promotion of coupled coordination between urban economic resilience and high-quality economic development has become an unavoidable choice to promote the accelerated development of the urban agglomeration in the middle reaches of the Yangtze River, as discussed below.

From 2010 to 2019, the urban agglomeration in the middle reaches of the Yangtze River's economic resilience and high-quality economic development have improved, and the coupling and coordination of the two has steadily increased, but the overall level remains low. Meanwhile, spatial differences within the urban agglomeration in the middle reaches of the Yangtze River are large, and provincial capitals have a strong siphoning effect. There is a significant gap between the cities in the middle reaches of the Yangtze River and the developed Yangtze River Delta urban agglomeration. The development of the urban agglomeration in the middle reaches of the Yangtze River has made some breakthroughs since the 13th Five-Year Plan, and provincial governmental cooperation mechanisms have been established, but the

overall trend of cooperation is high and low, and economic development is relatively slow. The Yangtze River Delta region is an important growth pole for China's economic and social development, and it is critical to the Yangtze River economic belt and the country as a whole. Han Dong [39] demonstrated that Shanghai, the central city of the Yangtze River Delta urban agglomeration, has a diffusion effect on the region and that the overall radiation intensity has a strong economic impact, whereas Chao Jing and Zhao Xinzheng et al [40] demonstrated that economic differences within the Yangtze River Delta urban agglomeration are small and tend to be reasonable. To effectively improve the high-quality economic development of the Yangtze River urban agglomeration, we should compare the successful experience of economic development in the Yangtze River Delta region to the current situation.

First, implement the "strong provincial capitals" strategy and strengthen the "growth poles." Provinces have been actively cultivating central cities and urban agglomerations in recent years in response to the national regional strategy of integrating "radiation from the point area" and "polarization and balance" to energize the development of provincial capitals and enhance the competitiveness of the entire province. The Hunan Province Twelfth Party Congress proposed implementing the strategy of "strong provincial capital," which is an important driving force for Changsha's economic development. The urban agglomeration in the middle reaches of the Yangtze River should be led by the provincial capitals of Wuhan, Changsha, and Nanchang in order to strengthen further connections with neighboring cities, realize the development of the same city, form a convenient and efficient metropolitan area, and promote the free flow and optimal combination of factors.

The creation of a "synergistic network" and the use of the "integration" method come second. We shall put into action the "14th Five-Year Plan" for the development of the urban agglomeration in the middle reaches of the Yangtze River in accordance with the top-level design guidelines of the central government. The spatial pattern of "three cores, three circles, three belts, and many nodes" is designed to encourage the coordinated development of small, medium, and large cities and small towns and to reduce the spatial disparities within the city circle. It is guided by scientific division of labor and synergistic development. The joint meeting method is employed as the catalyst to encourage cross-regional collaboration among the three sub-city groupings, drawing on the experience of the Yangtze River Delta. In addition, it actively collaborates with Wuhan City Circle, Changzhutan Urban Agglomeration, and Poyang Lake Urban Agglomeration to realize integrated development as soon as possible, and it promotes the accelerated development of the Yijingjing Urban Agglomeration, Xiangshi-Sui Urban Agglomeration, and Three Gorges Eco-Economic Cooperation Zone.

Enhance "resilience" and obtain "excellent quality" as a final goal. To support the high-quality development of the economy and to strengthen the economy's resilience in the three areas of resistance, recovery, and evolution. The 14th Five-Year Plan for the Development of the Midstream Urban Agglomeration of the Yangtze River proposes to foster regional innovation synergy with three science and technology innovation corridors, foster cooperation and docking of the Guanggu, Xiangjiang West Bank, and Ganjiang Cross-Strait Science and Technology Innovation Corridors, and foster industrial synergy and innovation of the cluster. We will increase the integration of resources and work to achieve breakthroughs in important fields like technical innovation and industrial optimization while relying on the "multi-combination" development strategy.

References

1. REN B P. New changes in China's economic growth in the new era and its path to high-quality development. Social Science Journal, 2018(5): 35-43.
2. Holling C S. Resilience and stability of ecological systems. Annual Review of Ecology and Systematics, 1973, 4(1): 1- 23.

3. SHAO Y W, XU J. Understanding resilience: a conceptual analysis based on integrated international literature review. Urban Planning International, 2015, 30(2): 48-54.
4. Reggiani A, Graff T D, Nijkamp P. Resilience：an evolutionary approach to spatial economic systems[J]. Networks and Spatial Economics,2002,2(2): 211 - 229.
5. Foster K A.A case study approach to understanding regional resilience[C]. IURD Working paper，2007(8).
6. Briguglio L, Cordina G, Farrugia N, et al. Economic vulnerability and resilience: Concepts and measurements. Oxford Development Studies, 2009, 37(3): 229-247.
7. Oxborrow L, Brindley C. Regional resilience in recessionary times: a case study of the East Midlands. International Journal of Retail & Distribution Management, 2012, 40(11): 882 — 899.
8. ZHANG M D, FENG X Q. Comprehensive evaluation on Chinese cities' resilience. Urban Problems, 2018(10): 27-36.
9. ZHANG P, ZHANG Z R, YUAN F H. A comparative study between high-quality growth and economic resilience enhancement of countries and their institutional arrangements. Social Science Front, 2019(8): 77-85.
10. Brakman, Garretsen, Van Marrewijk. Regional resilience across Europe： on urbanization and the initial impact of the Great Recession. Cambridge Journal of Regions, Economy and Society, 2015, 8(2): 309 - 312.
11. Caro P D. Recessions, Recoveries and Regional Resilience: an econometric perspective. Università Di Catania.
12. Cuadradoroura J R, Maroto A. Unbalanced regional resilience to the economic crisis in Spain：a tale of specialisation and productivity. Cambridge Journal of Regions, Economy and Society, 2016, 9(1): 153 - 178.
13. Todo Y, Nakajima K, Matous P. How do supply chain networks affect the resilience of firms to natural disasters? Evidence from the Great East Japan Earthquake. Journal of Regional Science, 2015, 55(2): 209 - 229.
14. SUN H, YUAN W P. A Study on the Relationship Between Economic Resilience and High-Quality Economic Development in Western China. Regional Economic Review, 2020(5): 23-35.
15. GUAN C L, ZHANG J T. Research on the relationship between economic resilience and high-quality economic development——taking 26 prefecture-level cities in Changjiang River Delta region as an example. Resource Development & Market, 2022, 38(2):194-201.
16. JIANG L, ZHOU H F, BAI L. Spatial differences in coupling degrees of economy, urbanization, social security and eco-environment in the middle reaches of Yangtze River. Resources and Environment in the Yangtze Basin, 2017, 26(5): 649-656.
17. LU L W, ZHANG Y, LI XF, et al. City quality evaluation of Yangtze River city group. Resources and Environment in the Yangtze Basin, 2014, 23(10): 1337–1343.
18. COSTANZA R.1995. Economic growth, carrying capacity, and the environment. Science, 15(1):89-90.
19. ZHANG W, ZHOU Y Y, HU G W. Coupling mechanism and space-time coordination of new-approach urbanization, new-approach industrialization and service industry modernization in megacity behemoths: a case study of ten cities in China. Scientia Geographica Sinica, 2016, 33(5): 562-569.
20. REN B P, GONG Y H. Study on the coupling of urbanization and high-quality development in the Yellow River Basin. On Economic Problems, 2022(3):1-12.
21. YU P, ZHANG J P. Coupled and coordinated evaluation of regional green finance and high quality development [J]. Statistics & Decision, 2021, 37(24): 142-146.

22. GAO N, MA Y F, LI T S, et al. Study on the coordinative development between tourism industry and urbanization based on coupling model: a case study of Xi'an[J]. Tourism Tribune, 2013, 28 (1): 62 - 68.
23. WENG G M, LI L Y. The coupling coordination degree and spatial correlation analysis on integrational development of tourism industry and cultural industry in China[J]. Economic Geography, 2016, 36(1): 178 - 185.
24. WANG J F, XU C D. Geodetector: principle and prospective[J]. Acta Geographica Sinica, 2017,72(1):116-134.
25. XU Y, ZHANG L L. The economic resilience of Chinese cities and its origin: from the perspective of diversification of industrial structure[J]. Finance & Trade Economics, 2019, 40(7): 110-126.
26. GUO J, XU Z Q. Research on the influence of industrial related variety on regional economic resilience——analysis of threshold effect based on regional innovation level[J]. Science & Technology Progress and Policy, 2019, 36(13): 39- 47.
27. CAI Y M, LI X Y, MENG L W. Evaluation and empirical evidence of regional economic resilience based on normal cloud model [J]. Statistics & Decision, 2022(6):55-59.
28. QI X, ZHANG J S, XU W X. A study on the evaluation of the development of county economic resilience in Zhejiang Province[J]. Zhejiang Social Sciences, 2019(5): 40-46, 156.
29. DING J J, WANG Z, LIU Y H, et al. Measurement of economic resilience of contiguous poverty-stricken areas in China and influencing factor analysis[J]. Progress in Geography, 2020, 39(6):924-937.
30. LI P, FU Y F, ZHANG Y F, et al. Can the productive service industry become new momentum for China's economic growth[J]. China Industrial Economics, 2017(12): 5-21.
31. Mei L, Chen Z. The convergence analysis of regional growth differences in China: the perspective of the quality of economic growth[J]. Journal of Service Science and Management, 2016, 9(6): 453-476.
32. MA R, LUO H, WANG H W, et al. Study of evaluating high-quality economic development in Chinese regions[J]. China Soft Science, 2019(7): 60-67.
33. LI J C, SHI L M, XU A T. Probe into the assessment indicator system on high-quality development[J]. Statistical Research, 2019(1): 4-14.
34. LIU R, GUO T. Construction and application of the high-quality development index——also on the high-quality development of northeast China's economy[J].Journal of Northeastern University (Social Science) , 2020, 22(1): 31-39.
35. WEI M, LI S H. Study on the measurement of economic high-quality development level in China in the new era[J]. The Journal of Quantitative & Technical Economics ， 2018(11): 3-20.
36. SHI B, REN B P. A Measurement of China's provincial economic high-quality development[J]. on economic problems, 2018(4): 1-6.
37. ZOU H, YU K Z, LI A L. A study on effects of pension insurance and health insurance on urban household consumption[J]. Statistical Research, 2013, 30(11): 60-67.
38. WANG L Y. The influence of age structure of population and endowment insurance system on urban residents' consumption——an empirical study based on provincial panel data[D]. Guangdong University of Foreign Studies, 2018.
39. HAN D. Study on the properties and intensity of economic radiation of central cities from the perspective of urban agglomeration: a comparative analysis of the Beijing-

Tianjin-Hebei and Yangtze River Delta[J]. Urban Development Studies, 2020, 27(12): 12-16.

40. CHAO J, ZHAO X Z, LI T S, et al. Comparative analysis on the dynamic characteristics of scale structure among three urban agglomerations in the Yangtze River Economic Belt based on multi-source nighttime light data[J]. Geography and Geo-Information Science, 2020, 36(1): 44-51.

Exploring the Tourism Destination Type Preferences of Disabled Tourists in Shanghai

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Abstract. In order to study the preferences of people with disabilities in their choice of destination type, Shanghai, a city rich in tourism resources and home to nearly one million permanent residents with disabilities, was chosen as a case study for this paper. A qualitative research approach was adopted, with semi-structured interviews chosen as the main means of data collection, and in-depth interviews were conducted between respondents through designed questions to understand the behaviour and constraints of disabled tourists. Through a thematic analysis of the interview content, this study found characteristics such as the overall infrequency of travel among disabled people in Shanghai, the large scope of travel, low income, preference for travelling with relatives and friends, and even if they can travel with the support of relatives and friends, the lack of accessibility and safety factors such as transport, scenic spots, restaurants and accommodation can affect the travel experience. The disabled people found based on the results of the thematic analysis have a preference for destinations with natural scenery, such as hilly areas and the seaside. The results of this study are expected to be of great significance in building a harmonious society and promoting the development of tourism for the disabled community.

Key words: Tourism destination type; disabled tourism; travel preferences

1. Introduction

By the end of 2019, over 40 million documented persons with disabilities had been registered in the basic data of the national disabled population, representing approximately 3% of the total population (Statistical Bulletin of the China Disabled Persons' Federation, 2019). This suggests that people with disabilities, as well as their relatives and friends who make up two to four times the total number of people with disabilities, will also be a huge potential group in the tourism market that cannot be ignored. And according to relevant data, more than 60% of existing disabled people in China have a strong desire to travel (Cheng et al, 2015). Therefore, the emphasis on the development of tourism for people with disabilities is an opportunity for both the disabled themselves and the tourism service industry.

Disability is an inevitable cost in the development of human society and people with disabilities are indeed important contributors to social development (Suntkul & Wantanee, 2014). Therefore, the quality of their overall living conditions reflects the level of civilisation in a society. Tourism is no longer just a necessary part of the daily life of the average tourist, but is also gradually becoming a spiritual and cultural life for people with disabilities.

Although there is a huge market potential, it has long been neglected (Zajadacz, 2017). Due to China's unique national conditions, tourism for people with disabilities is still in its infancy; there is still a lack of legislation to protect the rights of people with disabilities in tourism; most tourism facilities in China are still inaccessible to people with disabilities; the tourism industry has not yet paid enough attention to tourism for people with disabilities; there is a lack of information on accessible tourism that tourists with disabilities urgently need to know; and social promotion of tourism for people with disabilities is There is a serious lack of information on accessible tourism that disabled tourists urgently need to know, and a lack of social promotion of tourism for disabled people. Currently, China's tourism market for people with disabilities represents a small proportion of the overall market, but has great

potential for development. Many factors limit the full demonstration of this potential (Hu et al, 2019). People with disabilities often have specific travel needs and behaviours. For example, they have higher demands on the travel environment and their choice of destinations is limited to scenic spots and areas with high safety margins. However, the corresponding social environment is not well developed, which undermines their tourism development. Typical constraints emerge, such as the unregulated development of accessible catering systems, accommodation, transport systems, scenic spots and tourism information systems, thus making it more difficult for people with disabilities to travel.

Therefore, in order to study the preference of the type of tourist destinations chosen by disabled people when they travel, this paper selects Shanghai, which has rich natural tourism, cultural tourism and social tourism resources, as a typical tourist city, and summarises the types of tourist destinations favoured by disabled tourists through in-depth interviews with disabled tourists. The results of this study are expected to be of great significance in building a harmonious society and promoting the development of tourism for the disabled community as well as the diversification of the tourism industry.

2. Literature Review

2.1. Concept of Disabled Tourist

In order to study disability tourism, it is necessary to understand the relevant concepts and origins.

After World War II, a large number of books and articles on tourism for people with disabilities began to appear in developed Western countries due to the large number of disabled soldiers and civilians brought about by the war (Tao et al, 2019). However, it was not until the mid-to-late 1980s that scholars began to gradually develop research that referred to people with disabilities as subjects of tourism (Cavinato & Cuckovich, 1992). As the new century progressed, more scholars joined the research on this topic and advocated for the expansion of the field, such as claiming that tourism development should further focus on understanding and capturing the tourism needs of those with physical impairments in order to create a more tolerant and harmonious social atmosphere while reaping commercial benefits (Blichfeldt & Nicolaisen, 2011. Suntikul & Wantanee, 2014).

The concept of disability tourism is primarily referred to by the more formal term 'accessible tourism' (Darcy, 2010). Considering the disabled market segment as the main body of tourism from the perspective of consumer demand, accessible tourism represents the sum of the demand for tourism products and the purchasing power exhibited by this specific group, as well as the various tourism phenomena caused by them (Franz, 2006). As an integral part of society, tourism for people with disabilities has the characteristics of ordinary tourism, but it also has a unique nature due to the specificity of the disabled community. according to Darcy et al. (2010), accessible tourism is an effective process in which people with disabilities or older people with mobility impairments can travel independently and enjoy tourism-related services in the same way as ordinary people.

According to Suntikul & Wantanee (2014), the aim of accessible tourism is to achieve accessible tourism transportation, services as well as complaints in a given region, and to facilitate the sharing of necessary information such as resources, markets, infrastructure and brands. Hu et al. (2019) suggest that the essence of accessible tourism is to break through tourism barriers, focus on tourism economy and create a respectful accessible tourism environment.

Accessible tourism focuses on special groups who are hindered to varying degrees in tourism, including people with disabilities and other groups with reduced mobility, such as the elderly, pregnant women and children. It aims to provide convenient and accessible facilities,

special services and special products for these special groups to meet or enhance the accessibility of their tourism activities (Cloquet et al, 2018). For example, accessible tourism in Hong Kong and some European countries tends to provide accommodations for special groups. Although their definitions of persons with disabilities and their perceptions in accessible tourism differ, most of them are centred on accessibility and the construction of tourism markets (Devile & Kastenholz, 2018).

2.2. Tourism Destination Type

A tourist destination is a place where tourists are attracted to stay for a short period of time and visit. The tourism corridor connects the two regions of origin and destination and acts as a bridge for the entire tourism system. Some scholars define a tourism destination as "a place where tourism resources in a certain geographical space are organically combined with tourism-specific facilities, tourism infrastructure and other related conditions to become a destination for tourist stays and activities. Tourist places are sometimes referred to as tourist destinations, or tourist resorts, in different contexts."

Gunn (1988) The concept of the Destination zone (DZ), which is made up of several components such as attraction groupings, service communities, transit corridors and intra-district corridors. Some scholars also argue that "the destination is the centre of tourism activity". They argue that destinations bring together all the elements of tourism, including demand, transport, supply and marketing, in one effective framework and can be seen as centres of services and facilities that meet the needs of tourists. At the same time, they argue that the destination acts as the third element in Leiper's (1979) tourism system, but in many cases it is the most important one, as the destination and its image attracts tourists and drives people to visit, thus activating the whole tourism system. They define a destination as "the most important and vital part of tourism activity, the vehicle for tourism hospitality, the place where the tourist attractions and services required by the tourist are established." The development of modern tourism has changed the way people travel and the focus of destination management, so the concept of tourism destinations is also changing. People's perception of the concept of tourism destination is related to the content of tourism demand, and the change in tourism demand has led to a continuous adjustment in the perception of the connotation and extension of the destination, and a change in the management focus and marketing focus of the destination (Weng, 2018).

In terms of tourism motivation, the main types of destinations are: sightseeing, holiday, shopping, pleasure and business. In terms of landscape composition, the main types of tourist destinations are: ancient architecture, climate, flora and fauna resources, natural landscape, and human landscape (Yoo, 2018).

3. Methodology

This study considers a qualitative approach to research exploring the preferences of disabled tourists in their choice of destination type. While survey methods may be useful, they are too restrictive. A qualitative approach using interviews is appropriate when dealing with specific sensitive issues (Kvale, 1996; Kitchin, 2000). In this paper, we will conduct a convenience sample of the disabled tourist group, interview a selection of disabled tourists to obtain data and finally use thematic analysis to analyse the travel preferences of disabled tourists in Shanghai.

Convenience sampling, which is a non-probability form of sampling, was used in this study. The sampling used by the researcher does not provide every member of the target population to participate in the study, but rather the researcher selects the participants, either by recommendation from the researcher or by their own choice to participate in the study. Importantly, non-probability sampling does not allow the researcher to extend the results of

the study to the general population; instead, the results of non-probability sampling studies can only be applied to the participants in the study. This sampling technique usually selects clinical cases or participants around a location (e.g. a hospital), an internet site or a client membership list. Convenience sampling for qualitative research depends on the motivation of the people taking part in the study. This introduces motivational bias into the study. Motivation to participate may depend on a person's interest in the research topic, a desire to express an unsatisfactory viewpoint, or a desire to support a particular personal viewpoint (Stratton, 2021).

The analysis process of thematic analysis as a stand-alone qualitative descriptive method involves familiarising oneself with the data, generating initial codes, finding themes, reviewing themes, defining and naming themes, and producing reports. Thematic analysis provides the researcher with the core skills to conduct many other forms of qualitative analysis. In this regard, qualitative researchers should become more familiar with thematic analysis as a stand-alone, reliable method of qualitative analysis. Thematic analysis provides a purely qualitative, detailed and nuanced description of the data (Braun & Clarke, 2006).

As with most other qualitative studies, the selection of study participants was based on a judgemental technique of actively selecting the most productive sample to respond to (Marshall, 1996). The target audience for the interviews was based on a convenience sample of disabled tourists who were willing to accept the questionnaire and whose basic information is shown in Table 1.We attempted to conduct face-to-face interviews with disabled tourists, but due to travel difficulties during the pandemic. We chose to conduct online interviews such as telephone or FaceTime. The interview questions also revolved around past preferences for travel destination choices, constraints and expectations for future travel.

Table 1. Profiles of the respondents

Name	Gender	Age	Income/Month	Travel Frequency
S1	Male	73	5000-6000RMB	5-6/Year
S2	Female	60	1000-2000RMB	5-6/Year
S3	Female	83	4000-5000RMB	1-2/Year
S4	Male	82	5000-6000RMB	1-2/Year
S5	Male	76	10000-11000RMB	7-8/Year

In terms of privacy protection, reminders of relevant personal information matters were provided at the beginning of the interview and were completed anonymously to ensure that respondents were not influenced by concerns when being interviewed. The raw data collected during the survey was kept on a personal computer for the sole purpose of this paper, the screen was password protected and the data was encrypted to ensure security needs.

4. Findings

Four out of five respondents said that they prefer to visit natural areas, such as hills, seaside and other places of natural beauty.

S1 said, "I choose to travel every year in spring, summer and autumn, and I like to travel with a group, not too far or too close. I like to stay in nice places, especially in the hills, and I like to buy souvenirs and travel at a slow pace".

S2 says "I like to visit coastal cities because they have good natural scenery and their scenic spots are more unique. The food in coastal cities is particularly good for me and I especially like destinations with good food."

S3 said, "Because I am older and my legs are even worse, I can only travel with a tour group and I can't participate in many recreational activities, so I especially like coastal cities because the air is good and I feel relaxed by the sea."

S5 said "I like to travel in spring and summer, I also like to travel with a group and I like destinations with good nature, such as mountains and the sea. I also like short destinations because I prefer medium-priced products".

5. Conclusion and Limitation

Based on the content of the interviews with the respondents, it is clear that tourists with disabilities prefer destinations with natural landscapes, such as seaside, hills and mountains. These natural landscape destinations are all blessed with beautiful natural scenery. Disabled tourists travel less frequently due to their own special reasons, and destinations with good natural scenery can have a positive effect on the physical and mental health of disabled tourists while satisfying their willingness to travel.

Due to COVID-19 and the special nature of disabled tourists, this study was only able to interview five respondents through convenience sampling, and the respondents were older. Future research hopes to interview more young visitors with disabilities to obtain different content.

References:

3. Blichfeldt, B. & Nicolaisen, J. (2011). Disabled travel: not easy, but doable. Current Issues in Tourism, 14(1), 79-102.
4. Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative research in psychology, 3(2), 77-101.
5. Cavinato, J. & Cuckovich, M. (1992). Transportation and tourism for the disabled: an assessment. Transportation Journal, 31(3), 46-53.
6. Cheng, L., Zhang, T., Liao, X. (2015). Research on the internal mechanism of traveling decisions for the disabled-based on the theory of learned helplessness and negotiation theory. Tourism Science, 29(06):15-33.
7. Cloquet, I., Palomino, M., Shaw, G., et al. (2018). Disability, social inclusion and the marketing of tourist attractions. Journal of Sustainable Tourism, 26(1-3), 221-237.
8. Darcy, S. (2010). Inherent complexity: disability, accessible tourism and accommodation information preferences. Tourism Management, 31(6), 816-826.
9. Devile, E. & Kastenholz, E. (2018). Accessible tourism experiences: the voice of people with visual disabilities. Journal of Policy Research in Tourism, Leisure and Events, 10(3), 265-285.
10. Franz, P. (2006). People with disabilities: Accessible tourism. International Conference on Computers for Handicapped Persons. Springer, Berlin, Heidelberg.
11. Gunn, C. A. (1988). Vacationscape: Designing tourist regions. Van Nostrand Reinhold.
12. Hu, C. , Cole, S. , Wang, W. et al.(2019). The influence of accessibility and motivation on leisure travel participation of people with disabilities. Journal of Travel & Tourism Marketing, 36(1), 119-130.
13. Kitchin, R., 2000. The researched opinions on research: disabled people and disability research. Disability and Society 15 (1), 25 – 47.
14. Kvale, S., 1996. Interviews: An Introduction to Qualitative Research Interviewing. Sage Publications, London
15. Leiper, N. (1979). The framework of tourism: Towards a definition of tourism, tourist, and the tourist industry. Annals of tourism research, 6(4), 390-407.
16. Stratton, S. J. (2021). Population research: convenience sampling strategies. Prehospital and disaster Medicine, 36(4), 373-374.
17. Suntikul, K. & Wantanee, M. (2014). Best practice in accessible tourism: inclusion, disability, ageing population and tourism. Current Issues in Tourism, 17(1), 102-104.

18. Tao, B. , Goh, E. & Huang, S. (2019). Travel constraint perceptions of people with mobility disability: a study of sichuan earthquake survivors. Tourism Recreation Research, 44(3), 1-14.
19. Weng, L., & Huang, Z. (2018). A study of tourism advertising effects: Advertising formats and destination types.
20. Yoo, C. K., Yoon, D., & Park, E. (2018). Tourist motivation: an integral approach to destination choices. Tourism Review.
21. Zajadacz, A. (2017). Attitudes of future tourism sector employees towards organise accessible tourism. Management Studies, (5), 56.

Research on the current situation and countermeasures of catering development of tourism to regional economy——Guanggu region in Wuhan City of China

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Abstract. With the development of tourism, it beagins to have an impact on the regional economy of catering in Wuhan city.Driven by the policies of regional economy, various catering enterprises have developed particularly rapidly, which makes the brand start to have strong commercial value and economic influence.This paper investigates the development status of catering under the development policy of local regional economy, analyzes the factors affecting the development of catering and puts forward optimization suggestions for a series of development problems, The paper has five parts: the first part is the introduction. This paper introduces the research background, significance, research content and methods of this paper; The second part is literature review. Define the relevant concepts of the paper, elaborate the relevant research status and relevant theories, and analyze the current situation from the perspective of the new 4P theory; The third part is the design process of questionnaire and interview. Based on the research and theory of the second part, the questionnaire and interview outline of the influencing factors of the development status of catering under the regional economy are designed; The fourth part analyzes the development status and problems of catering in Wuhan Optical Valley. Present the current situation and trends through data tables, and then find out the problems combined with the results of questionnaires and interviews; The fifth part is the suggestions and countermeasures. According to the problems in the fourth part, suggestions for catering in Wuhan Optical Valley area are given for reference.

Key words: regional economy of catering;Wuhan Optical Valley;development problems

1. Introduction

With the continuous development of the economy and environmental changes, it will begin to have a crucial impact on the development of regional tourism. The six elements of clothing, food, housing, transportation, shopping and entertainment, which are a general summaries to tourism activity, having a very important position in tourism activities and are also a very important income of tourism. As far as the catering industry in the Wuhan Optical Valley area is concerned, the development status and research of relevant catering formats are relatively few, and the development of the entire catering market is relatively backward, which plays a research role in promoting the development and status of the tourism catering industry in the regional economy, which is in line with the development situation of the regional economy. It is necessary to analyze the problems existing in the tourism catering industry market in the Wuhan Optical Valley area and study the measures to improve the tourism catering industry market in the Wuhan Optical Valley area

1.1. The definitions and elements of creativity

Catering regional economy refers to the production complex produced by the interaction of internal factors and external conditions in the economic development of the catering industry in a certain region. A regional development entity with a certain region as its scope and closely combined with economic factors and their distribution. The economic development of catering areas will be restricted by natural conditions, socio-economic conditions, technical and economic policies and other factors.

The following three concepts should be defined for catering industry areas. Firstly, population security threshold: the location has 150000 fixed people, one catering store can be set up. The total population of urban areas determines the number of shops. Secondly, regional positioning design: take the provincial capital city as the center, radiate to the surrounding areas, and implement the regional chain operation strategy, which should be positioned at the regional level. Thirdly, headquarters implementation mode: promote cross-regional development by replicating regional headquarters ,design and implement regional headquarters.

The emergence of online celebrity hot spots has started a consumer market oriented by online celebrity economy, and then the consumption phenomenon of taking photos and punching cards in online celebrity restaurants has emerged, resulting in a series of online celebrity catering chain stores rapidly occupying the market. Build a restaurant with Internet popularity into a KOL[1] (Key Pinion Leader) with its own star effect and fans. Therefore, in view of the spread and push of the network, everyone's curiosity increased and a large number of "trendsetters" flocked to them, forming a long line with their own benefits and network popularity effect.

KOL restaurant is another innovative catering industry in the form of marketing and visual design in the traditional catering industry. Enterprises provide customers with drinks, food, facilities and equipment. It is an enterprise that provides complete supply, marketing and production. The basis of KOL restaurant is to meet the dietary needs of customers, but preferences are more dependent on consumers. With the gradual increase of consumption level, the level of consumer demand shows a diversified curve pattern, which leads to the upgrading of the catering industry today.

1.2. The definitions of theory and theory models

In 2009, Japan Telecom[2] Corporation proposed the AISAS model (Kobayashi). AISAS model is a typical product of the Internet age,they are attention,interest,search, action and share. In the new marketing concept, based on the features of search and share on the Internet, search and share will use big data to connect irrelevant groups. which reunite fragments and strengthen the marketing influence on target groups,to achieve the goal of win-win.

In 2010, Judy Strauss and Raymond[3] frost defined E-marketing as online marketing, which refers to using the wide dissemination of the Internet to carry out multi-channel publicity,production,create and transmit customer value, at same time systematically manage customer relations,benefit enterprises and relevant stakeholders. Nowadays, China has a large number of online user groups and the total consumption of enterprises who use the Internet to develop business sales channels still lags behind the developed market economy in the West. Therefore, for this reason, we need to deepen our understanding of the deep meaning of the Internet red economy.

1.3. Theory and creativity

4P marketing theory was put forward by Jerry McCarthy[4] in his book marketing in 1960, that is, products, prices, channels and promotions. 4P marketing theory is the authoritative theoretical framework of enterprise marketing and planning. Product, price, channel and promotion are the four elements of enterprise marketing, none of which is indispensable.

Product refers to the tangible or intangible substances that meet people's needs in transactions, including intangible services. It mainly includes the combination of factors such as product quality, design and service.

Price refers to the monetary value of products, mainly including basic price, discount price and preferential price. Product prices are regulated by market mechanisms, such as changes in market demand, raw material costs, processing fees and market competition.

Place refers to the whole process of products from production and sales to customers, mainly including storage, transportation and packaging.

Promotion refers to a series of marketing activities to sell brand products and refers to purposeful publicity activities.

Internet celebrity economy is a new economic trend that conforms to the development of the times. This phenomenon has brought unprecedented opportunities and challenges to the development of the traditional catering industry. In a way that is more in line with the upsurge of the times, it can make up for the novelty, creativity and quality that the catering industry ignored before. Affected by the Internet celebrity economy, the catering industry is taking the initiative to create, collect and realize traffic.This is actually a supplement to the traditional marketing concept and operation management mode. The traditional four classic marketing combinations can not accurately reflect the existing marketing activities in the new network economic environment. Therefore, under the influence of online celebrity economy, we need to look at the 4P theory from a new perspective and accurately grasp the development trend of regional economy.

Brand personification refers to the IP and specialization of the product brand, which includes the integration and unification of product quality, packaging design, cost performance, brand communication, brand logo and products. At the same time, building a brand personification is more conducive to deepening the public impression and reflecting the style and flavor of catering brand products. Public Internet refers to making full use of the excellent communication of the Internet to promote sales. Online and offline promotional activities are carried out at the same time to complement resources, expand the scope of promotions and reduce the limitations of traditional promotions. Promotional activities include free promotions, discount promotions and full discount promotions. Online and offline integration development, using big data to operate efficiently.

Participation refers to paying attention to the personalized needs of customers, improving their participation, experience and freshness, increasing the demand of target customers for products and determining the price. Including dining environment, personalized services, facilities and equipment, product value, brand quality and market demand, traditional catering is priced based on the factors that determine the price. Under the influence of online celebrity economy, the added value of catering products is also another way to reflect the value of products, thus setting off a new round of consumption stimulating behavior in the catering industry, Increase the proportion of public food expenditure in total personal consumption expenditure.

Path refers to the scientific planning activities for the channel, and the flow type introduction, attraction and Realization of the characteristics of catering brands. It mainly relies on the online communication of the Internet, such as QQ and circle of Wechat, product evaluation of live broadcast app bloggers, entertainment apps (Tiktok, Weibo, Xiaohongshu etc.) and life apps (Meituan, Dianpingetc.), and offline billboards and posters to maximize the added value of catering brand products and extra valued products, stimulate consumers' consumption desire, so as to achieve marketing purposes.

According to the traditional 4P theory marketing framework, this paper will analyze the catering marketing activities under the Internet celebrity economy from a new perspective, and then through the data collection of the current situation of the Internet celebrity economy at home and abroad, it is found that all industries and catering industry are actively using the power of the Internet celebrity economy to carry out marketing, to achieve the purpose of the sales. Look at the original 4P theory from a new perspective, highlight the key factors in it, and look at the development status and corresponding strategies of catering.

To better analyze the development status of the regional catering industry economy under the influence of the online celebrity economy, taking the online celebrity restaurant cluster in Wuhan Optical Valley as an example, this paper analyzes the market scale, market share, price and type structure of the online celebrity brands in the market, obtains the problems of the market,and summarizes the countermeasures and suggestions.

2. Method

2.1. Participants

The participants are catering consumers who have had consumption experience in online celebrity restaurants in Wuhan Optical Valley. The survey is mainly conducted through the questionnaire network. 100% of the questionnaire is distributed through the field questionnaire and filled in by Wechat, which ensures the attribute of "consumer" of the questionnaire.

2.2. Instruments

The instruments employed in the questionnaire mainly include： a) basic information. Basic information of consumers. This part is designed to understand the consumption orientation and consumption strength of different consumer groups. b) Consumer satisfaction and demand-related issues about the development status of online celebrity restaurants in Wuhan Optical Valley. In this part, consumers are required to answer the relevant questions about the four elements of Brand personification, public Internet, participation and path related to catering to the regional economy from a new perspective of 4P theory.

2.3. Experimental design and procedures

(1) Literature analysis

By consulting the relevant literature on the impact of online celebrity economy on the development status of catering, we can comprehensively understand the development status and influencing factors of online celebrity catering, and learn to refer to the research cases and methods of scholars, so as to lay a theoretical foundation for the research direction and content of this paper, so as to obtain the influencing factors and problems affecting the development status of catering in Wuhan Optical Valley, and then explore the development countermeasures.

(2) Questionnaire survey method

Using the survey method of issuing questionnaires, a formal survey was conducted on the samples of consumers who had consumption experience in online celebrity restaurants in Wuhan Optical Valley area, to obtain the survey data of consumers' Consumption Satisfaction and consumption demand for online celebrity restaurants, and then refine and classify these data to find out the factors affecting the development status of catering.

(3) Interview method

Through field interviews and investigations, interviews were conducted with consumers, service providers and managers to make up for the deficiencies of the questionnaire, deepen the understanding of the current situation of the development of online celebrity catering, find out the factors affecting the current situation of catering development, and analyze the results.

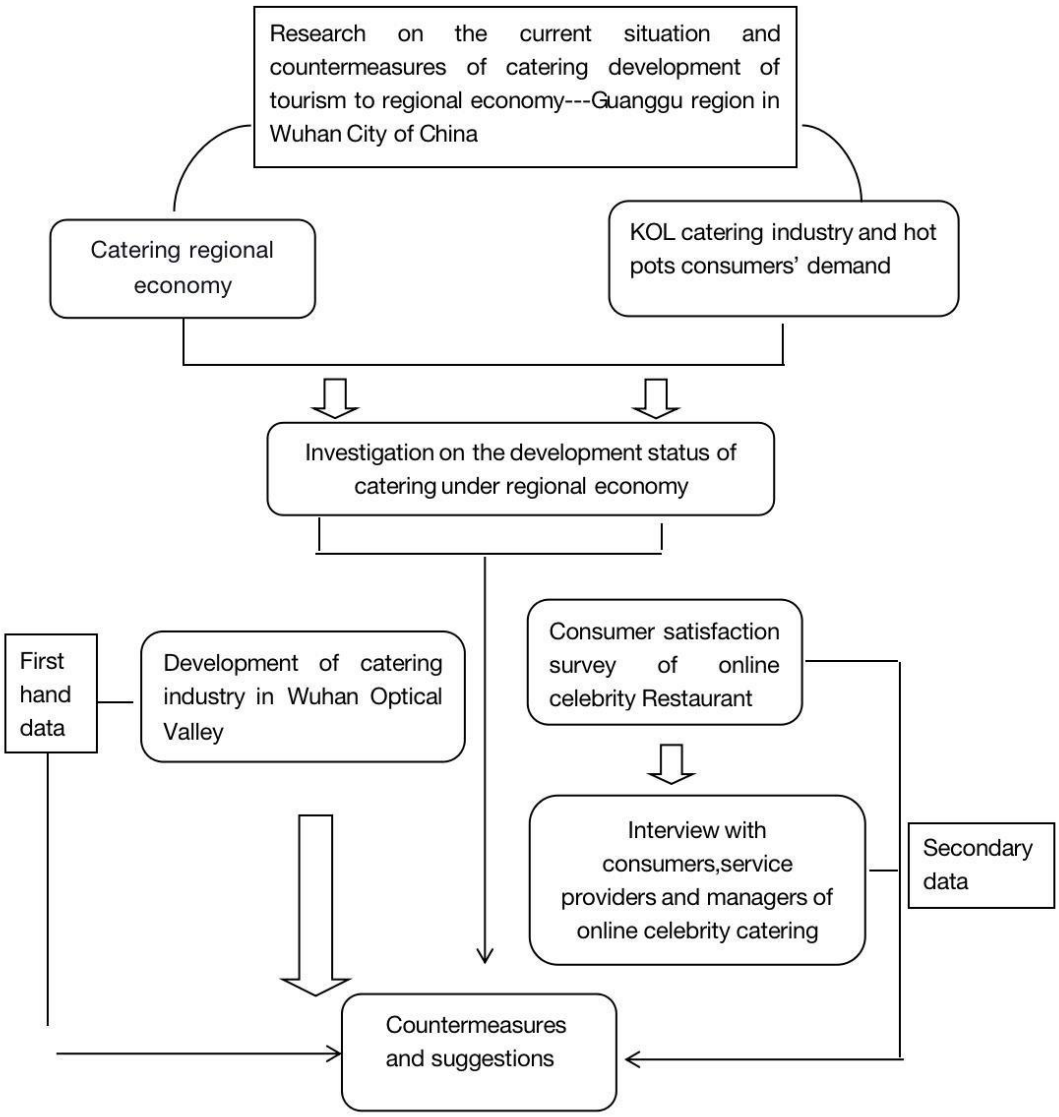
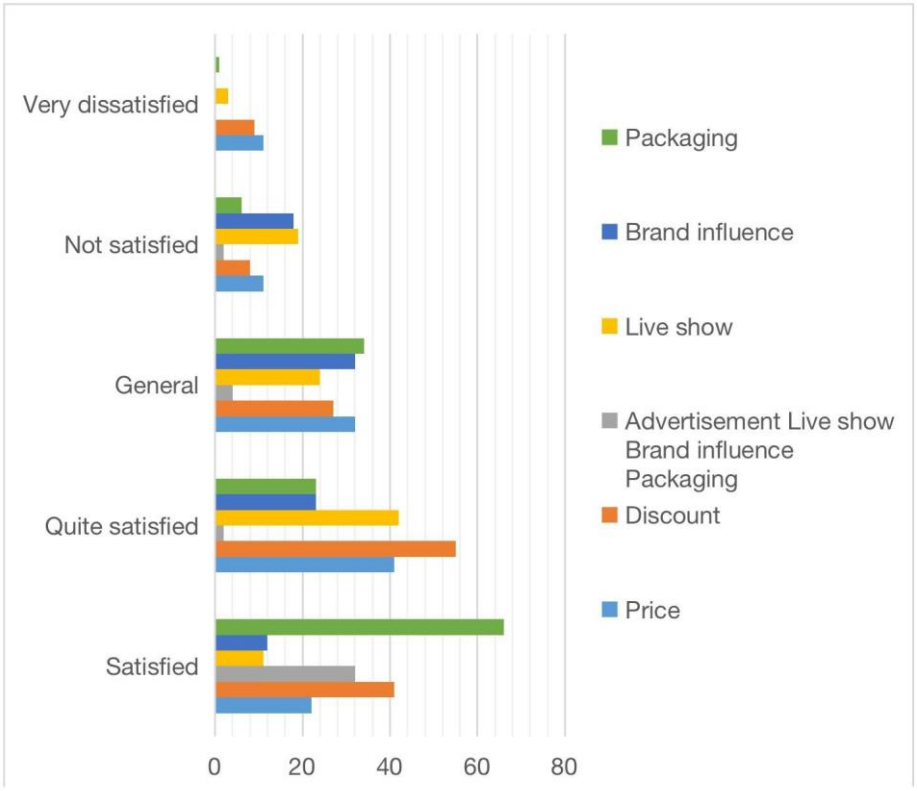


Fig.1.Analysis diagram of research ideas

2.4. Data analysis

According to the data results in table1 consumers tend to be satisfied with the price of online red restaurant, indicating that the price of online red restaurant is not an influencing factor affecting consumers' choice. Table1shows that consumers will pay more attention to the dining environment, personalized services and infrastructure equipment of the restaurant. Promotion methods prefer more direct discount promotions, and the price concessions will be more obvious. In terms of publicity channels, consumers are the most satisfied with life and entertainment apps, which is also the most important traffic publicity channel for online celebrity restaurants today, and the way to successfully realize the network traffic. In terms of products, consumers pay attention to the three points of product packaging design, brand communication and product quality, which happen to be the product elements of the "popular" products of KOL restaurant. The unique and novel packaging design, the massive dissemination and reprint of high-quality product publicity pictures and small videos, and the excellent product taste have successfully stood out from the public eye and created the sales myth of "popular" products.

Table.1 Statistical table of consumer satisfaction analysis

Project	Degree of satisfaction
Price Product Place Promotion	

According to the comprehensive results of the questionnaire, the group that will choose to consume in the online celebrity restaurant will prefer to have both product quality and appearance needs. The high price of the product needs to be different from the products with general market prices in the restaurant's additional services, environment, facilities and equipment. It will also need to make updates on more apps for entertainment and lifestyle audiences to maintain close interaction with consumers, Irregular discount promotions will stimulate consumers' consumption desire.

3. Results

From the new perspective of 4P theory, online celebrity restaurant is a pricing method different from traditional restaurants, which determines the price not according to value, but according to demand. Meeting the personalized needs of consumers is the first. We should pay attention to consumers' sense of experience, satisfaction and freshness, improve consumers' satisfaction, and establish feelings with the brand.

3.1. Improvements in knowledge of creativity

The content of brand personalities has no characteristics and needs to be enriched.The characteristic brand image will strengthen the consumption attraction and content richness of the brand, mobilize the satisfaction of consumers' initiative and brand cognition[5], and meet consumer needs. There are differences in the content composition of different restaurant brand images, which leads to few prominent and characteristic catering brand images in the market, leading to competitive differences, and the need to enrich the content of brand images.

The marketing driving ability of the Internet is different.The promotion strategy of marketing activities is the embodiment of the driving ability of Internet marketing. Promotional activities will rely on the advantages of the Internet to carry out channel marketing. Some restaurants in Wuhan Optics Valley still do not make good use of the advantages of the Internet. Compared with restaurants that flexibly use the Internet to promote and maintain customer loyalty, the marketing driving ability of restaurant products will be different.

Customer needs are biased, resulting in differences in services.Because different restaurants have different product pricing and restaurant positioning, it will lead to different customer demand performance and more biased consumption, which will also lead to differences in restaurant services.

There are differences in publicity channel resources.The publicity channel of KOL restaurant mainly relies on the network to carry out scientific communication activities, import, attract and realize the flow of catering brands, optimize the allocation of products and their added value to brand restaurants, and show the best effect to customers, so as to attract customer flow and stimulate consumption. Due to the different investments in publicity channels of brand restaurants, there will be a gap in publicity channel resources, and the publicity effect will be different.

3.2. Improvements in abilities of creativity

Attach importance to brand image and expand product types.Undoubtedly, online celebrity restaurants need to learn to label themselves, build the characteristics of public opinion consumption, meet the new and exciting experience of product, make good use of the entertainment methods they are interested in, publicize the brand personalities, and attract traffic into consumption hot-spots.KOL catering needs to expand its product types[6]. After the market status of ACE products is stable, it needs to develop new sub line products, gradually enrich the range of products in the unit price, and gradually enrich its brand strength.

Internet promotional activities need to track customer dynamics in time and make marketing adjustments. The public Internet promotion activities of KOL restaurant need to be closely followed up with customers, and customers' response feedback can be adjusted in time according to the market status so that the development pace can be unified online and offline.

Meeting customers' needs is the best embodiment of the added value of online celebrity catering[7].The customer demand of KOL restaurant pays more attention to the personalized demand of customers, which belongs to the soft demand of customers, including dining environment, personalized service, facilities and equipment, brand quality, and so on. The best embodiment of these added values is that after the price of the product is higher than the average market price, consumers still feel satisfied with the feedback on the price. Because the personalized demand value of customers has reached the expected standard, the price premium is also acceptable to consumers.

Scientific planning of channels.The channel marketing of KOL restaurant needs scientific planning and overall planning[8]. Register official accounts on the major app software commonly used by the public today, release some real-time updates, spread the small videos of publicity through different channels, attract attention and traffic heat, and then scientifically carry out marketing planning, write different copies according to the audience characteristics of different channels, and conduct phased marketing to strengthen the public's impression of the brand. Publicize the advantages and characteristics of brand products to maximize value, stimulate consumers' consumption desire, and achieve marketing purposes.

4. Discussion

The results show that what need catering should do well is its restaurant products, maintain good quality control and research and development of new products, standardize services, reduce the differences between stores, pay attention to the personalized needs of customers, and maintain the emotional connection with customers. Irregular discount promotions will lead to a sharp increase in performance and increase brand popularity.

5. Conclusions

The development of tourism needs the integration of regional economic development and cooperation. The catering industry is an important achievement of the tourism economy. The catering industry in Wuhan Optical Valley is very representative, representing the current consumption level and people's living standards in this region.The new 4P marketing concept will be more in line with the development status of Wuhan's regional economic catering industry, and will better drive economic growth and the development prospects of tourism.

Reference

1. Veer Kontiokari,2018.Key opinion leaders:who are they and why do they matter,Liana Technologies.
2. Kobuyashi.Y,2009,A study of engagement in Japan:Aoyama Journal of Business.
3. Jackson BB,1985,Winning and Keeping Industrial Customers:The Dynamics of Customer Relationship, Lexington:Lexington Books.
4. Guang Xu and Honggen Shen,2017,Research on the development of internet economy in contemporary China.Urban Journal.
5. Rui Ai,2017,2017 China Internet Economic Development Report,Tourism economy. 6.Linlin Shao,2016,Current situation and development trend of network marketing in China,Modern Economic Information.
6. Jie Cai and Yuanyuan Fu,2017,An investigation on the economic development of tourism regions in Wuhan,Modern economy.
7. Heng Zhan,Zhide Chen and Meng Wang,2015,Social network marketing tracking.

How did Built Environment Affect Urban Vitality in Urban Waterfronts? A Case Study in Nanjing Reach of Yangtze River

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Abstract. The potential of urban waterfronts as vibrant urban spaces has become a focus of urban studies in recent years. However, few studies have examined the relationships between urban vitality and built environment characteristics in urban waterfronts. This study takes advantage of emerging urban big data and adopts hourly Baidu heat map (BHM) data as a proxy for portraying urban vitality along the Yangtze River in Nanjing. The impact of built environment on urban vitality in urban waterfronts is revealed with the ordinary least squares (OLS) and geographically weighted regression (GWR) models. The results show that (1) the distribution of urban vitality in urban waterfronts shows similar agglomeration characteristics on weekdays and weekends, and the identified vibrant cores tend to be the important city and town centers; (2) the building density has the strongest positive associations with urban vitality in urban waterfronts, while the normalized difference vegetation index (NDVI) is negative; (3) the effects of the built environment on urban vitality in urban waterfronts have significant spatial variations. Our findings can provide meaningful guidance and implications for vitality-oriented urban waterfronts planning and redevelopment.

Keywords: urban waterfronts; urban vitality; built environment; big data; geographically weighted regression; Yangtze River

1. Introduction

Urban waterfronts, as the important part of a town or city adjoining water area (i.e., river, lake, sea and ocean, and harbor), have a unique spatial interface and attractive waterscape [1–4]. Moreover, urban waterfronts also have obvious advantages in terms of economic development, ecological environment, social interaction, and cultural heritage [5–8]. The redevelopment of urban waterfronts, which has become a well-established global trend, provides urban waterfronts with new functions (e.g., leisure, recreation, retail, and tourism) to satisfy both economic and social needs [9–13]. In recent decades, a growing body of studies has focused on the redevelopment of urban waterfronts as an important way for cities to improve their vitality, attraction, and international competitiveness [14–16]. In China, the development of urban waterfronts is now facing new opportunities for transformation and redevelopment [17–19]. Therefore, assessing urban vitality in urban waterfronts and deciphering its influencing mechanisms are crucially important for urban waterfronts planning and design.

The concept of urban vitality is brought into view by Jacobs [20] when it was noted that the presence of more active streets could encourage more people to engage in various activities, whether commercial or residential. Jacobs maintained that vibrant urban space was positive to create a diverse city life. Lynch [21] later defined urban vitality as to what extent vital functions and biological requirements of individual are buttressed by the capacity of the environment. Maas [22] described urban vitality as a representation of spatial quality involving the continuous presence of people, activities and opportunities, as well as the physical

environment in which these activities occur. Montgomery [23] claimed that the characteristics of successful urban places tend to have a more vibrant public realm breeding rich human activities. While there is no consensus on the definition of urban vitality, human interactions as well as activities have commonly been the focus of urban vitality research.

In the era of big data, the availability of massive crowdsourced data has become a prominent part of characterizing urban vitality in geography and urban studies [24]. Generally, current research of urban vitality can be categorized into two streams: measuring urban vitality and examining its determinants. The first research stream applies various crowdsourced data to assess the spatiotemporal characteristics of urban vitality. The mobile phone data, social media data, GPS tracking data, as well as Baidu heat map (BHM) data serve as the most dominant proxies of urban vitality by reason that these data provide detailed information regarding people's behavioral characteristics [25–29]. The second research stream delves into the relationship between urban vitality and its determinants. Scholars claimed that built environment characteristics, such as building density, development intensity, and transportation network, have significant effects on urban vitality [30–34]. These studies have enriched the literature of urban vitality and provided meaningful insights for creating vibrant urban space. For example, well-designed public spaces and small street blocks provide opportunities for more diverse human activities and interactions, and thus foster livable streets and vibrant neighborhoods [35–37]. However, most previous studies ignore the spatiotemporal analysis of urban vitality in specific areas, especially for urban waterfronts. Therefore, it is necessary to apply reliable crowdsourced data to effectively assess urban vitality in urban waterfronts.

In this paper, the BHM data collected in Nanjing is adopted to investigate the spatiotemporal analysis of urban vitality in urban waterfronts. Besides, both ordinary least squares (OLS) and geographically weighted regression (GWR) models are used to quantify the associations between urban vitality and built environment characteristics in urban waterfronts. This study is intended to (1) explore the spatiotemporal characteristics of urban vitality in urban waterfronts through the analysis of BHM data; (2) examine how built environment characteristics correlates with urban vitality in urban waterfronts; and (3) afford useful insights and references as to fostering urban vitality in urban waterfronts.

2. Literature Review

2.1. The Measurements of Urban Vitality

Urban vitality, as a vital element for achieving a higher quality of human life, describes the attractiveness, diversity, and competitiveness of public spaces [25,38]. However, how to accurately measure urban vitality remains a challenging issue. Traditional data collection methods, such as field survey and on-site observation, provide detailed human activities information that includes gender, age, characteristics, and activities and behavior of users [39,40]. Such methods, however, are usually costly and time-consuming, and thus may not be suitable for investigating urban vitality at a large scale [41].

Fortunately, in recent years, the rise of crowdsourced data sources, notably data derived from mobile phones as well as social media, offer massive opportunities for observing various human activities and interactions [24]. For example, Nadai et al. [42] proposed a method to measure urban vitality with mobile phone records and examined the association between urban vitality and diversity in the Italian context. Yue et al. [26] quantified neighborhood vitality based on mobile phone data and investigated the association between the point of interest (POI)-based mixed use and neighborhood vitality. Wu et al. [25] suggested that social media check-in data can be used as a proxy for characterizing spatiotemporal patterns of urban vitality in Shenzhen. Recently, BHM data, as a kind of crowdsourced data regarding human activity, provide a new angle to portray population distribution and urban dynamics [43,44].

Numerous novel studies have tapped into the BHM data as a crucial tool in the research of green spaces and parks [43,45,46], urban population aggregation characteristics [47,48], and urban structure and land use [49]. In contrast to social media data and other traditional datasets, BHM data can provide real-time analysis for the dynamics of human activities on daily or hourly intervals [43]. However, comprehensive studies using BHM data to characterize urban vitality are rare, thus this study attempts to adopt the BHM data as the proxy for describing the spatiotemporal characteristics of urban vitality in urban waterfronts.

2.2. The Relationship Between Built Environment and Urban Vitality

According to classical theories in urban planning and design [20,23,50], the built environment proves to produce significant effects on the creation of urban vitality in urban spaces. Many existing attempts to link urban analytics and design have been less well-received by urban planners and designers [32], while Salingaros [51] and Alexander [52] have called for new analytical processes, which are derived from principles in urban structure and complexity, are applied in urban design. More recently, substantial efforts have been devoted to examining the relationship between built environment and urban vitality integrated with quantitative analysis [27,32,33,41]. For example, Jacobs-Crisioni et al. [53] investigated the impact of dense and mixed land use on urban activity intensity in Amsterdam, and verified that higher densities and mixed land use contribute to higher urban vitality. Sung et al. [54] attempted to apply Jacobs's urban design theory to study the urban vitality of Seoul, and the empirical findings point to the significant role of mixed use, small-scale blocks, as well as density in improving the urban vitality. Conducted a study for five megacities in China, Xia et al. [55] found a remarkable positive spatial autocorrelation that connects urban land use intensity with urban vitality based on a local indicator of spatial association (LISA) method. Mouratidis and Poortinga [37] provided evidence that neighborhood density and land use mix are positively associated with urban vitality, whereas green space is found to be associated with lower urban vitality.

Furthermore, the traditional global regression model (e.g., OLS regression model) has been verified as an effective method in unearthing the impact of various built environment characteristics on urban vitality [27,31,41]. However, the global regression model may not be able to adequately exhibit the spatial nonstationarity and actual phenomena, as the obtained global relationships are constant within the entire study area and can only reflect the average conditions [56,57]. In this context, the geographically weighted regression (GWR) model, which overcomes the limitations of the global regression model (i.e., OLS) and can effectively solve the problem of spatial nonstationarity, was introduced to explore the geographical varying relationship by direct simulation of local nonstationary data [58–60]. Although GWR has been widely applied in many fields of applied geography [58,61,62], the efforts are still insufficient to uncover the local correlations between built environment characteristics and urban vitality in urban waterfronts.

From the above review, it is apparent that urban vitality has close associations with the built environment variables. Nevertheless, researches that put their focus on the impact of built environment characteristics on urban vitality in urban waterfronts are still limited. Furthermore, few studies have applied the GWR model to investigate the spatial variations in the influence of built environment on urban vitality. Therefore, this article serves as an attempt to extend and expand the previous research by quantifying the associations that connect built environment characteristics and urban vitality in urban waterfronts based on the BHM data and the application of OLS and GWR models.

3. Data and Methods

3.1. Study Area

Nanjing, a historical city located in the Yangtze River Delta region of eastern China, is the capital of Jiangsu Province. The Yangtze River runs through the city and divides it into two regions. The development strategy of Nanjing city centers on creating a humanistic, green and innovative modern city that enjoys international reputation and global influence [63]. For the development of Nanjing city, urban waterfronts along the Yangtze River have a great development potential, the important urban landscape and tourist resource, as well as the symbol of geography, history and culture. Combining with neighborhoods and road networks along the Yangtze River, this study focused on the urban waterfronts with a range of 3−6km from the shoreline along the Yangtze River in Nanjing.

The analytic unit for studying urban vitality is important [26]. Based on the previous research that focused on the spatial analysis of urban vitality with big data [25,33], this study applied a grid-based method (spatial resolution 1 km*1 km) as the neighborhood-scale unit to measure spatiotemporal urban vitality in urban waterfronts, and then to explore how built environment variables is related to urban vitality. As shown in Figure 1, the study area can be divided into 1239 spatial units.

3.2. Data

3.2.1. BHM Data

BHM, as a common type of crowdsourced data in China, provides a powerful tool to describe the real-time distribution, density, and dynamics of population. This crowdsourced data gathers the geolocated locations provided by the mobile phone users who use application products provided by Baidu (e.g., Baidu search, Baidu map, and Baidu cloud, etc.), and then displays the relative population distinguished by colors, where red represents high density, and blue represents low density (Figure 1). Recent studies have verified that BHM data could be used as a reasonable proxy for measuring the dynamics of human activities in different areas [29,43]. In this study, therefore, the BHM data at hourly intervals from 6:00 to 22:00 across the Nanjing city were collected on a weekday (October 14th in 2020, Wednesday) and a weekend (October 17th in 2020, Saturday) (Figure 1). In total, 34 BHMs (spatial resolution 3.5m*3.5m) were adopted for analysis.

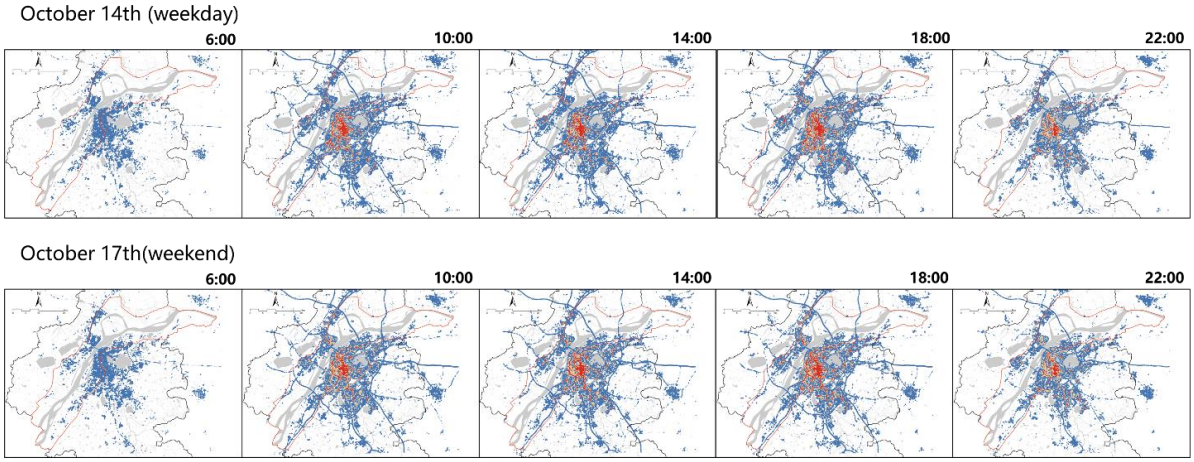


Figure 1. The sample data of BHM data collected on October 14th and October 17th in 2020.

3.2.2. Other Complementary Data

In this research, multi-source data were employed to quantify built environment characteristics, including point of interest (POI), building footprints, bus and subway stations, polygon of the Yangtze River, and the normalized difference vegetation index (NDVI) data. POI datasets were collected from Baidu map (available from https://map.baidu.com/), which

provides free API interfaces and detailed location information on geographic entities, such as commercial facilities, traffic facilities, and green spaces and squares. These data have substantially assisted many earlier related studies to reflect land use [25,27]. In our study, therefore, as many as 264,001 POIs were adopted to measure functional density and mixed use. The detailed building footprint data was also acquired from Baidu map (available from https://map.baidu.com/), and served the effort to evaluate the building density and floor area ratio. The information as to transit stations/stops were derived from Nanjing public transportation website (available from http://nanjing.gongjiao.com/). Such data, which provides useful traffic information, were utilized to measure the distance to public transport stations. Polygon data of the Yangtze River, which was derived from the Nanjing Master Planning (2011–2020) [63], was used to measure the distance to shoreline. The NDVI data (spatial resolution 30 m*30 m) was calculated based on the Landsat 8 OLI image, which was downloaded from the Geospatial Data Cloud (available from http://www.gscloud.cn/). This vegetation data was used to measure the degree of vegetation coverage for urban waterfronts.

3.3. Methods

3.3.1. Evaluating Urban Vitality in Urban Waterfronts

The BHM data, as an important population-oriented visualization product, could directly indicate real-time population density as distinguished by colors on the map [45,64]. This data ranges from 0 to 7 and the larger value means more human activities. Fan et al. [43] proposed a method to assess the vitality of urban parks through BHM data. This study adopted the BHM data-based method for measuring urban vitality and calculated the average urban vitality value of each spatial unit. The calculation was performed using a so-called "Zonal Statistics" in ArcGIS 10.5, which referenced the BHM data-based method described by Fan et al. [43]. The average urban vitality value can be quantified as follows:

$$Q_i = \frac{\sum_{i=1}^{n} A_i}{n * S_i} \quad (1)$$

Where Q_i is the average urban vitality of spatial unit i of per day, A_i is the urban vitality of spatial unit i at a given time, S_i is the area of spatial unit i, n = 6:00, 7:00, 8:00, … 22:00 (17 time slots).

3.3.2. Associated Built Environment Variables

Good built environment features tend to promote the development of vibrant streets, neighborhoods, and of course, urban waterfronts [23,31,33]. Previous studies have suggested that many built environment characteristics are associated with urban vitality, include building density, road intersections, functional density, mixed land use, greenspace, and accessibility [26,27,32,33,37,65]. Based on previous studies and data availability, we established built environment variables from four major dimensions, namely density, diversity, accessibility, and vegetation. The density dimension has three variables, namely the building density, floor area ratio, road intersections, and functional density. The diversity dimension is mainly measured by mixed use. The accessibility dimension including two variables, namely the distance to public transport stations and the distance to shoreline. The vegetation dimension is mainly measured by the NDVI. The detailed quantification variables are listed in Table 1.

Table 1. Description of built environment variables.

Dimensions	Variables	Abbr.	Descriptions	Data source
Density	Building density	*BD*	The building density of each square kilometer grid	map.baidu (2020)
	Floor area ratio	*FAR*	The floor area ratio of each square kilometer grid	map.baidu (2020)
	Road intersections	*RI*	The number of road intersections of each square kilometer grid	Open Street Map (2020)
	Functional density	*FD*	The number of POI of each square kilometer grid	map.baidu (2020)
Diversity	Mixed use	*MU*	The Shannon entropy is used to calculate the mixed use [27,41], $D = -\sum_{1}^{n} p_i \ln(p_i)$, where D is mixed use index, p_i is the proportions of each of the POI types (residential POI, commercial POI, traffic POI, office POI, science, education and health POI, and green space and square POI), and n is the number of the POI types, in this case n = 6.	map.baidu (2020)
Accessibility	Distance to public transport stations	*DPTS*	The distance to the nearest bus or subway stations of each square kilometer grid	nanjing.gongjiao.com (2020)
	Distance to shoreline	*DS*	The distance to the nearest shoreline of each square kilometer grid	Nanjing master planning (2011-2020)
Vegetation	Normalized difference vegetation index	*NDVI*	The average value of *NDVI* of each square kilometer grid, $NDVI = \frac{NIR - Red}{NIR + Red}$, where NIR denotes near-infrared band, and Red is the red band.	Landsat 8 OLI, spatial resolution 30 m × 30 m (2020)

3.3.3. Global and Local Regression Models

Initially, this article explored the relations that connect urban vitality and built environment in urban waterfronts from a global perspective. The global regression model is conducted by the OLS regression model, which serves as a commonplace and effective statistical model for research concerning urban vitality [33,66]. The OLS regression is expressed as thus:

$$y = \beta_0 + \sum_{j=1}^{m} \beta_j x_j + \varepsilon \qquad (2)$$

here y stands for the dependent variable, x_j for the j th built environment indicators, β_j for the corresponding estimated coefficient, ε and for the residual.

Second, this study investigated the spatial heterogeneity in the effect of built environment on urban vitality in urban waterfronts from a local perspective. The local regression model is conducted by the GWR model, which is a location-dependent method to characterize the spatial nonstationarity by fitting a regression model at each local observation, weighting

nearby observations around each subject point based on a distance decay function [67]. The GWR model is formulated as follows:

$$y_i = \beta_0(u_i, v_i) + \sum_{i=1}^{m} \beta_j(u_i, v_i) x_{ji} + \varepsilon_i \quad (3)$$

where i represents the spatial unit i, y_i denotes the value of urban vitality of the spatial unit i, x_{ji} is the j th built environment indicators of the spatial unit i, m stands for the total number of spatial units, ε_i denotes the random error term of the spatial unit i, (u_i, v_i) signifies the location of spatial unit i, $\beta_0(u_i, v_i)$ stands for the intercept at the location i, and $\beta_j(u_i, v_i)$ represents the local estimated coefficient of the built environment variable x_{ji}.

For the geographical weighting function, a fixed Gaussian distance decay function [56], which assumes that things in closer proximity give rise to more robust influence, is adopted in our study. The bandwidth defines the scope of the spatial weighting function and in the meantime bears on the degree of the local regression model's calibration [67]. The weighting function along with the best bandwidth size in the model adopted is determined through the corrected Akaike information criterion (AICc), which demonstrates the extent to which the model is consistent with actual phenomena, and the numbers of degrees of freedom in the varied models are considered too [68].

4. Results

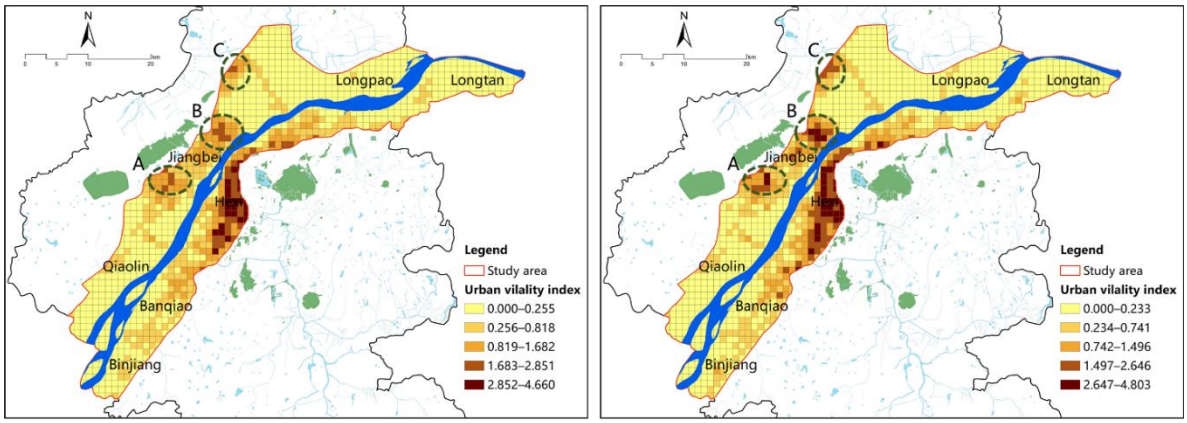
4.1. Characteristics of Urban Vitality in Urban Waterfronts

According to the BHM data, urban vitality values were classified into as many as five grades according to natural breaks in ArcGIS 10.5. In general, Figure 2 illustrates that urban vitality in urban waterfronts displays similar spatial distributions on weekdays and weekends, although local differences can be observed. Specifically, as shown in Table 2, the maximum and mean of urban vitality in urban waterfronts on weekends (maximum of 4.803 and mean of 0.382) are slightly higher than that on weekdays (maximum of 4.660 and mean of 0.380).

Table 2. The statistical characteristics of urban vitality index in urban waterfronts on weekdays and weekends

	Maximum	**Minimum**	**Mean**	**Median**	**SD**
weekdays	4.660	0.000	0.380	0.041	0.715
weekends	4.803	0.000	0.382	0.029	0.737

In addition, the distribution of urban vitality in urban waterfronts shows obvious agglomeration characteristics on both weekdays and weekends. Figure 2 demonstrates that the identified vibrant core in urban waterfronts located in the southern Yangtze River regions are the urban central areas (Hexi), whereas the northern regions are mainly town centers of Nanjing, including Zhujiang (A in Figure 2), Qiaobei (B in Figure 2), and Dachang (C in Figure 2). These identified vibrant cores are basically consistent with the urban growth of Nanjing.



(a) weekdays (b) weekends

Figure 2. Spatial characteristics of urban vitality index in urban waterfronts: (a) urban vitality on weekdays; (b) urban vitality on weekends.

4.2. OLS Regression Analysis and Global Relationships

The OLS regression model was deployed to examine the global relationship between urban vitality on weekdays and weekends and built environment characteristics in urban waterfronts. As the regression results are reported in Tables 3 and 4, BD, FAR, RI, FD, MU, DPTS, DS, and NDVI are significantly associated with urban vitality on weekdays and weekends in urban waterfronts along the Yangtze River in Nanjing. All of these variables are significant at the 0.05 confidence level. The adjusted R square is 0.850 for weekdays and 0.843 for weekends, thus verifying that the independent variables determined are able to explain 85.0% and 84.3% of the urban vitality on weekdays and weekends in urban waterfronts. In addition, this study examined the variance inflation factor (VIF) values of each built environment variable, which are all far less than 10, indicating that no multi-collinearity exists between the independent variables.

Table 3. *Regression results of urban vitality by OLS model on weekdays*

Variable	Coefficient	t-statistic	Std.	VIF
BD	1.021	5.315**	0.192	4.874
FAR	0.182	5.309*	0.034	5.784
RI	0.020	7.20**	0.003	1.983
FD	0.002	29.812**	0.000	3.085
MU	0.065	5.106**	0.012	1.813
DPTS	−0.014	−1.484**	0.009	1.447
DS	0.032	6.493**	0.005	1.362
NDVI	−0.290	−3.717**	0.078	1.383
AICs = 346.960				
Adjusted R^2 = 0.850				

* significant at the 0.05 level, ** significant at the 0.001 level.

Table 4. Regression results of urban vitality by OLS model on weekends

Variable	Coefficients	t-statistic	Std.	VIF
BD	0.690	3.407**	0.203	4.874
FAR	0.291	8.069**	0.036	5.784
RI	0.015	5.143**	0.003	1.983
FD	0.002	28.709**	0.000	3.085
MU	0.053	3.993**	0.013	1.813
DPTS	−0.016	−1.681**	0.010	1.447
DS	0.033	6.309**	0.005	1.362

NDVI	−0.269	−3.276**	0.082	1.383
AICs = 479.678				
Adjusted R^2 = 0.843				

* significant at the 0.05 level, ** significant at the 0.001 level.

Moreover, Tables 3 and 4 show that the BD, FAR, RI, FD, MU, and DS have positive associations with the urban vitality in urban waterfronts. Among all built environment variables, the BD (1.021 for weekdays and 0.690 for weekends) has the strongest positive associations with urban vitality in urban waterfronts, followed by another density variable, FAR (0.182 for weekdays and 0.291 for weekends), demonstrating that high-density is significantly correlated with sustained urban vitality. Besides, our results show that the MU (0.065 for weekdays and 0.053 for weekends) has a positive correlation with urban vitality in urban waterfronts, which overlaps with Jacobs's view that a diversity of urban functions motivate to spend more time around urban spaces and undertake varied activities. The DS (0.032 for weekdays and 0.033 for weekends) has positive associations with urban vitality in urban waterfronts, demonstrating that the more proximity to the shoreline, the lower urban vitality. As shown in Tables 3 and 4, the DPTS (−0.014 for weekdays and −0.016 for weekends) is found to have a negative association with urban vitality, thus indicating that convenient public transport can generate more urban vitality in urban waterfronts. Notably, the NDVI (−0.290 for weekdays and −0.269 for weekends) has a significant negative association with urban vitality in urban waterfronts.

4.3. GWR Analysis and Spatial Variations

A further examination with GWR models was conducted to provide an insightful understanding of the local correlations between urban vitality and built environment in urban waterfronts. As shown in Tables 5 and 6, the adjusted R-squared values of GWR models (0.880 for weekdays and 0.871 for weekends) have increased in contrast with those derived from OLS regression models (0.850 for weekdays and 0.843 for weekends). Furthermore, the AICs values of GWR models (111.032 for weekdays and 269.201 for weekends) are remarkably lower than those of OLS regression models (346.960 for weekdays and 479.678 for weekends). The improvement of adjusted R-squared values and the significant decrease in AICs values indicate that the GWR model has a better capability to interpret the correlations between built environment characteristics and urban vitality in urban waterfronts.

Table 5. Regression results of urban vitality by GWR model on weekdays

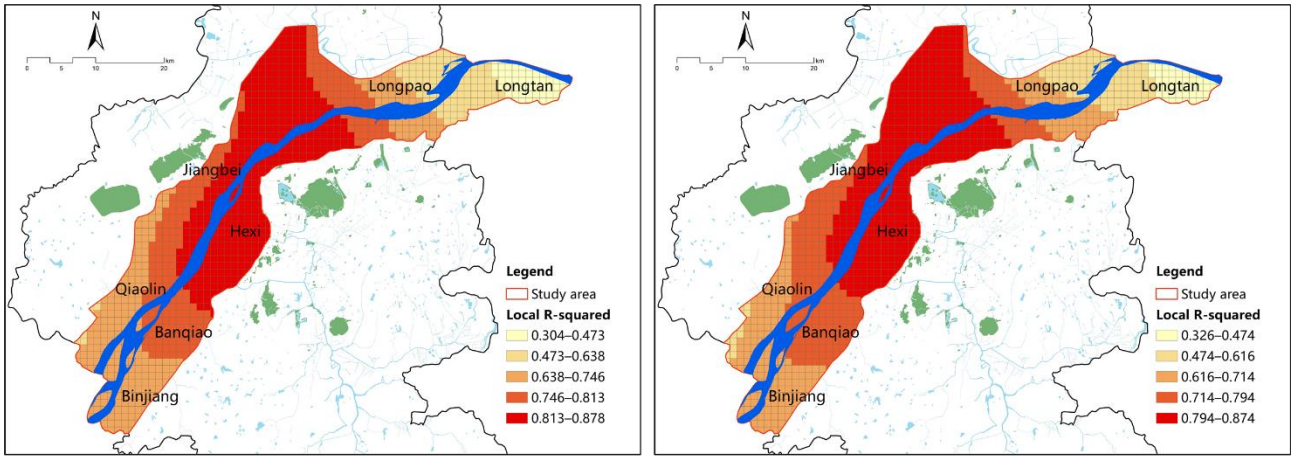
Variable	Mean	Std.	Min	Lower quartile	Median	Upper quartile	Max
BD	0.734	1.564	−1.676	−0.065	0.761	1.104	13.239
FAR	0.322	0.308	−0.609	0.194	0.539	1.084	2.646
RI	0.016	0.009	−0.008	0.011	0.014	0.023	0.037
FD	0.002	0.001	−0.000	0.001	0.002	0.002	0.004
MU	0.049	0.042	−0.041	0.021	0.035	0.079	0.183
DPTS	−0.040	0.040	−0.195	−0.059	−0.025	−0.010	−0.001
DS	0.037	0.035	−0.001	0.016	0.020	0.050	0.137
NDVI	−0.223	0.149	−0.894	−0.281	−0.188	−0.114	−0.006
AICs = 111.032							
Adjusted R^2 = 0.880							

Table 6. Regression results of urban vitality by GWR model on weekends

Variable	Mean	Std.	Min	Lower quartile	Median	Upper quartile	Max
BD	0.392	1.516	−2.913	−0.506	0.398	0.925	11.171
FAR	0.377	0.268	−0.445	0.264	0.355	0.409	2.266

RI	0.012	0.010	−0.014	0.006	0.009	0.018	0.035
FD	0.002	0.001	0.000	0.002	0.002	0.002	0.004
MU	0.030	0.035	−0.059	0.017	0.030	0.065	0.130
DPTS	−0.024	0.047	−0.214	−0.077	−0.024	−0.009	−0.000
DS	0.038	0.034	−0.001	0.017	0.026	0.048	0.141
NDVI	−0.211	0.132	−0.732	−0.269	−0.177	−0.112	−0.000
AICs = 269.201							
Adjusted R^2 = 0.871							

Figure 3 demonstrates that under the GWR models, the spatial characteristics of local R-squared values are similar on weekdays and weekends. The local R-squared values exhibit notable spatial variations, demonstrating that the explanatory capacity of the GWR models is different for the spatial location of urban waterfronts. It is obvious that the central regions of urban waterfronts (Hexi and Jiangbei) have a relatively higher explanatory capacity with the GWR models. In addition, it is detected that the spatial characteristics of the local R-squared value display a decay tendency from central regions to peripheral areas.



(a) weekdays (b) weekends

Figure 3. Spatial characteristics of local R-squared values with the GWR model: (a) local R-squared values on weekdays; (b) local R-squared values on weekends.

Figures 4 and 5 make it clear that with respect to the spatial variations of local estimated coefficients of all the built environment variables on weekdays and weekends, the deeper color represents larger coefficients. For variables positively related, darker colors stand for a stronger positive effect, while for variables negatively related, such as DPTS and NDVI, paler colors denote a stronger negative effect.

As shown in Figure 4, the BD, FAR, RI, and FD were found to have positive impacts on the urban vitality in most urban waterfronts on weekdays and weekends. Figures 4(a) and 4(b) illustrate that BD had a more significant positive impact on the urban vitality in the central and western regions of urban waterfronts (Hexi, Jiangbei, and Longtan). Figures 4(c) and 4(d) demonstrate that FAR presents a greater positive driving on the urban vitality in the eastern and western regions of urban waterfronts (Longtan and Binjiang). This influence dwindled by degrees from the outer to the center. Figures 4(e) and 4(f) show that RI had a slight positive driving on the urban vitality in the various urban waterfronts. Figures 4(g) and 4(h) depict that FD had a slight positive driving on the urban vitality in the western regions of urban waterfronts (Longtan, and Longpao), whereas a slight negative driving in the eastern regions of urban waterfronts (Binjiang).

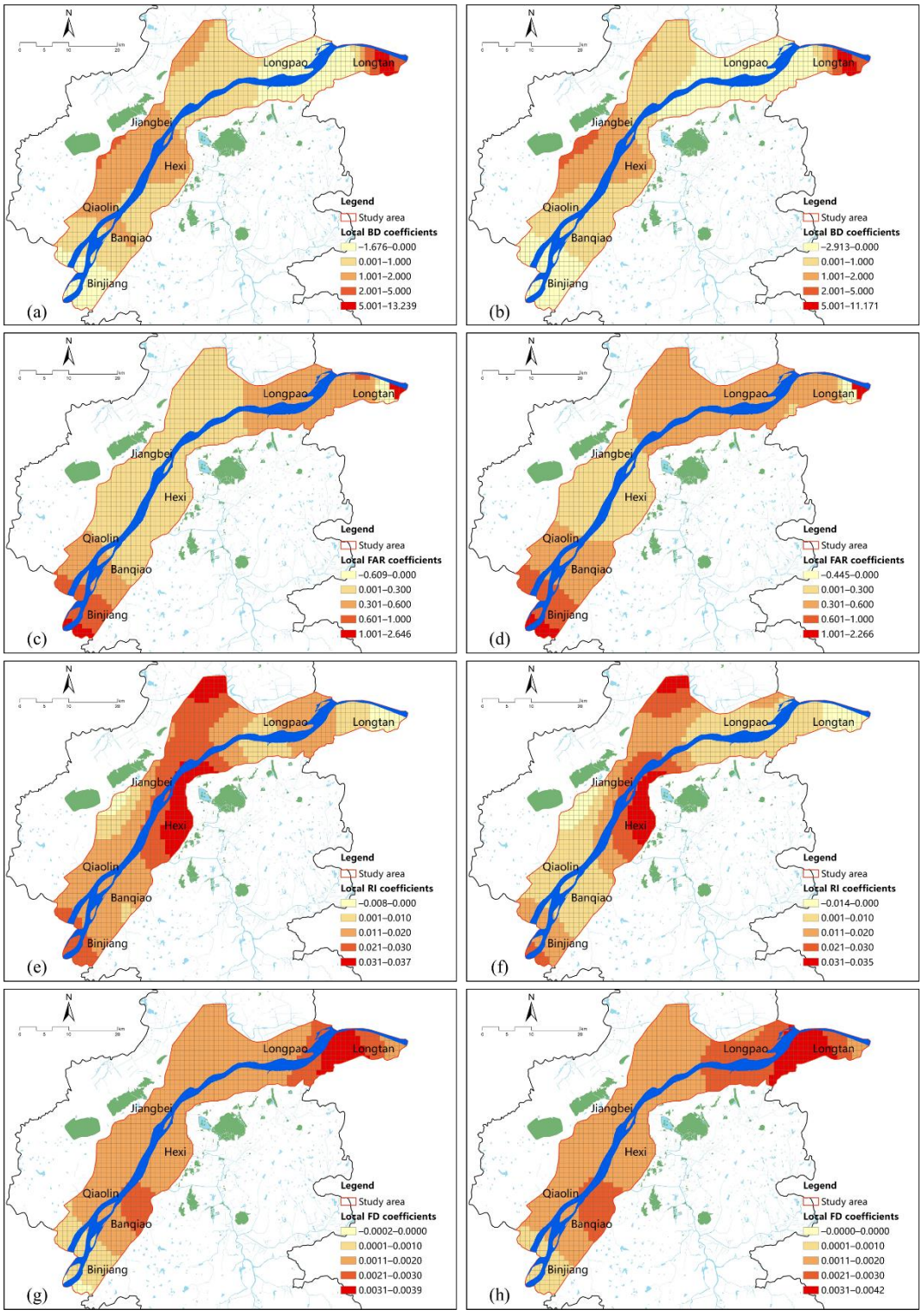


Figure 4. Spatial characteristics of estimated coefficients of built environment variables with GWR: (a) local BD coefficients on weekdays; (b) local BD coefficients on weekends; (c) local FAR coefficients on weekdays; (d) local FAR coefficients on weekends; (e) local RI coefficients on weekdays; (f) local RI coefficients on weekends; (g) local FD coefficients on weekdays; (h) local FD coefficients on weekends.

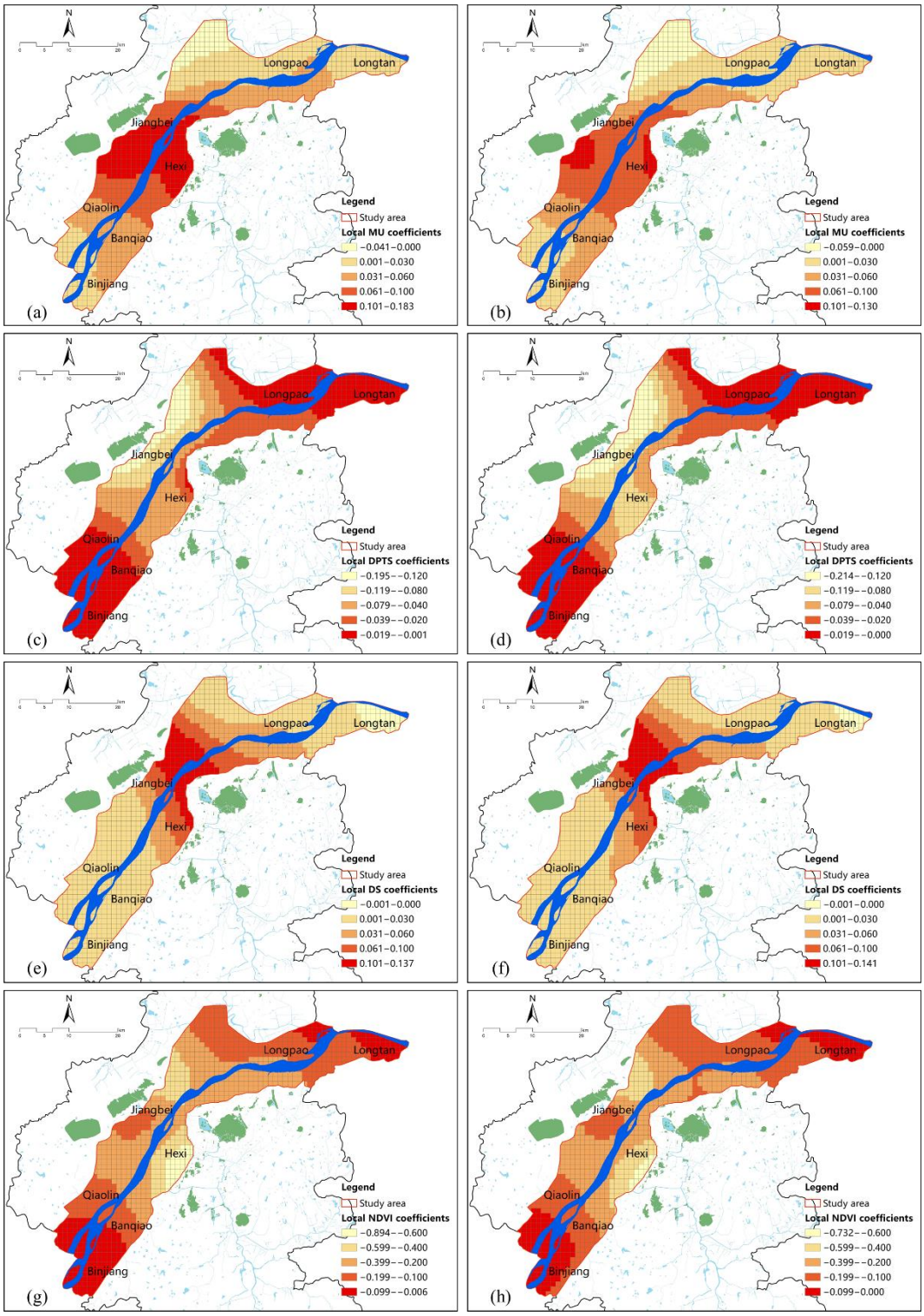


Figure 5. Continued: (a) local MU coefficients on weekdays; (b) local MU coefficients on weekends; (c) local DPTS coefficients on weekdays; (d) local DPTS coefficients on weekends; (e) local DS coefficients on weekdays; (f) local DS coefficients on weekends; (g) local NDVI coefficients on weekdays; (h) local NDVI coefficients on weekends.

As shown in Figure 5, the MU and DS were found to have positive impacts on the urban vitality in most urban waterfronts on weekdays and weekends, while DPTS and NDVI show significant negative influences on the urban vitality. For MU, a remarkable positive effect took place in the central regions of urban waterfronts (Hexi and Jiangbei), whereas a negative effect was detected in the northern area (Figures 5(a) and 5(b)). For DS, the spatial characteristics of

the correlation coefficients were higher in the central regions of urban waterfronts (Hexi and Jiangbei), and the impacts gradually decreased from the core area to the suburbs (Figures 5(e) and 5(f)). Figures 5(c) and 5(d) demonstrate that DPTS has a significant negative effect in the central regions of urban waterfronts (Hexi and Jiangbei). With regard to NDVI, a strong negative effect can be observed in various regions of urban waterfronts, and the central regions of urban waterfronts located in the southern Yangtze River regions (Hexi) have the strongest negative effect (Figures 5(g) and 5(h)).

In a word, the variables in relation to built environment characteristics and urban vitality present significant spatial variation within the whole area studied, demonstrating the spatial nonstationary relations between these variables and urban vitality in urban waterfronts. The OLS model provides the global associations that connect built environment characteristics and urban vitality in urban waterfronts, and the GWR model further discovers some distinctive differences in various regions by taking account of spatial autocorrelation and spatial heterogeneity.

5. Discussion

5.1. Towards Establishing a BHM Data-based Method for Assessing Urban Vitality in Urban Waterfronts

Emerging crowdsourced data enable urban planners and policymakers to assess urban vitality with less expense but more efficiency [24]. In particular, real-time crowdsourced data provides a dynamic perspective for urban space. However, how to develop an effective and accurate method to assess spatiotemporal urban vitality remains a challenging issue. Therefore, this study aims to propose a BHM data-based approach to assess spatiotemporal urban vitality in urban waterfronts, which is a response to the increasing interest in adopting emerging crowdsourced data and new analytical methods into urban vitality studies [25,32]. The results suggest that the distribution of urban vitality in urban waterfronts shows similar agglomeration characteristics on weekdays and weekends. Furthermore, the identified vibrant cores based on the BHM data tended to be the important city and town centers, which is largely consistent with the urban growth of Nanjing city. It is also supported by an earlier study pointing out that the identified vibrant cores are mainly town centers in Shanghai city [33]. This study suggests that the BHM data-based method can be extended to other rapidly urbanizing areas.

5.2. The Influencing of Built Environment Characteristics on Urban Vitality in Urban Waterfronts

Understanding the relationship between built environment characteristics and urban vitality could provide significant implications for cultivating more vibrant urban spaces and enhancing the urban quality of life. In this study, OLS and GWR models are employed to quantify the association between urban vitality and built environment characteristics in urban waterfronts. The OLS regression results indicate that the BD (1.021 for weekdays and 0.690 for weekends), FAR (0.182 for weekdays and 0.291 for weekends), and MU (0.065 for weekdays and 0.053 for weekends) have a remarkable influence on urban vitality in urban waterfronts. This finding can further support the importance of density and diversity in urban spaces, which was empirically evidenced by recent studies [31,32]. Dovey and Pafka [69] also provided convincing evidence that density concentrates more people and places within walkable distances and diversity produces a greater range of walkable destinations. Besides, the results show that the NDVI (−0.290 for weekdays and −0.269 for weekends) has a significant negative association with urban vitality in urban waterfronts. This suggests that more vegetation coverage may restrain the sense of liveliness. A study by Mouratidis and Poortinga [37] in Oslo metropolitan area, also found that a negative relationship exists between

green space and urban vitality. In some sense, the low urban vitality can be said to partly account for the calming and restorative effects of green spaces [70].

The GWR model also proves effective to analyze the local associations between variables under the category of built environment and urban vitality in urban waterfronts. As shown in Figures 4 and 5, the correlations of the built environment variables with urban vitality exhibit considerable spatial variations within the whole area studied. It reflects the impact of built environment variables on urban vitality has apparent spatial heterogeneity. Specifically, taking variables such as BD and MU as examples, more significant positive impacts on urban vitality in urban waterfronts were found in the central regions (Hexi and Jiangbei), whereas negative impacts were found in the peripheral area. For DPTS, a strong negative effect can be observed in the central regions (Hexi and Jiangbei), demonstrating that these regions have more convenient public transport, and then higher urban vitality. A study by Liu et al. [71] also showed that traffic access and land use mix have strong positive correlations with urban vitality in the central area rather than peripheral area. Besides, our findings suggest that the DS has positive associations with urban vitality in urban waterfronts, especially in the central regions (Hexi and Jiangbei), demonstrating that the more proximity to the shoreline, the lower urban vitality. Similarly, a study by Liu et al. [18] in Shanghai city, showed that traffic accessibility has a negative effect on the urban vitality in urban waterfronts. This could be attributable to that several urban waterfronts near the central regions in our study are characterize by less connectivity to the shoreline and monotonous landscape. Therefore, it is important to realize that the openness of shoreline and diversity landscape of urban waterfronts will enhance the vitality of urban waterfronts.

5.3. Limitations and Future Studies

This study also has several limitations. First, even though the BHM data can serve as a reliable proxy for human activities and interactions by reason that it reflects the dynamic distribution of population in urban space, this data is unlikely to represent all age and social groups (especially the older adults) and the different types of activities. Future research could attempt to combine multiple data sources (e.g., social media and mobile phone) and traditional surveys to extract more representative information for urban vitality [72]. Second, this study adopted a grid with the 1 km *1 km spatial resolution as the spatial unit to investigate the effect of built environment characteristics on urban vitality in urban waterfronts. It is likely that more granular data can help us divide urban areas into more fine-scale spatial units, in contrast to the 1 km *1 km spatial unit, and hence permit more accurate examination. Finally, this study has primarily focused on the built environment variables that affect urban vitality in urban waterfronts, while certain other variables (e.g., social economy, landscape quality, and historic culture) also have influences on urban vitality in urban waterfronts [5,8,73,74]. Researches could further explore the relationship between other variables and urban vitality in urban waterfronts under the proposed method in the future.

6. Conclusion

The increasing demands of urban residents for high-quality urban life have triggered substantial attention concerning urban vitality and built environment, as well as their relationships. However, questions about how the built environment characteristics influence urban vitality in urban waterfronts have not been thoroughly answered. Accordingly, this study proposed a method to uncover the spatiotemporal traits of urban vitality in urban waterfronts involving BHM data. Moreover, the effect of built environment characteristics on urban vitality in urban waterfronts is revealed with the OLS and GWR models. The results prove that (1) the identified vibrant cores based on the BHM data tended to be the important city and town centers, which is largely consistent with the urban growth of Nanjing city; (2) the BD has the strongest positive associations with urban vitality in urban waterfronts, while the NDVI

is negative; (3) the influences of the built environment characteristics on urban vitality in urban waterfronts have significant spatial variations.

The major contributions of this article are threefold: First, this study develops a practical approach for policymakers and urban planners to deepen the understanding of the spatiotemporal characteristics of urban vitality in urban waterfronts with the BHM data. This study demonstrates that the BHM data can serve as a reliable proxy for human activities and interactions. For future work, it may be useful to apply the BHM data in different cities for assessing urban vitality. Second, this study presents a way to examine the local relationship between the built environment characteristics and urban vitality in urban waterfronts by the GWR model. Compared with the OLS regression model, the GWR model fits the regression model at each local observation point and can greatly capture the spatial variation in the local relationship between built environment characteristics and urban vitality in urban waterfronts. Third, the study in Nanjing city proves the feasibility of the approach. Our findings suggest that high urban vitality in urban waterfronts has a strong positive correlation with the BD, FAR, as well as MU, thus appropriately increasing density and diversity may be an effective way for improving urban vitality in urban waterfronts. These findings can provide policymakers and urban planners a comprehensive overview of urban vitality, which has significant implications for vitality-oriented urban waterfronts planning and redevelopment.

References

1. Kostopoulou, S. On the revitalized waterfront: Creative milieu for creative tourism. *Sustainability* **2013**, *5*, 4578–4593.
2. Hoyle, B. Urban waterfront revitalization in developing countries: The example of Zanzibar's Stone Town. *Geogr. J.* **2002**, *168*, 141–162.
3. Keyvanfar, A.; Shafaghat, A.; Mohamad, S.; Abdullahi, M.a.M.; Ahmad, H.; Mohd Derus, N.H.; Khorami, M. A Sustainable Historic Waterfront Revitalization Decision Support Tool for Attracting Tourists. *Sustainability* **2018**, *10*, 215.
4. Ma, Y.; Ling, C.; Wu, J. Exploring the Spatial Distribution Characteristics of Emotions of Weibo Users in Wuhan Waterfront Based on Gender Differences Using Social Media Texts. *ISPRS Int. J. Geo-Inf.* **2020**, *9*, 465.
5. Hagerman, C. Shaping neighborhoods and nature: Urban political ecologies of urban waterfront transformations in Portland, Oregon. *Cities* **2007**, *24*, 285–297.
6. Girard, L.F.; Kourtit, K.; Nijkamp, P. Waterfront Areas as Hotspots of Sustainable and Creative Development of Cities. *Sustainability* **2014**, *6*, 4580–4586.
7. Shah, S.; Roy, A.K. Social sustainability of urban waterfront-the case of carter road waterfront in Mumbai, India. *Procedia Environ. Sci.* **2017**, *37*, 195–204.
8. Sairinen, R.; Kumpulainen, S. Assessing social impacts in urban waterfront regeneration. *Environ. Imp. Assess. Rev.* **2006**, *26*, 120–135, doi:10.1016/j.eiar.2005.05.003.
9. Avni, N.; Teschner, N.a. Urban Waterfronts: Contemporary Streams of Planning Conflicts. *J. Plan. Lit.* **2019**, *34*, 408–420, doi:10.1177/0885412219850891.
10. Breen, A.; Rigby, D. *The New Waterfront: A Worldwide Urban Success Story*; Thames and Hudson: London, UK, 1996.
11. Hoyle, B. Global and Local Change on the Port-City Waterfront. *Geogr. Rev.* **2000**, *90*, 395–417.
12. Cheung, D.M.-W.; Tang, B.-S. Social order, leisure, or tourist attraction? The changing planning missions for waterfront space in Hong Kong. *Habitat Int.* **2015**, *47*, 231–240, https://doi.org/10.1016/j.habitatint.2015.01.006.
13. Brownill, S. Just add water: Waterfront regeneration as a global phenomenon. In *The Routledge Companion to Urban Regeneration*; Leary, M.E., McCarthy, J., Eds.; Routledge: London, 2013; pp. 45–55.

14. Chang, T.C.; Huang, S. Reclaiming the City: Waterfront Development in Singapore. *Urban Stud.* **2010**, *48*, 2085–2100, doi:10.1177/0042098010382677.
15. Gordon, D.L.A. Managing the changing political environment in urban waterfront redevelopment. *Urban Stud.* **1997**, *34*, 61–83, doi:10.1080/0042098976276.
16. Erbil, A.Ö.; Erbil, T. Redevelopment of Karaköy Harbor, Istanbul: Need for a new planning approach in the midst of change. *Cities* **2001**, *18*, 185–192, https://doi.org/10.1016/S0264-2751(01)00010-5.
17. Wang, J.; Lv, Z. A historic review of world urban waterfront development. *City Plan. Rev.* **2001**, *25*, 41–46.
18. Liu, S.; Lai, S.-Q.; Liu, C.; Jiang, L. What influenced the vitality of the waterfront open space? A case study of Huangpu River in Shanghai, China. *Cities* **2021**, *114*, 103197, doi:10.1016/j.cities.2021.103197.
19. Wu, J.; Li, J.; Ma, Y. A Comparative Study of Spatial and Temporal Preferences for Waterfronts in Wuhan based on Gender Differences in Check-In Behavior. *ISPRS Int. J. Geo-Inf.* **2019**, *8*, 413, doi:10.3390/ijgi8090413.
20. Jacobs, J. *The Death and Life of Great American Cities*; Vintage: New York, 1961.
21. Lynch, K. *Good City Form*; MIT Press: Cambridge, MA, USA, 1984.
22. Maas, P.R. *Towards a Theory of Urban Vitality*; The University of British Columbia: Vancouver, BC, Canada, 1984.
23. Montgomery, J. Making a city: Urbanity, vitality and urban design. *J. Urban Des.* **1998**, *3*, 93–116, doi:10.1080/13574809808724418.
24. Niu, H.; Silva, E.A. Crowdsourced Data Mining for Urban Activity: Review of Data Sources, Applications, and Methods. *J. Urban Plan. Dev.* **2020**, *146*, 04020007.
25. Wu, C.; Ye, X.; Ren, F.; Du, Q. Check-in behaviour and spatio-temporal vibrancy: An exploratory analysis in Shenzhen, China. *Cities* **2018**, *77*, 104–116, https://doi.org/10.1016/j.cities.2018.01.017.
26. Yue, Y.; Zhuang, Y.; Yeh, A.G.O.; Xie, J.-Y.; Ma, C.-L.; Li, Q.-Q. Measurements of POI-based mixed use and their relationships with neighbourhood vibrancy. *Int. J. Geogr. Inform. Sci.* **2016**, *31*, 658–675, doi:10.1080/13658816.2016.1220561.
27. Wu, J.; Ta, N.; Song, Y.; Lin, J.; Chai, Y. Urban form breeds neighborhood vibrancy: A case study using a GPS-based activity survey in suburban Beijing. *Cities* **2018**, *74*, 100–108, https://doi.org/10.1016/j.cities.2017.11.008.
28. Kim, Y.-L. Seoul's Wi-Fi hotspots: Wi-Fi access points as an indicator of urban vitality. *Comput. Environ. Urban Syst.* **2018**, *72*, 13–24, doi:10.1016/j.compenvurbsys.2018.06.004.
29. Yang, J.; Cao, J.; Zhou, Y. Elaborating non-linear associations and synergies of subway access and land uses with urban vitality in Shenzhen. *Transp. Res. Part A Policy Pract.* **2021**, *144*, 74–88, doi:10.1016/j.tra.2020.11.014.
30. Long, Y.; Huang, C.C. Does block size matter? The impact of urban design on economic vitality for Chinese cities. *Environ. Plan. B Urban Anal. City Sci.* **2017**, *46*, 406–422, doi:10.1177/2399808317715640.
31. Zhang, A.; Li, W.; Wu, J.; Lin, J.; Chu, J.; Xia, C. How can the urban landscape affect urban vitality at the street block level? A case study of 15 metropolises in China. *Environ. Plan. B Urban Anal. City Sci.* **2020**, doi:10.1177/2399808320924425.
32. Ye, Y.; Li, D.; Liu, X. How block density and typology affect urban vitality: An exploratory analysis in Shenzhen, China. *Urban Geogr.* **2018**, *39*, 631–652, doi:10.1080/02723638.2017.1381536.
33. Huang, B.; Zhou, Y.; Li, Z.; Song, Y.; Cai, J.; Tu, W. Evaluating and characterizing urban vibrancy using spatial big data: Shanghai as a case study. *Environ. Plan. B Urban Anal. City Sci.* **2019**, *47*, 1543–1559.

34. Frank, L.D.; Engelke, P.O. The Built Environment and Human Activity Patterns: Exploring the Impacts of Urban Form on Public Health. *J. Plan. Lit.* **2001**, *16*, 202–218, doi:doi: 10.1177/08854120122093339.
35. McAndrews, C.; Marshall, W. Livable Streets, Livable Arterials? Characteristics of Commercial Arterial Roads Associated with Neighborhood Livability. *J. Am. Plann. Assoc.* **2018**, *84*, 33–44, doi:10.1080/01944363.2017.1405737.
36. Forsyth, A.; Hearst, M.; Oakes, J.M.; Schmitz, K.H. Design and Destinations: Factors Influencing Walking and Total Physical Activity. *Urban Stud.* **2008**, *45*, 1973–1996, doi:10.1177/0042098008093386.
37. Mouratidis, K.; Poortinga, W. Built environment, urban vitality and social cohesion: Do vibrant neighborhoods foster strong communities? *Landsc. Urban Plan.* **2020**, *204*, 103951, https://doi.org/10.1016/j.landurbplan.2020.103951.
38. Xia, C.; Zhang, A.; Yeh, A.G.O. The Varying Relationships between Multidimensional Urban Form and Urban Vitality in Chinese Megacities: Insights from a Comparative Analysis. *Ann. Am. Assoc. Geogr.* **2021**, 1–26, doi:10.1080/24694452.2021.1919502.
39. Azmi, D.I.; Karim, H.A. Implications of Walkability Towards Promoting Sustainable Urban Neighbourhood. *Procedia Soc. Behav. Sci.* **2012**, *50*, 204–213, https://doi.org/10.1016/j.sbspro.2012.08.028.
40. Filion, P.; Hammond, K. Neighbourhood land use and performance: The evolution of neighbourhood morphology over the 20th century. *Environ. Plan. B Plan. Des.* **2003**, *30*, 271–296.
41. Tu, W.; Zhu, T.; Xia, J.; Zhou, Y.; Lai, Y.; Jiang, J.; Li, Q. Portraying the spatial dynamics of urban vibrancy using multisource urban big data. *Comput. Environ. Urban Syst.* **2020**, *80*, 101428, https://doi.org/10.1016/j.compenvurbsys.2019.101428.
42. Nadai, M.D.; Staiano, J.; Larcher, R.; Sebe, N.; Quercia, D.; Lepri, B. The Death and Life of Great Italian Cities: A Mobile Phone Data Perspective. In Proceedings of the 25th International Conference on World Wide Web, Montreal, QC, Canada, 11–15 April 2016.
43. Fan, Z.; Duan, J.; Lu, Y.; Zou, W.; Lan, W. A geographical detector study on factors influencing urban park use in Nanjing, China. *Urban For. Urban Green* **2021**, *59*, 126996, https://doi.org/10.1016/j.ufug.2021.126996.
44. Tan, X.; Huang, D.; Zhao, X.; Yu, Y.; Leng, B.; Feng, L. Jobs housing balance based on Baidu thermodynamic diagram. *J. Beijing Norm. Univ. Nat. Sci.* **2016**, *52*, 622–627.
45. Zhang, S.; Zhang, W.; Wang, Y.; Zhao, X.; Song, P.; Tian, G.; Mayer, A.L. Comparing Human Activity Density and Green Space Supply Using the Baidu Heat Map in Zhengzhou, China. *Sustainability* **2020**, *12*, 7075.
46. Lyu, F.; Zhang, L. Using multi-source big data to understand the factors affecting urban park use in Wuhan. *Urban For. Urban Green* **2019**, *43*, 126367, doi:10.1016/j.ufug.2019.126367.
47. Li, J.; Li, J.; Yuan, Y.; Li, G. Spatiotemporal distribution characteristics and mechanism analysis of urban population density: A case of Xi'an, Shaanxi, China. *Cities* **2019**, *86*, 62–70, doi:10.1016/j.cities.2018.12.008.
48. Feng, D.; Tu, L.; Sun, Z. Research on Population Spatiotemporal Aggregation Characteristics of a Small City: A Case Study on Shehong County Based on Baidu Heat Maps. *Sustainability* **2019**, *11*, 6276.
49. Wu, Z.; Ye, Z. Research on urban spatial structure based on Baidu heat map: A case study on the central city of Shanghai. *City Plan. Rev.* **2016**, *40*, 33–40.
50. Gehl, J. *Life Between Buildings: Using Public Space*; Island Press: Washington, DC, USA, 1971.

51. Salingaros, N.A. Complexity and Urban Coherence. *J. Urban Des.* **2000**, *5*, 291–316, doi:10.1080/713683969.
52. Alexander, C. *The Nature of Order, Book Three: A Vision of A Living World: An Essay on the Art of Building and The Nature of the Universe*; The Center for Environmental Structure: Berkeley, CA, 2005.
53. Jacobs-Crisioni, C.; Rietveld, P.; Koomen, E.; Tranos, E. Evaluating the Impact of Land-Use Density and Mix on Spatiotemporal Urban Activity Patterns: An Exploratory Study Using Mobile Phone Data. *Environ. Plann. A Econ. Space* **2014**, *46*, 2769–2785, doi:10.1068/a130309p.
54. Sung, H.; Lee, S.; Cheon, S. Operationalizing jane jacobs's urban design theory: Empirical verification from the great city of seoul, korea. *J. Plann. Edu. Res.* **2015**, *35*, 117–130.
55. Xia, C.; Yeh, A.G.-O.; Zhang, A. Analyzing spatial relationships between urban land use intensity and urban vitality at street block level: A case study of five Chinese megacities. *Landsc. Urban Plan.* **2020**, *193*, 103669, doi:10.1016/j.landurbplan.2019.103669.
56. Fotheringham, A.S.; Charlton, M.E.; Brunsdon, C. Geographically weighted regression: A natural evolution of the expansion method for spatial data analysis. *Environ. Plan. A* **1998**, *30*, 1905–1927, doi:10.1068/a301905.
57. Fotheringham, A.S.; Brunsdon, C. Local forms of spatial analysis. *Geograph. Anal.* **1999**, *31*, 340–358.
58. Su, S.; Lei, C.; Li, A.; Pi, J.; Cai, Z. Coverage inequality and quality of volunteered geographic features in Chinese cities: Analyzing the associated local characteristics using geographically weighted regression. *Appl. Geogr.* **2017**, *78*, 78–93, doi:10.1016/j.apgeog.2016.11.002.
59. Zhao, P.; Xu, Y.; Liu, X.; Kwan, M.-P. Space-time dynamics of cab drivers' stay behaviors and their relationships with built environment characteristics. *Cities* **2020**, *101*, 102689, doi:10.1016/j.cities.2020.102689.
60. Lin, Y.; Hu, X.; Zheng, X.; Hou, X.; Zhang, Z.; Zhou, X.; Qiu, R.; Lin, J. Spatial variations in the relationships between road network and landscape ecological risks in the highest forest coverage region of China. *Ecol. Indic.* **2019**, *96*, 392–403, doi:10.1016/j.ecolind.2018.09.016.
61. Li, C.; Li, F.; Wu, Z.; Cheng, J. Exploring spatially varying and scale-dependent relationships between soil contamination and landscape patterns using geographically weighted regression. *Appl. Geogr.* **2017**, *82*, 101–114, doi:10.1016/j.apgeog.2017.03.007.
62. Wang, Y.; Dong, L.; Liu, Y.; Huang, Z.; Liu, Y. Migration patterns in China extracted from mobile positioning data. *Habitat Int.* **2019**, *86*, 71–80, doi:10.1016/j.habitatint.2019.03.002.
63. Nanjing Planning Bureau. *Nanjing Master Planning (2011–2020)*; Nanjing, China, 2017. Retrieved from http://ghj.nanjing.gov.cn/ghbz/ztgh/201705/t20170509_874089.html
64. Fang, L.; Huang, J.; Zhang, Z.; Nitivattananon, V. Data-driven framework for delineating urban population dynamic patterns: Case study on Xiamen Island, China. *Sustain. Cities Soc.* **2020**, *62*, 102365, https://doi.org/10.1016/j.scs.2020.102365.
65. Meng, Y.; Xing, H. Exploring the relationship between landscape characteristics and urban vibrancy: A case study using morphology and review data. *Cities* **2019**, *95*, 102389.
66. Tang, L.; Lin, Y.; Li, S.; Li, S.; Li, J.; Ren, F.; Wu, C. Exploring the Influence of Urban Form on Urban Vibrancy in Shenzhen Based on Mobile Phone Data. *Sustainability* **2018**, *10*, 4565.

67. Fotheringham, A.S.; Brunsdon, C.; Charlton, M. *Geographically Weighted Regression: The Analysis of Spatially Varying Relationships*; John Wiley & Sons: New York, NY, USA, 2003.
68. Akaike, H. Likelihood of a model and information criteria. *J. Econom.* **1981**, *16*, 3–14.
69. Dovey, K.; Pafka, E. What is walkability? The urban DMA. *Urban Stud.* **2020**, *57*, 93–108, doi:10.1177/0042098018819727.
70. Hartig, T.; Mitchell, R.; De Vries, S.; Frumkin, H. Nature and health. *Annu. Rev. Public Health* **2014**, *35*, 207–228.
71. Liu, S.; Zhang, L.; Long, Y.; Long, Y.; Xu, M. A New Urban Vitality Analysis and Evaluation Framework Based on Human Activity Modeling Using Multi-Source Big Data. *ISPRS Int. J. Geo-Inf.* **2020**, *9*, 617.
72. Cui, N.; Malleson, N.; Houlden, V.; Comber, A. Using VGI and Social Media Data to Understand Urban Green Space: A Narrative Literature Review. *ISPRS Int. J. Geo-Inf.* **2021**, *10*, 425, doi:10.3390/ijgi10070425.
73. Evans, G. Measure for Measure: Evaluating the Evidence of Culture's Contribution to Regeneration. *Urban Stud.* **2005**, *42*, 959–983, doi:10.1080/00420980500107102.
74. Wu, J.; Li, J.; Ma, Y. Exploring the Relationship between Potential and Actual of Urban Waterfront Spaces in Wuhan Based on Social Networks. *Sustainability* **2019**, *11*, 3298, doi:10.3390/su11123298.

Travelling in the Digital Era: Offbeat travel as a way towards Sustainability

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Abstract. In an inherently digital world (Pink 2016) societal practices such as travelling have undergone radical transformation (Dickinson et al 2014). Travel experiences can now be shared quickly and conveniently (Kang & Schuett 2013) on and through the new media platforms such as Facebook, YouTube, Instagram and Blogs. This has witnessed the emergence of new categories of niche travel such as offbeat travel in India. Offbeat travel is about making conscious choices inclined towards the local, the natural- where to stay, what to do and how to travel, to have authentic experiences as opposed to the 'staged' in commercial tourism. It encourages responsible choices during travel, contributing to a newer and holistic approach towards attaining sustainability. However, in the context of travel, sustainability has always been looked at either from the supply or demand side perspective, the focus restricted to studying attitude and behaviours towards the environment (Lin & Lee 2020, Chow, Cheng & Chuang 2019) or environmental issues. This study rather looks at offbeat travel as a holistic approach towards sustainability where the concern and a sense of responsibility exists for the local, the cultural and the natural. It follows a digital ethnographic approach, analyzing and focusing on texts, photographs, videographic posts on Facebook, Blogs, Instagram and YouTube, and conducting offline interviews of travellers and social media influencers. The boundaries of the digital field were constructed (Markham 2016) by firstly identifying the digital ecosystem of new media which facilitates the generation of travel related content, followed by locating the research relevant community, here, the offbeat travellers within this ecosystem. Results show offbeat travel naturally entails responsible travel behaviour and promotes responsible travel practices through the simultaneous documentation and preservation of the local, cultural and natural heritage of places on the new media platforms, thus leading to a more conscious and holistic approach to sustainability. The study can make significant contributions to the understanding and approach towards sustainability, specifically in a post-Covid world, and can throw light on the future of sustainable travel.

Keywords: New Media, Travelling, Digital, Sustainability, Responsible Travel

Introduction

The notion of travelling has changed with the introduction of the digital. Travel is now represented on the online social spaces of the internet, in the form of stories, podcasts, vlogs, photographs through the digital devices like mobile phones, tablets etc. This uploaded information ranges from reviews, experiences, to travel tips, suggestions and so on. This information has made travel easier and faster than ever before, as people living in an inherently digital world are always connected to each other, and thus can share information at the blink of an eye. This information is often called user-generated content. People have now turned to 'produsers', as they are simultaneously producing and consuming the content themselves. The same holds for a traveller. Travellers are now creating and co-creating experiences (Stavrianea, A. and Androniki, Kavoura 2015) through the digital. The digital thus allows the travellers to directly map their travel on the new media platforms through text, photographs and videos. Various niche categories of travel can now be identified and studied through this information. This data thus holds potential to be studied for a variety of purposes, such as understanding the changing concept of sustainability in the digital era. As the world now

realizes the need of sustainability more than ever, the concept needs to be approached in a more holistic and conscious manner. Offbeat travel, as an emerging niche category of travel in India is one such category that is constructed both online and offline. The travellers are now increasingly using the digital to represent their travel experiences. Moreover, the new media platforms allow creative presentation of these experiences which can be easily consumed by the online audience in any medium, be it text, photograph, or video. Offbeat travel is all about authentic experiences, which the traveller seeks through the local element. This however needs efforts in the decision-making process as the travellers needs to carefully differentiate the local, the authentic from the 'staged', the commercial. It is this responsible choice-making which makes offbeat travel sustainable in nature. Since these choices are made constantly while travelling, a traveller naturally becomes a responsible traveller, imbibing the responsible behaviour and thus having a conscious approach towards sustainability.

Conceptual Background

The changing nature of travel:

"As society has become networked, and networks have become ubiquitous through the use of mobile telephones, societal practices are undergoing a radical transformation, none more so than in the domain of travel" (Dickinson et al 2014). The notion of travelling has changed as it is now represented through hand-held mediums such as mobile phones on multiple social media platforms. The introduction of the digital technologies has thus transformed the way people travel, and how they experience travel. For instance, travelers now frequently use the internet in different stages of their travel, including pre-trip, on-road, and post-trip periods to plan, research, book and share experiences (Lou, 2014). Internet-based social media technologies also enable the travelers to quickly and conveniently share their travel experiences" (Kang & Schuett 2013) through photographs, videos, and texts. These digital spaces thus have "the ability to create an immersive experience to its users, where they feel as if they are "being there" (Kim, M.; Jeon, C.; Kim, J, 2017). With the advancement of internet technologies immersive experiences are now being provided by new forms of augmented reality (AR) such as virtual space tourism (Damanjov and Crouch 2017). Other than space, virtual tourism has been offering mass virtual visitations to actual tourism destinations, often acting as a substitute to actual travel (Pestek and Sarvan 2021). AR and virtual reality, which provides immersive experiences for potential tourists to explore tourism destinations prior to visiting, act as a marketing tool in the tourism sector (Dieck, Deick and Moorhouse 2018). Most studies in the context of travel have been conducted to assess tourists' understandings and motivations to travel (Griffin and Muldoon 2020).

As digitalisation has left no segment of the tourism ecosystem untouched, it is simultaneously creating a disruption in the tourism economy, bringing in new stakeholders (including travellers) who equally participate in the system. This has led to the disappearance of some of the roles of tourism industry stakeholders, and the introduction of new roles (such as increasing numbers of social media managers, developers etc. with digital skills) as well as new stakeholders such as the 'travellers' who are now playing multiple roles as content creators, decision-makers, guides, etc through UGC. They are the creators or co-creators" (Stavrianea, A. and Androniki, Kavoura 2015) of travel related content, and are simultaneously co-creating experiences (Sugathan & Ranjan 2019). Hence, with a lot of user-generated content, coming directly from the travellers and the immense use of the digital technologies in the domain of travel, there is an increasing need to understand how travellers now understand the concept of sustainability and whether the new emerging categories of travel can contribute to sustainable travel as the world today is in need to adopt sustainability in every sphere of life, more than ever.

As a result of the digital new categories of travelers have emerged such as 'global nomads' (individuals who engage in long-term mobility, travelling for three years or more between different countries, Kannisto 2014), 'digital nomads' (increased blurring of the boundaries of work and leisure allied to the growth of digital technology has given this group the freedom to work anywhere they can connect to the Internet, Richards 2015), 'smart tourists', 'backpackers, flashpackers', long-term travelers etc. Offbeat travellers are yet another category of travellers who are using the digital space to express their travel experiences. This category has been explained in detail while discussing the study. However, one should take note that the introduction of the digital has also led to the introduction and identification of niche category of travellers, those which couldn't be identified earlier due to lack of availability and accessibility of data.

Conceptual development of Sustainability in the context of travel:

Sustainability has mostly been studied either from the supply (tourism industry) and demand (tourists) side perspective in the context of travel (Sanchez and Fernandez 2016), generally for design strategies and marketing planning. This trend has been seeing changes as a lot of existing sustainable tourism studies now investigate the perspectives of the residents of the destination (Lee and Xue 2020). On the other hand, from the demand side perspective, studies have assessed the attitudes and behaviours of tourists to understand their perspectives on sustainability, and their implications for sustainable destination management (ibid). In the context of tourist attitudes and behaviours, the studies have been restricted to understanding Environmentally Responsible Behavior (ERB) (Lin and Lee 2020), ecologically responsible attitudes (Chow, Cheng & Cheung 2019), hence, focussing on attitudes and concerns of individuals specifically towards environmental issues (and in specific locations such as 'protected parks' or 'ecologically sensitive areas' such as wetlands) to improve sustainable development at these sensitive destinations. However, the introduction of the digital space to share information related to travel, has led scholars to study behaviours and attitudes using user-generated data from the new media platforms, specifically the social networking sites (SNS). For instance, Storiadris (2020) analyses the sustainable and responsible behaviour (SRB) of the 'smart tourists' (ST) influenced by the use of SNS (Social Networking Sites) during the three stages of travel cycle: pre-consumption, consumption on site and post-consumption. They prepare a framework focussing on specific dimensions of sustainability and responsible behaviour such as reading about the history of the destination, getting insights of the local culture, social context, etc., learning while engaging in tourism, influencing other fellow travellers to behave in responsible and sustainable manner in order to understand the attitude-behaviour gap and minimize their negative environmental impacts.

The concept of sustainability further gained new understandings in the wake of Covid-19. As the world realized the importance of planet earth more than ever before. There now exists a need to stimulate people to adopt new ways of thinking, behaving and operating that are more closely aligned with the goals of sustainable development. There is a need of 'global consciousness' of aligning one's ways with the goals of SD (Galvani, Lew & Perez 2020). In the context of travel, this has been seen as a 'new opportunity for a more sustainable tourism' (Romagosa 2020, Ioannides & Gyimothy 2020) as scholars predict the future of travel. Responsible tourism now holds the new and better way of achieving sustainability. Responsible tourism practices need to be based on learning from the previous flaws in order to avoid future mistakes. This leadership role can be used to build and foster sustainability approaches among consumers and households (Rausser et al., 2018) and the development of sustainable tourism strategies at all levels" (Rausser, Strielkowski and Korneeva 2021).

Methodology

Qualitative e-research is "an umbrella term used to describe methodological traditions for using Information and Communication Technologies [including social media] to study perceptions, experiences or behaviours through participants' verbal or visual expressions, actions or writings (Luke, Sloan and Anabel Quan-Hasse 2017). The study thus followed digital ethnography that "transfers the ethnographic tradition of the researcher as an embodied research instrument to the social spaces of Internet (Airoldi 2018). Purposive sampling was adopted to strategically choose the travellers travelling offbeat and seeking offbeat experiences. New media platforms of Facebook, Instagram, YouTube and Blogs were used to collect the data as these platforms allow easy transmission of the content from one medium to the other, and the consumers can easily shift from one medium to the other to consume information according to their preferences. Blogs stand as the oldest form of social media (Liza, Sarah et al 2017) and thus hold significance as one of the constant mediums through which e-WOM can be shared.

The popular search engine Google was used to retrieve a list of offbeat travellers. The search parameters included but were not limited to 'travel bloggers in India', 'top Indian travel bloggers', and 'popular Indian travellers'. A list of 46 travellers was retrieved initially which was then screened by carefully looking at the travellers' profile section, genre of travel they followed, awards and recognitions (all of which inclined towards their interests and practices of travelling offbeat). Finally, a list of 17 travellers was prepared (which was also later updated during the research process). The next step was to select the posts specifically talking about offbeat travel. This was done by firstly creating a list of synonyms for the term 'offbeat' as mentioned by Oxford, Merriam Webster and Cambridge dictionaries: peculiar, quaint, wild, strange, unusual, unconventional, rare. Secondly, certain terms used by the travellers for defining 'offbeat' travel such as unexplored, uncharted, unknown, remote, and unusual were also included in the comprehensive list. These words were used as major keywords in the 'search tab' of the digital platforms for selecting the relevant posts. The data was collected till February 29, 2020 from the date of establishment of the travellers' accounts as the study focussed on the contemporality of the posts which was impacted as a result of the Covid-19 pandemic. The selected posts were carefully stored in Word and Excel sheets for further analysis using content analysis method.

Ethics

"The fact that different ethical and philosophical frameworks… exist means that disagreement about ethical research practice in online research settings will be inevitable." (James & Busher, 2015). However, "it is important that the researcher acknowledges the ethical considerations while working with the material" collected (Budge 2018). Consent from the users on Facebook and Blogs was received before using the data (textual or visual) to include as examples in this article. "Process ethics" (Ugoretz 2017) was followed where the researcher constantly considered the ethics of the decisions as issues arose and methods were adjusted accordingly. As these new media platforms frequently keep on changing their features, and users can upload and erase information anytime they want to, it becomes more important for the researcher to keep on adjusting the ethics of decision-making while collecting the data for study.

Positionality

An inherent position which the researcher has acquired as a result of the changing advancements in technology is that of a 'digital immigrant' - "someone who did not grow up immersed in digital culture" (Prensky 2001). While this can have both advantages and disadvantages, Ugoretz (2017) writes that this makes the researcher a 'Strategic naivete' which makes her open to learning and understanding better about the community/individuals. Though the position of a researcher as an 'insider' or 'outsider' always remains in conflict

while working in a digital space, it is important to be aware of one's positioning to limit the "presuppositions, biases, assumptions, theories, or previous experiences to see and describe the essence of a specific phenomenon" (ibid). The researcher thus held the position of an insider looking at travel both as a consumptive practice within the larger tourism industry, while constantly reflecting on her position throughout the research process, to bring clarity in her positioning in future studies.

Data Handling

The users present on new media platforms have the flexibility of editing or deleting their posts anytime they want to. In-order to work with stable data set, all the posts selected were stored in a MS Word file to ensure data safety for analysis. Field Notes were also inserted into tables in MS Word with proper headings, date and time of observation. These were finally printed on A4 sheets for ease of handling the material. Other important information collected such as links to the post and date and time of posting were inserted in MS Excel sheets. Since "content analysis can be conducted with any written material as well as media such as drawings photographs and video" (Sandorova 2014), this was considered the apt method for analysis of the posts. This included a careful and holistic reading (Budge 2020) of the posts. Thematic coding was followed producing codes and themes at various stages after which the coded data was finally analysed.

Discussion

- The construction of offbeat travel

Offbeat travel, as a niche category of travel, exists in the way travellers undertake the activity of travel. This involves constantly making choices that brings one close to the local, the cultural and natural heritage of the place. A traveller seeking authentic experiences generally makes three major choices- 'where to stay', 'what to do', and 'how to travel', which also ultimately defines their offbeat experiences. Apart from this, offbeat travel is shaped by the following factors:

The traveller seeks authentic experiences through the local: The category of travellers practicing offbeat travel retains a few characteristics of the previously defined '*explorer*' who "chooses off-beat paths, arranges the trip alone, associates with the locals and resorts to comfortable accommodation" (Cohen 1972), the *'drifter'* who spurns all connections with the tourism industry, has no fixed itinerary and immerses with the local culture (Cohen 1972), and Smith's (1977) *explorer* who are very limited in numbers, looking for discovery and involvement with local people. Drawing similar characteristics from these categories, but looking for 'authentic' immersive experiences, exchanging cultural values, and understanding the ordinary as 'extraordinary' are the offbeat travellers. They do not look for 'staged experiences' as is done in commercialized tourism, are aware of 'staged authenticity'[24], rather all their choices are directed towards experiencing the place as it exists. Offbeatness to them is the suddenness of the discovery of the local, the natural, where they discover something different from that which the 'travel guide' suggests, or is customized for the tourist experience.

Offbeat travel can take place anywhere- from far away remote places to rural areas, cities etc: offbeat travel can mean going to remote, secluded areas, tucked far away from cities, major tourist hotspots, and can also be exploring one's own place of residence or a touristy

[24]MacCannell's (1973) second stage of 'front and back stage' notions of 'authenticity' where the locals perform a staged idea of authenticity for the tourists to consume.

place but through the eyes of the local. The aim is not only to find the 'unusual', 'not so popular', or 'places not suggested on the internet' but also the 'ordinary', 'everyday'.

Seasonality often plays an important role in defining offbeat travel and experiences: Seasonality is a universally recognized global tourism phenomenon" (Corluka 2019) where the general assumption is that "there will always be fewer tourists in the off seasons and with large during the peak seasons" (Rajamani & Rizal 2014). Since the traveller's choices are not guided by tourist guidebooks, and other curated package trips, they have the freedom to visit places during off seasons or any other season other than the peak which makes their experience of the place very different from that of tourists. The curiosity is about visiting a place at its original form, going an extra mile, and putting efforts to experience something different, yet the usual, just the way it exists.

Offbeat experiences can be both difficult to have and also effortless: offbeat travel can be as effortless as walking on a random road and coming across a picturesque view of the entire city from some corner of a building, or can be filled with risk and a certain amount of fear and thrill such as trekking deep into the jungle and suddenly coming across a waterfall.

The above parameters are well considered by the travellers while travelling offbeat. These are reflected on the new media platforms where the travellers share their experiences through texts, photographs and videos. The construction of offbeat travel thus takes place by answering the three questions mentioned above. These are discussed in detail in the following paragraphs:

Where to Stay? (Redefining the concept of accommodation during travel to have authentic experiences)

Offbeat travellers make choices that bring them close to the people of the place, their culture, food, and living practices. They prefer home-stays, both community and private to not only peek into the culture of the place, but to understand and become a part of it. They do not look for standardized services and hospitality as in commercial tourism, but believe in making genuine connections and establishing friendships with the locals that can last forever. Apart from these stays, offbeat experiences are defined by any stay which promises authenticity and carefully embeds both the cultural and the natural. For instance, luxury stays too can provide offbeat experiences. Travellers themselves at times select stays which provide similar experiences, thus redefining the meaning of different kinds of stays. The following table explains this and presents how the same is constructed on the online space of new media platforms:

Table:1 Accommodation

Type of Accommodation	Experiences	Meanings of Experiences

Private Home-stays	"Just as I am beginning to get restless, the gentleman (owner of the house – Mohd. Afzal) appears with a cup of tea and asks me if I have eaten anything since morning…He asks me to stay at his home for the night and pay a nominal fee." (9th January, 2018. Travelshoebum. Facebook)	• "a homelike atmosphere allowing them to experience host culture and pristine nature in more authentic way" (Yasami, Awang & Teoh 2017).
Community Home-stays	"hearing soul-stirring music echoing from a tribal hamlet in the valley below" "randomly chatting with locals as you stroll around the village, because no one is in a hurry or weary of talking to strangers" (March 6, 2017. @Shivya. Instagram)	• "a deeper connection with the community's culture, tradition, and daily life (Yasami, Awang & Teoh 2017). • "come across land, people, culture and cuisine of any place in its perfect aspect unlike hotel accommodation" (Venkatesh and Mukesh 2015),
Heritage stays	"staff at the hotel are of the sweetest souls I have met…make you feel at home…My room exuded a royal charm…Food was simply divine full of local flavours and farm freshness" (September 3, 2019. @travelseewrite. Instagram)	• staying in old properties surrounded by history, culture, as well as getting to know the life of the people who owned it. • not only preserve the histories of the place, but also contribute to local livelihoods by appointing them as caretakers of the place.
Luxury Stay	"The rooms were super comfortable and grand but the highlight again was the many different ways in which the local traditions and styles were	• the element of the local creates offbeat experiences in a place loaded with luxury

	incorporated in the interiors of the rooms and the property as such" (Spetember 29, 2013. The Wandering Soul's Wander Tales. Blog)	• The secluded location- delivering a sense of being away from the crowd and close to the culture
Nature Stay	Bird-ing and ngs to do in Anant Rasa, Shitlakhet, Almora. A Soul Window. Blog)	• Not necessarily stays claimed by nature-based tourism • Not suggested by guidebooks/tourism brochures etc. • Encountering the cultural and the natural

Source: Developed by Author, 2022

The table above clearly shows that travellers look for authentic experiences as they travel offbeat. While doing so, they redefine the meaning of accommodation by opting for stays which bring them close to the nature and culture of the place. Their offbeat travel is then defined by the choices they make to seek these experiences. These choices however also are responsible in nature as they directly benefit the local economies, respect their culture, work as support to the local communities, and ultimately leads to the preservation of the natural and the cultural heritage of the place. These choices appreciate places the way they exist. For instance, a house surrounded by lush green environment, in the vicinity of a jungle can turn into a 'nature stay' for an offbeat traveller. The following lines selected from a blog explain how the traveller found his nature stay at a house located amidst the coffee plantation:

"A bumpy and foggy ride through the coffee plantations to the home stay was exhilarating. Nestled beautifully among the coffee plantations and small hills, this cosy place is off the common travel routes…The whole morning was spent listening to the birds chirping, and the water droplets dripping".

("Sakleshpur- A Sojourn among Coffee Beans !!" April 18, 2011. Tales of a Nomad. Blog)

Places like the one mentioned above need not be necessarily a standard nature stay unlike the one presented in commercial tourism, or those designated as one by some travel agency/tourist organization. There are many places like these where travellers find their offbeat experiences by exploring and experimenting with their choices, responsible choices inclined towards local and authentic experiences, and thus leading to the practice and promotion of responsible travel.

What to do? (gaining offbeat experiences through the local, the cultural and the natural)

Offbeat travellers avoid sight-seeing as in commercial tourism, but are rather interested in socializing and interacting with the locals, participating in their everyday activities, local

festivals, understanding their customs and rituals, adjusting with the local's lifestyle and pace of life, savouring local food, visiting places suggested by locals, and so on.

Travellers are rather interested in understanding the place and its people. They make certain choices to gain offbeat experiences, choices inclined towards the local, cultural and natural heritage of the place. The following points summarize what these offbeat travellers do to gain offbeat experiences and how these firmly align with the characteristics of responsible travel as well:

- *Socializing with the locals:* Travellers find interacting with the locals to be one of the best ways of understanding the place as the "local's sense of place is primarily shaped by aspects in everyday life: occupation, property, social relationships" (Klanicka et al 2006) and so authenticity. The feelings they associate with it are mostly 'happiness', 'peacefulness', 'belonging', 'affection', feeling of being 'welcomed' and 'accepted' etc. Not only do they wish to be friends with them, but it is about establishing meaningful connections. Offbeat travel to them is exchanging stories with the locals, and respecting their stories. This in-turn provides the locals a healthy space where they can freely express themselves, thus bringing their stories directly to the world. This further encourages and promotes responsible travel to a larger audience online. Socialization takes place through random interactions on the streets, randomly chatting with the locals, participating in the local's everyday lives by tagging along with them in their everyday chores, attending their ceremonies and rituals if allowed, participating in festivals, savouring local food with them.

Table:2 Gaining offbeat experiences through the local, cultural and natural heritage

What they (travellers) do?	Experiences	Experiences leading to Responsible Travel
• Random everyday chats and encounters with the locals	Like when I walk in the mornings to the river Cauvery, where the locals cross the river on their metal coracle boats with a rope, I chat with an old woman who work in the coffee plantations and smartly dressed young girls on their way to school- even if there isn't much of a common language between us." (February 27, 2018. @shivya)	Understanding and respecting the local's way of life
• The Local: A traveller's guide to a place	"But as it turns out, this famous temple that only the locals know about and frequent, also happens to have the best view of the entire Himalayan Range in Kumaon."	Avoiding tourist guide-books, taking suggestion from locals, experiencing the place through the local's eye.

	(January 21, 2016. @neelima. Instagram)	
• Seeking hospitality from the locals	"Whether seeing them harvesting in the fields, cooking traditional cuisine, working in their homes, food habits, or hearing folklore, I got to see their way of life up close" (Why I chose Himalayan Farmstays in Phyang Village…October 21, 2019. My Travel Diary. Blog)	Rejecting the standard definition of hospitality as provided by the tourism industry, rather focussed on exchanging cultural, social, environmental values with their hosts.
• Participating in Local festivals	"#mountainpeopleunite", "#friendship", "#celebration", "#bridaldance", "#lifeinaremotearea (August 1, 2019. @sandeepachetan. Instagram)	chanced encounters with local festivals, indirectly contributing to the cultural sustainability of the place
• Savouring local food	"In typical Kashmiri style, a "table turner" was set up before us. Porcelain cutlery followed. The cups and saucers were soon filled with Kashmiri Shirchai (salted tea) with fresh baked roth (local biscuits). ("Kashmir travel itinerary: Offbeat and for all. April 5, 2016. Sandeepachetan's Travel Blog. Blog)	desire for local food indirectly has "positive effects on local resident's sense of cultural belonging" (Stalmirska, A. 2021)

*Table continued on next page

Apart from the different ways of socializing with the locals, there are other activities which the travellers like doing to gain the true essence of a place and its people. These activities indirectly result in contributing to the development and upliftment of local communities. They not only lead to the promotion and preservation of the cultural and natural heritage of the place, but also instil a sense of pride among the locals about their heritage. The following are the examples for the same:

- *Informed choices to experience the Local: Going offbeat by being an Informed traveller:* Many entrepreneurships in the sector of travel and tourism have their policies inclined towards sustainable practices, going local in every way possible, involving local communities. Such places provide the travellers the opportunity to be directly in touch with the locals, and also to indirectly reduce their carbon footprint by choosing

the sustainable, the eco-friendly. By taking informed decisions to gain offbeat experiences, travellers thus become responsible travellers. Traveller Shivya Nath chose the community home-stay at Munsiari, a small village located in the state of Uttarakhand, India to have her offbeat experience. This community home-stay is entirely run by the woman of the village and is supported by Himalayan Ark (a social enterprise that has aided local women to set up homestays, directly earn revenues from their homestays, and trained them as trekking and birdwatching guides). By making an informed choice, Shivya directly contributed to the development of the community. The following table shows how she gained her offbeat experience by contributing to the community she stayed with:

Table: 3 Gaining offbeat experiences by making Informed choices

Practices leading to Responsible Travel	**Traveller's way of gaining offbeat experiences**
Getting involved in local projects, helping them grow by sharing knowledges, thus contributing back to the place	volunteered for a digital workshop organized by Wikipedia in the village, helped open an Instagram channel – "a channel where teens and adults share pictures and stories of things that matter to them: the 50-odd bird species in their backyard, the joy of school holidays" (www.cntraveller.in)
Joining hands for a better tomorrow	helped the women to achieve the required skills of running their Instagram page by organizing an Instagram and photography workshop,
Being responsible: Understanding the social and environmental issues of the place and its people:	attended the women self-help group meetings, assisted them in planting seeds in their new polyhouse, supported their complaints to the local magistrate's office, lent her ears to the stories of everyday lives of local women
Using the social media platform to support local's initiative	used her blog page to raise funds for the community, made the readers aware of their initiative, and also sought for ideas for improving the digital skills of the people from her online audience to support the community from far awa

Source: Developed by Author, 2022

Travellers feel for the places they travel to and the people they encounter. They exhibit a sense of concern and care both for the culture and the nature of the place. This makes them want to give something back to the place, which has provided them with offbeat experiences. They have their own ways of doing so. However, it was understood through the data that they are majorly concerned with the environmental impacts of overtourism and so they do their bit to make the locals as well as the prospective travellers aware of it. They undertake self-initiated projects which leads to the preservation and protection of their planet. For instance, Shivya started her own campaign called 'I love Spiti' involving the locals and the travellers passing by to make the valley of Spiti plastic free. For this, she organized meetings with local stakeholders to install water re-fill stations, met with women SHG to talk about adverse effects of storing water in plastic bottles, and also did an art-work installation of 'I Love Spiti' near

one of the main entrances to the valley, so that the tourists passing by can receive their message:

Image:1 Art-work installation from used plastic bottles conveying the message to make the valley plastic-free. (Source: September 20, 2017. The Shooting Star. Blog)

How to Travel? (gaining offbeat experiences by travelling responsibly)

Offbeat travellers choose to travel in a way that makes them absorb the place, and experience it holistically. They prefer certain modes of travel that allow them to do so, such as cycling, walking, strolling around, hitch-hiking, hiking etc. They rather choose *local transport* or *alternate modes* of transport over personal vehicles, which provides them with opportunities to strike a conversation with the locals, know about their everyday lives, often ending up in finding a stay at a local's house, savouring the local cuisine with a local family, or getting to know about a 'hidden' place**.** These ways of travelling are also eco-friendly in nature, reducing one's carbon footprint, and thus minimizing the negative impacts of tourism at a micro-level. These are responsible ways of travelling.

Table:4 Gaining offbeat experiences by travelling responsibly

Walking	prefer exploring places at their desired pace and choose random paths, which often leads them to 'unknown' destinations, observe and absorb the everydayness of a place, hence something which is unusual, and non-touristy.	"walking in quiet streets… randomly stopping by a family run eatery to have Goan thali" (October 16, 2018. @bikepacking_trekker)
Cycling	"intimate contact with nature and contact with local population, as well as access to the places off the beaten track or remote territories" (Hannam, Zuev & Witte 2021).	"We've been riding our bicycles everywhere. Cafe-hopping, golden sunsets, art galleries, architecture that has stood the test of time …old trading settlements, the smell of spices, priceless antiques. There's so much to discover in the quaint by-lanes." (February 29, 2020. @shivya)

Strolling around	Sudden encounters with the people and their culture, their everyday lifestyles	"There are some feelings a photo can't capture… or randomly chatting with locals as you stroll around the village, because no one is in a hurry or weary of talking to strangers…"[25] (March 6, 2017. @shivya)

Source: Developed by Author, 2022

The travellers wish to travel at their own pace; stopping by at random pit-stops, soaking in the surrounding environment, going to places otherwise inaccessible by four-wheelers etc. For instance, Travellers Sandeepa and Chetan believe that one can have the pleasure of offbeat experiences and also travel responsibly, as they rejoice in *slow travel* which according to them is more about connecting with the locals and giving back to the place: *"Just walk around in the by-lanes. Maybe take a bus route that only the locals take? Or sit in a café and sense the beat of the place. Talk to the waiter or the guy who comes here for breakfast everyday. Why not ask him what he does on his week-ends? What's his favourite museum/garden/palace/church?*[26] These responsible ways of travelling indirectly leads one to travel sustainably. These ways are not adopted rather they are a natural way of finding offbeat experiences, being close to the culture and nature of the place.

Conclusion

The three questions which the travellers ask themselves answer how offbeat experiences are gained through choices that ultimately contribute to sustainability in travel. These choices are made taking time and efforts and so these are informed choices, providing the travellers an immersive and holistic experience through the people, the culture and nature of the place. These choices firmly align with the characteristics of responsible travel; contributing to the local economy, supporting the communities especially women and children, reducing the negative impacts of tourism, contributing to the preservation of the natural, social and cultural heritage of the place, understanding the local, environmental and social issues of the place, being culturally sensitive and respecting the local culture, trying to learn about the culture, and so on. The difference which offbeat travel makes is the construction of offbeat travel on the online spaces of new media platforms lead to the simultaneous documentation and preservation of the local, the cultural and the natural. This documentation of the consciousness and awareness of the local, the cultural and the natural indirectly promotes responsible travel behaviour and responsible travel practices to the online consumers, often those who are prospective travellers. Offbeat travel thus introduces a way of travelling which has more to do with travel ethics and travel behaviour. It highlights the significance of bringing in responsible behaviour in every aspect of travel so that sustainability can be approached in a holistic manner. It pushes on the idea of travelling consciously, and making responsible choices, not only to gain authentic experiences, but also to bring sustainability in travel. It thus encourages a more holistic approach towards attaining sustainability.

References:

1. Airoldi, Massimo. 2018. "Ethnography and the Digital Fields of Social Media". International Journal of Social Research Methodology. 21 (6): 661-673.
2. Budge, Kylie. 2018. "Visitors in Immersive Museum Spaces and Instagram: Self, Place-Making, and Play." The Journal of Public Space, no. Vol. 3 n. 3.

[25] https://www.instagram.com/p/BRTFwc1gjrl/ (Accessed September 19, 2020)
[26] https://sandeepachetan.com/slow-travel-responsible-cheaper/ (Accessed January 20, 2021)

3. 121–38. https://doi.org/10.32891/jps.v3i3.534.
4. Budge, Kylie. 2020. "Visually Imagining Place: Museum Visitors, Instagram, and the City". Journal of Urban Technology. 27 (2): 61-79.
5. Chow, Alice S.Y., Irene N.Y. Cheng, & Lewis T.O. Cheung. 2017. "Self-Determined Travel Motivations and Ecologically Responsible Attitudes of Nature-Based Visitors to the Ramsar Wetland in South China." Annals of Leisure Research 22 (1): 42–61. https://doi.org/10.1080/11745398.2017.1359791
6. Cohen, E. 1972. "Toward a sociology of inter-national tourism". Soc. Res. 39(1):164-82
7. Corluka, Goran PhD. 2019. "Tourism Seasonality - an Overview." Journal of Business Paradigms, January. https://www.academia.edu/40454689/TOURISM_SEASONALITY_AN_OVERVIEW
8. Damjanov, Katarina, & David Crouch. 2018. "Extra-planetary mobilities and the media prospects of virtual space tourism". Mobilities. 13 (1): 1
9. Dario tom Dieck, M. Claudia tom Dieck, Timothy Jung & Natasha Moorhouse (2018) Tourists' virtual reality adoption: an exploratory study from Lake District National Park, Leisure Studies, 37:4, 371-383, DOI: 10.1080/02614367.2018.1466905
10. Dickinson, Janet E., Karen Ghali, Thomas Cherrett, Chris Speed, Nigel Davies, & Sarah Norgate. 2012. "Tourism and the Smartphone App: Capabilities, Emerging Practice and Scope in the Travel Domain." Current Issues in Tourism 17 (1): 84–101. https://doi.org/10.1080/13683500.2012.718323.
11. Dimitri Ioannides & Szilvia Gyimóthy (2020) The COVID-19 crisis as an opportunity for escaping the unsustainable global tourism path, Tourism Geographies, 22:3, 624-632, DOI: 10.1080/14616688.2020.1763445
12. Galvani, A., Lew, A. & Perez, M. S. 2020. "COVID-19 is expanding global consciousness and the sustainability of travel and tourism." Tourism Geographies, 22:3, 567- 576, DOI: 10.1080/14616688.2020.1760924
13. Hannam, Kevin, Gareth Butler, Alexandra Witte, & Dennis Zuev. 2021. "Tourist's Mobilities: Walking, Cycling, Driving and Waiting." Tourist Studies 21 (1): 57–69. https://doi.org/10.1177/1468797621992931.
14. James, Nalita & Hugh Busher. 2015. "Ethical issues in online research," Educational Research and Evaluation 21, no. 2: 89-94, 89
15. Kang, M. & Michael A. Schuett. 2013. "Determinants of Sharing Travel Experiences in Social Media." Journal of Travel & Tourism Marketing. 30. 107 - 93.
16. Kannisto, P. 2018. "Travelling like locals: Market resistance in long-term travel". Tourism Management, 67, 297–306. DOI:10.1016/j.tourman.2018.02.009
17. Kim, Mingyu, Changyu Jeon, & Jinmo Kim. 2017. "A Study on Immersion and Presence of a Portable Hand Haptic System for Immersive Virtual Reality" Sensors 17, no. 5: 1141
18. Klanicka, Susanne, Matthias Buchecker, Marcel Hunziker, & Ulrike Müller-Böker. 2006. "Locals' and Tourists' Sense of Place." Mountain Research and Development 26 (1): 55–63.
19. Kurtz, Liza C., Sarah Trainer, Melissa Beresford, Amber Wutich, & Alexandra Brewis. 2017. "Blogs as Elusive Ethnographic Texts: Methodological and Ethical Challenges in Qualitative Online Research." International Journal of Qualitative Methods.
20. Lee, S.W., & Xue, K. 2020. "A model of destination loyalty: integrating destination image and sustainable tourism". Asia Pacific Journal of Tourism Research, 25:4, 393-408

21. Luo, X., S. Huang, & G. Brown. 2014. "Backpacking in China: A Netnographic Analysis of Donkey Friends' Travel Behaviour". Journal of China Tourism Research. 11 (1): 67-84.
22. Pestek, A. and Sarvan, M. (2021), "Virtual reality and modern tourism", *Journal of Tourism Futures*, Vol. 7 No. 2, pp. 245-250. https://doi.org/10.1108/JTF-01-2020-0004
23. Pink, Sarah, Heather A Horst, John Postill, Larissa Hjorth, Tania Lewis, & Jo Tacchi. 2016. Digital Ethnography: Principles and Practice. London; Thousand Oaks, California: Sage Publications
24. Rajamani, Asokan & Rizal, Dr. Praveen. 2014. "Seasonality of Tourism: A major constraint for the growth of tourism in the regional economy of Sikkim state, India". International Journal of Current Research. Vol. 6, Issue, 06, pp.7211-7218, June, 2014
25. Rausser G., Strielkowski W., Korneeva E. 2021. "Sustainable tourism in the digital age: Institutional and economic implications". Terra Economicus 19(4): 141–159. DOI: 10.18522/2073- 6606-2021-19-4-141-159
26. Richards, Greg. 2020. "Designing Creative Places: The Role of Creative Tourism." Annals of Tourism Research 85 (November): 102922. https://doi.org/10.1016/j.annals.2020.102922.
27. Romagosa, Francesc. 2020. "The COVID-19 crisis: Opportunities for sustainable and proximity tourism". Tourism Geographies, 22:3, 690-694, DOI: 10.1080/14616688.2020.1763447
28. Sanchez, Y., Fernandez, P. 2016. "In search of the pro-sustainable tourist: A segmentation based on the tourist "sustainable intelligence"", Tourism Management Perspectives, 17:3, 59-71
29. Sandorova, Z. 2014. "Content analysis as a research method in investigating the cultural components in foreign language textbooks". Journal of language and culture education, pg. 95- 123.
30. Sloan, Luke, & Anabel Quan-Haase. 2016. The SAGE Handbook of Social Media Research Methods, 55 City Road, London: SAGE Publications Ltd.
31. Smith, V. L. (ed.) 1977. "Hosts and guests: The anthropology of tourism". Philadelphia: University of Pennsylvania Press.
32. Stalmirska, Anna Maria. 2021. "Local Food in Tourism DestinationDevelopment: The SupplySide Perspectives", Tourism Planning & Development
33. Stavrianea, A., & Androniki Kavoura. 2015. "Social Media's and Online User-Generated Content's Role in Services Advertising." https://doi.org/10.1063/1.490785
34. Sugathan, Praveen, & Kumar Rakesh Ranjan. 2019. "Co-Creating the Tourism Experience." Journal of Business Research 100 (July): 207–17. https://doi.org/10.1016/j.jbusres.2019.03.032.
35. Tom Griffin & Meghan Muldoon (2020) Exploring virtual reality experiences of slum tourism, Tourism Geographies, DOI: 10.1080/14616688.2020.1713881
36. Ugoretz, Kaitlyn. 2017. "A Guide to Unobtrusive Methods in Digital Ethnography" https://www.researchgate.net/publication/331287677_A_Guide_to_Unobtrusive_Methods_in_Digital_Ethnography.
37. Venkatesh, R. & Mukesh, H.V. 2015. "The Role of Homestays in promoting Rural Tourism." Global Journal for Research Analysis, 4(4), 1-3.
38. Yasami, M., Awang, K., & Teoh, K. 2017. "Homestay Tourism: From the Distant Past up to Present". PEOPLE: International Journal of Social Sciences, 3(2), 1251-1268

Study status quo and propose sustainable livelihoods models at Thuong Lo commune, Nam Dong district, Thua Thien Hue province

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Abstract. Thuong Lo is a mountainous commune with more than 90% ethnic minorities; the livelihood of the commune people is mainly agricultural and forestry production. People's livelihood activities take place in terrain, land, water sources, and weather with many disadvantages; the level and methods of agricultural production and cultivation are still minimal, mainly manual, low productivity, systematic risk, and natural disasters. The article used sociological survey methods, in-depth interviews, and expert methods… to assess livelihood sources and the current status of livelihood models at Thuong Lo commune, Nam Dong district. Based on recent research, the article proposes to replicate highly effective models and builds new livelihood models with higher levels of sustainability in the context of increasingly complex climate change. Some proposed sustainable livelihood models suitable for the locality include the community tourism linkage chain, model of linking and developing non-timber forest products value chain, garden economy model, combined organic animal husbandry, and cottage industry…

Keywords: sustainable livelihoods, models, Thuong Lo commune.

1. Introduction

The term livelihood was first used in the mid-1980s by Robert Chambers, then developed by Chambers, Conway (1992). The concept of livelihood is understood as "livelihood consisting of the necessary possibilities, resources, and activities as means of living for people" (Chambers & Conway, 1992).

Based on the above concept, many scientists and other organizations have developed the concept of livelihood. In 2001, UK Department for International Development (DFID) introduced the concept of livelihood to guide its support activities. Accordingly, livelihoods "include the abilities, resources, and activities necessary as means of living for people" (Chambers & Conway, 1992). A livelihood consists of possibilities, assets (including both material and social resources), and necessary activities to earn a living. In development, the concept of livelihood is always associated with the need for sustainable development and cannot be separated.

Researchers have proposed a sustainable livelihoods framework to assess the sustainability of livelihoods. A livelihood analysis framework is a comprehensive model that puts people at the center of the analysis process to develop development strategies. DFID (2001) and most studies suggest that humans rely on five primary sources of capital: human, natural, material, financial, and social to secure livelihoods or reduce poverty (DFID, 2001).

Sustainable livelihoods were first proposed by Swa minathan (1991) and are defined as “livelihood options include ecological security, economic efficiency, and social equity while emphasizing the articulated and harmonious relationship between ecological, economic

and social systems". Sustainable livelihoods are consistent with sustainable development and have rich connotations. According to Chambers & Conway (1992, page 296) (Chambers & Conway, 1992), sustainable livelihood development also entails preserving and advancing present and future livelihood methods, such as intergenerational equity. At the macro level, sustainable livelihoods require population stability, relief from environmental pressures, orderly economic development, and sustainable resource management. At the micro level, sustainable livelihoods require farmers to have enough food and money to meet their basic needs; availability of resources, income, and collateral that help them maintain and hedge against risks (McCracken & Pretty, 1988) (McCracken & Pretty, 1988). In Vietnam, some livelihood researchers have synthesized the concept of livelihood and applied it to practice. When researching rural areas, Duy Hop and his colleagues deeply analyzed the motivation and the selection of suitable livelihood models based on the theory of Khinh - Trong. This perspective allows households to choose one or the other livelihood model and the factors influencing their choice (Hop, 2007). Research by Vo Tong Xuan and his colleagues is concerned with the issue of livelihood when it is related to land issues. Recently, livelihood research has focused a lot on transforming the economic structure of human communities and groups.

The study by Ngo Phuong Lan on agricultural restructuring from rice farming to shrimp farming in the Mekong Delta, a new direction of livelihood development, analyzed people's motivations and goals, emphasizing the role of social capital in choosing livelihoods (Lan, 2014). Or Nguyen Van Suu (2014), Nguyen Duy Thang (2007), and Chu Manh Trinh's scholarly research on the livelihoods of those living on the outskirts of Hanoi during the urbanization process in 2008 (Trinh, 2008). Nguyen Van Suu has presented a sustainable livelihood strategy that fosters growth and lessens poverty (Suu, 2015). In Cat Tien National Park, Nguyen Dang Hiep Pho (2016) adopts a framework for sustainable livelihoods (Pho, 2016) to give employment opportunities to ethnic minorities. In the coastal areas of Nam Dinh province, poverty and current livelihoods are studied by Tran Thi Hong Nhung (2017) (Nhung, 2017). In Nghe An (Hao, 2017), Bui Minh Hao (2017) researches sources of livelihood capital and suggests livelihood models. Most authors stress the importance of land, social capital, and connected ties in economic development and allude to the variables that influence people's livelihoods, risk tolerances, and means of subsistence.

Thuong Lo is a mountainous commune with more than 90% ethnic minorities. People's livelihood is mainly agricultural and forestry production in the unfavorable terrain, land, water sources, and weather conditions; the level of a part of the people is still limited; agricultural production and farming methods are still backward... Main livelihood activities include farming, animal husbandry, forestry, and aquaculture. Over the years, the state and local authorities have paid attention to and supported people in developing production and diversifying livelihoods. There has been a transformation in the structure of crops with economic value, the formation of model gardens, and projects on breeding cows and hybrid pigs have been implemented. They have brought specific results, contributing to creating jobs, gradually stabilizing life, and reducing poverty for households. However, in general, besides the achieved results, there are still many limitations that are: Intensive farming, restructuring of valuable crops in the villages is still slow, the proportion of sample gardens is little and does not meet the criteria, the quality of gardens is not high, inefficient mixed gardens account for a relatively high proportion, many gardens bring low income (Results of the Implementation of the Project on Economic Development of the Garden in the Period of 2017-2021., 2021).

The main reason is that the application of science and technology to farming in the locality is still limited; the people have not paid investment in intensive agriculture and plant care due attention, and the garden area is still small and fragmented. A part of some people still have the thought of relying on the investment and support of the state; people have not

yet dared to set up a garden. Agricultural production activities in the condition that the terrain is mainly mountainous, and the climate has many abnormal fluctuations such as floods and droughts, the cultivation area of the households is fragmented (Report Summarizing Agricultural Production Tasks in 2021 and Implementing the Winter-Spring Crop in 2021-2022, Agricultural Production Plan in 2022., 2022). Therefore, the construction of sustainable livelihood models in Thuong Lo commune is an urgent issue for Thuong Lo commune people to contribute to sustainable poverty alleviation for ethnic minorities and ethnic minorities. Limit human impact to the extent to which the ecosystem can recover and re-develop.

2. Research Methods

Methods of data collection, analysis, and processing: Including collecting and analyzing primary and secondary data and related documents from Thuong Lo Commune People's Committee, Commune Statistics Office, Department of Agriculture, Department of Cadastral, Department of Natural Resources and Environment, Department of Agricultural Extension, Veterinary Medicine... to give an overview and conclude the current socio-economic development situation in Thuong Lo commune. . We use the software Excel, SPSS, Arcgis, Mapinfo… to analyze qualitative and quantitative data, charts, diagrams, and maps (Son et al., 2013).

Sociological survey method: the authors have built 01 survey form for households with survey content about main livelihoods, livelihood capital, income, experiences, and innovations livelihoods of households in commune.. In this method, we use Slovin's (1984) formula to determine the number of survey samples (Son & Quan, 2021):

$$n = \frac{N}{1 + N * e^2}$$

In which, n: sample size to be determined

N: overall size.

e: permissible error. Usually, three commonly used error rates are ±01 (1%), ±0.05 (5%), and ±0.1 (10%), of which the most common is ±0.05.

Total survey questionnaire 186 household votes. Investigation period: from May 2022 to June 2022.

Criteria for selecting households to participate in the interview, the person chosen to participate in the discussion must satisfy the following conditions:

+ Age: from 25 years old and up.

+ Relationship in the household: the head of the household, the main source of income for the whole family.

+ Time of settlement: at least five years living in the survey area.

In-depth interview method: Using semi-structured interview method: a) Interviewing households (information on livelihood sources, income, people's awareness of sustainable livelihood development, damage level) due to the impact of climate change and extreme climate phenomena...); b) Interview with local authorities (information on socio-economic development, development orientation, knowledge and experience in adapting to extreme climate phenomena...). The collected information is for local authorities after processing. If there is a lack of information, a direct phone interview will be conducted to supplement the data on the topic to achieve the best results (Son et al., 2014).

Interviewees include the Head of Commune Economic Department, Vice president of the commune; Head of the Department of Natural Resources, Environment and Agricultural

Extension, Border Guard, and Chairman of Farmers Association.

Expert method: This method is applied in the research process to get the opinions of scientists in assessing the effectiveness of socio-economic and environmental aspects and the current status of economic models. Ecological economy; seek advice on solutions to develop sustainable livelihood models for mountainous communes. Use expert methods to establish criteria for the evaluation process. We have sent questionnaires to 06 experts, asking for opinions on the requirements and the weight of the bars. After synthesizing experts' views, the authors have completed the set of standards to serve the research process of the topic (Lang et al., 2022).

Field method: the authors have carried out field surveys and studied the current status of production activities, livelihood sources, and livelihood activities, compared with documents on nature, economy - society, and land use situation in the field. The results of field studies are an essential basis for proposing sustainable livelihood models (Son et al., 2017).

3. Results

3.1 Overview of the study area

Thuong Lo commune is a mountainous commune of Nam Dong district, about 1 km southwest of Khe Tre town center, with geographical coordinates from $16^0$02'36" to $16^0$09'51" north latitude and from $107^0$42'19" to $107^0$51'35" East longitude.

The total natural land area of the commune is 10,646 ha. Agricultural land is 9,905.78 ha, accounting for 93%, and non-agricultural land is 203,9 ha, accounting for 1.9%. Unused land is 537 ha, accounting for 5.1% of the total natural land area (Report on Elaboration of Annual Socio-Economic Development Plan 2020, 2021., 2021), (Son et al., 2022).

The administrative unit consists of 3 villages: Cha Mang, Ria Ho, and Doi. The administrative boundaries are determined as follows: to the north, it borders Khe Tre town; the west borders Thuong Nhat commune; the East borders Huong Loc commune; to the south, it borders Dong Giang district - Quang Nam province.

The terrain of the commune is mainly hilly; from the valley of Khe Tre town, the landscape gradually rises in all three directions, east, west and south. It consists of 3 main types as follows: terraced valley topography or narrow alluvial ground along Ta Trach riverside; low mountainous terrain is widely distributed from Khe Tre valley in 3 directions east, west, and south to mountainous areas with an altitude of over 700m; The average mountainous terrain is distributed in the south with a height of about 1000 m (Hang et al., 2021).

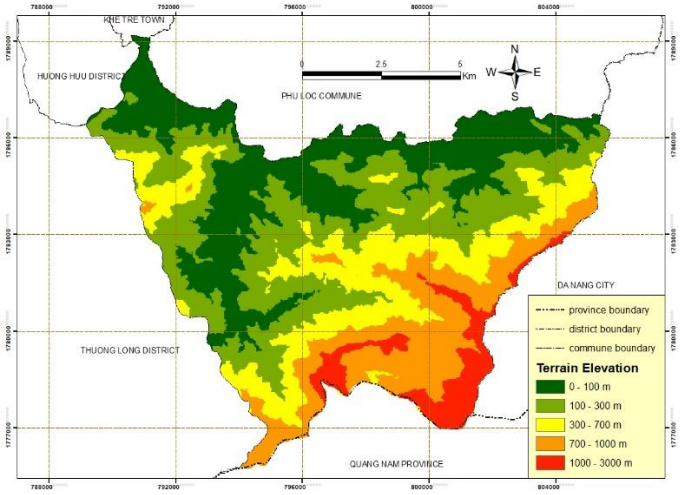


Image 1: Topographic map of the study area

Thuong Lo is one of six ethnic minority communes of Nam Dong district, the whole commune is mainly Co Tu ethnic group, accounting for 95%, and Kinh ethnic group only accounting for 5%. People here still face many difficulties, with low education levels, outdated farming practices, slash-and-burn farming, and hunting of wild animals still occur. Production activities are heavily affected by natural disasters and are degrading natural resources. Therefore, developing sustainable livelihood models is urgent, contributing to poverty reduction for ethnic minorities in mountainous areas, protecting natural resources, especially forest resources, and ensuring national security in border areas.

3.2. Sources of economic development capital of Thuong Lo commune

3.2.1. Natural Capital

The total natural area of the commune is 10,646 ha (Report on Elaboration of Annual Socio-Economic Development Plan 2020, 2021., 2021). Agricultural land accounts for 98.04% of the total land area of the commune with about 10,473 ha. Agricultural production land has only nearly 308.36 hectares, accounting for 2.90% of the total agricultural land area, mainly perennial and annual crops. With 10,160 ha, forest land makes up 95.46% of the commune's total natural land area. Special-use forest land makes up 64.8%, protection forest land makes up 18.09%, and land production forests make up only 12.50% of the total natural land area due to the mountainous commune's peculiarities as part of the Bach Ma national buffer zone. Non-agricultural land accounts for a very small proportion, only 1.58% of the commune's total natural land area, including residential and specialized land. The unused land area of the commune is tiny, accounting for only 0.02% of the total natural land area (Report on Land Statistics Results in 2018, Thuong Lo 2019.).

Agricultural production is the main economic activity of households, but the production land area is tiny. The commune's agricultural land area is 308.36 ha. The average land area per household is low. On average, each home is only about 310.6 m^2 of agricultural land. The commune's forest land area is large but mainly special-use forest land. The production of forest land in the commune is 1,333.3 ha, concentrated in areas with relatively complex traffic, so planting and consuming forest trees will have higher costs and low profits.

Thuong Lo commune is located in the tropical monsoon humid belt, influenced by two main wind directions: the Northeast monsoon occurs from October to February next year, and the Southwest monsoon occurs from February to September, especially the summer months are hot and dry, causing the temperature to rise. The average annual temperature of the district is 24.60C, the highest temperature lasts from April to September, and the temperature difference between day and night is 10 - 120C. The average annual humidity is 86%, the highest humidity in October to December is equivalent to the month with the highest rainfall of the year and reaches 93%, the lowest humidity is in June to August and reaches 80 %, and there are days when the moisture comes 50%.

The average annual rainfall reaches 4,576 mm, the area with the highest rainfall in the country. Rainfall is concentrated from October to December, accounting for 65% of the total annual rainfall. The annual rainfall is generally very suitable, creating favorable conditions for some crops to grow. However, excessive rain also causes serious consequences such as erosion and yearly flooding. The number of storms is quite large, usually starting in June, the most in September and October (Natural and Socio-Economic Characteristics of Nam Dong District., 2019).

The water source of the commune is mainly water from Ba Ran river, Thuong Lo hydroelectric dam on Ba Ran river. In addition to providing electricity, this work also prevents floods for downstream, creates environmental landscapes, and supplies water irrigation and domestic water for people in the lakebed area.

The forest potential of the commune is quite large; forestry land has the most significant area with 10,160 ha, accounting for 95.46% of the total natural land area of the commune, mainly special-use forest land (accounting for 64.8%). Protection of forest land accounts for 18.09%, and production of forest land accounts for only 12.50% of the total natural land area (Report on Land Statistics Results in 2018., 2019). The commune is in Bach Ma National Park's buffer and core zones. This place has Ba Ran river and streams in the forest, creating beautiful streams and waterfalls, which are great potential for developing ecotourism.

3.2.2. Human capital

Thuong Lo commune is one of the least populated communes in Nam Dong district. In 2021, the commune has 349 households; 1,516 people, 324 ethnic minorities, and 1,415 people; The rest are ethnic Kinh. Each ethnic group has its own identity, especially the cultural identity of the Co Tu ethnic group will attract tourists to visit and enjoy.

To better understand the commune's socio-economic development status, we surveyed 186 households in 3 villages. The total number of household members surveyed is 945, an average of 4.5 people per household. The population size of the commune is more significant than that of the delta communes. Because ethnic minorities mainly characterize the commune, the number of families with three or more children is higher than in the delta.

The commune's per capita income in 2021 reached VND 42.3 million. The number of poor households by the end of 2021 was 12, estimated at 3.44%, and near-poor families were 17, accounting for 4.89%. However, the number of homes at risk of falling back into poverty and becoming poor is still high, especially the near-poor households with a very high risk of falling back into poverty.

Labor of the commune is mainly agricultural labor; non-agricultural labor accounts for a meager percentage. In 2018, the proportion of agricultural, forestry, and fishery workers accounted for more than 90% of the total number of employees in the commune; industrial workers were only about 1.6%, and service workers were approximately 3.0% of the total number of employees working in the commune.

In terms of education level, the illiteracy rate is still high compared to the average level of the district and province. Currently, about 10% of the population of 186 surveyed households are still illiterate. All the illiterate people are ethnic minorities. In the school year 2021, the total number of students at all levels is 371: 136 in primary school, 80 in secondary school, and 37 in high school. The proportion of people with intermediate or higher degrees accounted for 24.7%. However, very few receive vocational training and find jobs suitable for their trained profession (Report on the Implementation of the Socio-Economic Plan in 2021 and Socio-Economic Development Tasks in 2022. Upper Highway, 2022., 2022).

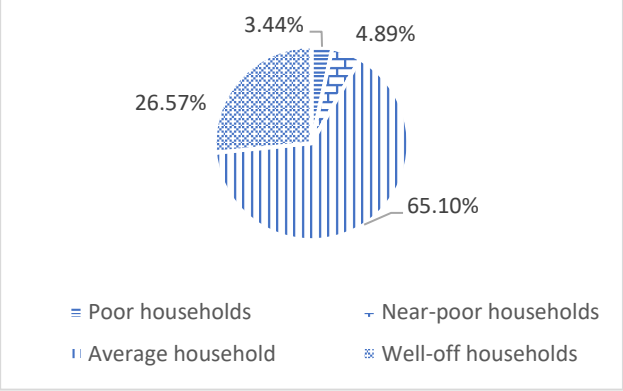


Figure 2. Graph of the household structure by income

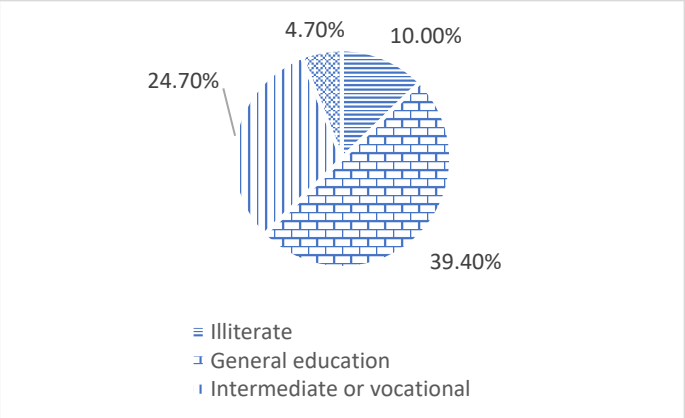


Figure 3. Graph of the household structure by education level

3.2.3. Finance capital

The survey results on the households' capital show that the families' equity is very low; most homes have less than 10 million VND. The number of households with money from 10 million to less than 50 million is only five; The number of families with capital from 50 million to less than 100 million has five homes, and the number of homes with money from 100 million VND has only three households. The primary source of capital for families is loans. The number of households with bank loans is 31, accounting for 14.7% of the total number of households surveyed. However, bank loans for homes are low, averaging only 10-30 million VND/household, short term, about three years, mainly in the loan program to support product development under the Program submit the national target for the period of 2018 -2020 (Results of Implementation of Production Development Support Models Funded by the National Target Program, Period 2018 -2020., 2022).

Although the State has many incentives for the poor to borrow capital, in reality, the amount of loans through the Bank for Social Policies and the Bank for Agriculture and Rural Development of Vietnam is still small, the loan period is short, and the loan procedures are short which is cumbersome. In many cases, people get loans that do not coincide with or are not timely in the production season, so the loan efficiency is not high, which easily leads to using loans for the wrong purpose. Many poor households get loans but do not have a plan to use capital or do not know how to use money effectively. Many families do not use loans to invest in product development but spend on buying household appliances, home repair, eating, living...

3.2.4. Social capital

In the villages, all people participate in mass organizations to bring benefits from the organizations. People can participate in propaganda sessions, training, entertainment activities, sports movements, and festivals. Regularly promote the initiative "All people unite to build civilized lifestyles and cultural families in residential areas"; carry out effective propaganda; enhance the standard of the commune's cultural, sporting, and tourist activities; and strengthen and update the Party's undertakings and guiding principles as well as the State's laws and policies to increase public awareness.

Thuong Lo commune has 95% of the population of Co Tu ethnic group. The people here keep many unique traditional cultural features such as a village, Guoi house (Communal house); local products such as forest honey, genuine Ta Oi brocade weaving, and wickerwork; traditional dishes of the Co Tu ethnic group such as buffalo croissants, tube barbecue, pork belly, lam rice, fish meat, frozen meat, and home-cooked wines; Traditional music with dances, singing, gong and drum instruments...

All the manners and customs, dance, singing, blowing musical instruments... are typical of the ethnic minorities, traditional crafts, food culture, costumes, and architecture of the Guoi house of the people in here. This place will be great potential to develop community tourism models.

3.2.5. Physical capital

- *Equipment and utensils for household life.* Along with economic development, people's life in the Thuong Lo commune has improved dramatically. According to the survey results, most households have televisions, mobile phones, electric lights, and fans for family living needs. Each household has at least one phone, and the number of households with two or more phones accounts for most of the total number of households surveyed. The household appliances with the least percentage of households use air conditioners, computers, and washing machines. Due to living conditions in rural areas, these appliances consume large amounts of electricity, so very few households use them.

Means of production. Maintain and improve the quality of 19 achieved criteria, keep the commune up to the new countryside, towards building an enhanced new countryside commune. The campaign to create new rural regions has received excellent feedback from the populace, particularly with regard to the accomplishment of goals that fall under their purview, such as enhancing and renovating homes and undertaking other projects worth more than 4,65 billion VN; in the year, there are 20 households upgrading and restoring their homes, of which 06 homestays serve tourists, building 12 new septic tanks, 15 households renewing green fences, 08 other fences; renewing 05 solid concrete gates; investing in the lighting system of Cha Mang village road, the environmental landscape in the area is increasingly spacious, green - clean - bright.

The implementation of poverty reduction policies for the people is always timely. Low-interest loans have helped poor, near-poor, and households just emerging from poverty build their household economies. Adopting the reproductive cow, cow, and pig model has increased its efficacy, promoting sustainable development and reducing poverty.

Motorbikes are an essential means of transport for people to travel and transport goods. The number of households with motorbikes is 186; some homes have 2 - 3 motorbikes. The machines for production are mainly water pumps, pesticide sprayers, and lawn mowers. Other devices are rarely used by households, such as food processing machines, agricultural dryers, etc., due to their high cost but are seldom used; only large production households invest.

Table 1. Means of production of households in Thuong Lo commune

Machines	**Number of households with different types of machines**	**Rate (%)**
Total households	186	100,0
The number of households has motorbikes	186	100,0
Sowing machine	0	0
Rice harvester	0	0
Lawnmower	10	4,7
Motorized thresher	3	1,4
Ovens, dryers for agricultural products	1	0,4
Food processing machine	11	5,2
Animal feed processing machine	5	2,3
Pumps for production	21	10
Woodworking machine	6	2,8
Pesticide spray machine	132	62,8

Other machines	41	19,5

(Source: Investigational data in 2022)

- *Housing, health care, education.* In the commune are 349 residential houses, including 335 permanent and semi-permanent houses that meet the standards prescribed by the Ministry of Construction and 04 non-permanent homes. In the commune area, there are no dilapidated temporary houses (Report Explaining Tasks and Cost Estimate of General Construction Planning of Thuong Lo Commune, Nam Dong District, Thua Thien Hue Province in the Period of 2021 - 2030., 2021).

Regarding education, the commune currently has a preschool with facilities including 05 classrooms and ten function rooms, the school's campus area is 3,183 m^2, of which the construction area is 270m^2. 01 Thuong Lo Primary School with facilities including 07 classrooms and 07 function rooms, the school's campus area is 1,488 m^2, of which the construction area is 720 m^2.

Regarding health, the commune health station was built in Doi village in 2011 and has met the standards; it currently has six staff. However, in recent years, the station has been deteriorating and significantly affecting people's medical examination and treatment situation (Son et al., 2017).

- *The infrastructure.* Traffic in the commune is improving day by day. Intercommune and district roads are 2.8 km long and have been asphalted. The 4.8 km long village trunk road has been concreted. Having a length of 2.34 kilometers and being made of concrete, 10.4 km of concrete proportioning road are used for production; guaranteed freight.

Domestic electricity: The number of transformer stations serving domestic electricity is 03 stations with a total capacity of 350 KVA; 4.7 km low voltage transmission line, guaranteed power system. Currently, in the commune, 100% of households use electricity. The power source is guaranteed for the production and daily life of families and production facilities (Report Explaining Tasks and Cost Estimate of General Construction Planning of Thuong Lo Commune, Nam Dong District, Thua Thien Hue Province in the Period of 2021 - 2030., 2021).

The system of canals for irrigation in the commune is solidified 2,676m^2, ensuring water for 19.3 ha of two-crop wet rice (Report Explaining Tasks and Cost Estimate of General Construction Planning of Thuong Lo Commune, Nam Dong District, Thua Thien Hue Province in the Period of 2021 - 2030., 2021).

3.3. Main livelihood models in Thuong Lo commune

3.3.1. Agricultural

Agro-forestry production is currently an essential livelihood of the commune. In 2021, the production value of agriculture, forestry, and the fishery was estimated at 31,411 million VND: Agriculture reached 18,561 million VND, accounting for 50.09%; Forestry reached 12,296 million VND, accounting for 39.15%; Marine Products Industry reached 554 million VND, accounting for 1.76% (Report on the Implementation of the Socio-Economic Plan in 2021 and Socio-Economic Development Tasks in 2022. Upper Highway, 2022., 2022).

Crop livelihood. The main farming livelihood of the commune is growing rice, some cereal crops, other crops, and a garden economy. In wet rice: 19.3 ha, the average yield is 53.6 quintals/ha, the output is 93.80 tons; Corn: 29.5 ha, the average yield is 36 quintals/ha, and output is 106 tons. Total grain production reached 200 tons; Root crops for flour: 42.5 ha (in which industrial cassava is 34 ha, yield 232 quintals/ha, the output is 788.8 tons, sweet potatoes 5 ha, yield 47 quintals/ha, output 23.5 tons, other starch crops 1.0 ha, yield 50 quintals/ha, output 5 tons); Food crops: 30.2 ha (of which: vegetables of all kinds 15 ha, yield 79.5 tons;

all sorts of beans 15 ha, estimated output 7.8 tons, chili plants 0.2 ha, yield 0. 12 tons); Other annual plants: 6 ha.

In terms of garden economy: In 2021, the total area of Thuong Lo commune's garden is 26.5 hectares, of which the home garden area is 23 hectares, the hill garden area is 3.5 hectares; the average garden area per household is 761m^2, The total number of families with gardens is 327/349 households, of which 35 gardens are good, accounting for 10.7%; excellent and average gardens are 246 gardens, accounting for 75.2%; mixed gardens, inefficient are 37 gardens, accounting for 11.3%; there are 09 acacia plantations in the garden, accounting for 2.7%. The value of income from the garden economy in 2021 will reach about 40 million VND/ha.

Regarding rubber trees: The total remaining rubber area in the commune is 55 hectares, the regular exploitation area is about 55 hectares, and the exploitation output is about 302 tons.

Livestock livelihoods. The total herd of cattle and poultry in the whole commune currently has 22,408 heads (of which: cattle 2,112 heads; poultry 20,296 heads, an average of 58 heads/household), specifically: Buffalo: 25 heads; cows 395 heads; pigs 1,657 heads; 35 goats. Most households raise 1-3 buffaloes or cows. The number of families raising five or more buffaloes or cows accounts for only about 10% of the surveyed households. Due to the commune's location in the mountains, homeowners keep cows and buffaloes, allowing them to graze in the forest. Currently, the commune is putting into practice project models like the Model/Project of Raising Wild Boars Under the Sustainable Poverty Reduction Program with the Scale of 12 Pigs/03 Households, of which the State Budget Supports 50 Million VND, 15 Million VND from the People. The sustainable poverty reduction program employs 19 cows per home breeding cow model, with 250 million VND from the state budget and 87.5 million VND from the people's fund. The people themselves gave up the sow-raising plan, which involved a 10m2 area and five piglets for a cost of 7.5 million VND. The family invested 3 million VND in the model of producing siamese chickens and ducks on a scale of 300m2 with a population of approximately 300 (including 200 siamese ducks) (Results of Implementation of Production Development Support Models Funded by the National Target Program, Period 2018 -2020., 2022). Regarding livestock production, although there is a trend of development, it is not strong; the price of feed increases, so livestock households face many difficulties, including widespread grazing. The people have not paid much attention to the work of reinforcing barns, planting grass, and storing straw as fodder for livestock in the rainy and cold season.

Image 4: Model of breeding cows and hybrid pigs of farmer Le Si Doi, Thuong Lo commune

Total poultry: 19,485 heads. Poultry raising is mainly chicken, duck, and swan. In the commune, there is only one household raising poultry on a farm with a flock of about 300 chickens and 300 ducks; the rest are kept small. Each home grows a small number of poultry;

the raising primarily meets the family's needs; it has not turned into a business, and the raising process has not been active. The methods used by the general public to care for and raise chicken are primarily based on experience and a lack of research; these methods result in low productivity, numerous illness risks, high production costs, and low selling prices, which range from 80 to 100 thousand VND per kilogram.

Forestry livelihoods: According to statistics, by 2021, the total planted forest area of the commune will be 560 hectares, growing and taking care of plantations are interested in people, and the area of new planting and replacement planting after exploitation is 105 hectares. Total revenue from forestry activities in 2021 is VND 12,296 million. Funding to support forest management and protection is 940 million VND for 04 communities and 12 groups of households (In which: forest environment services 443 million VND, Carbi project support 497 million VND, funding for planting foreign forest products timber, medicinal plants to support projects and programs with a budget of 91 million VND) (Report Summarizing Agricultural Production Tasks in 2021 and Implementing the Winter-Spring Crop in 2021-2022, Agricultural Production Plan in 2022., 2022).

The Commune People's Committee is implementing the forest enrichment and development project of NTFPs until 2022, mobilizing people to register for the project on forest enrichment and development of non-timber forest products (2022 People's Committee of Thuong Lo Commune, 2022). During the year, the community and group of households planted 59 hectares of indigenous trees and non-timber forest products according to the district's schemes, programs, and projects in which: The district's NTFP development scheme (supporting 50% of plant varieties) 35 ha of Non-timber forest products have been planted (in which: 4 ha of Homalomena occulta, 16 ha of Chukrasia tabularise, 15 ha of Erythrophleum fordii) for 02 communities and 06 groups of households to manage and protect forests; SiDa project program: Support to plant 24 hectares of trees of all kinds (Flagellaria indica, Zingber zerumbert sm) for 04 community groups with a support budget of 3 million VND/ha.

Aquatic livelihoods. Currently, the entire commune has 3.4 hectares of ponds and lakes, of which 2.7 hectares are used for farming. This yields 5.8 tons of produce, and more than 9,500 fish, primarily grass carp and monoecious tilapia, are raised there. However, the remaining area was turned into vegetable gardens due to unstable water resources.

3.3.2. Cottage industry and tourism

Regarding the cottage industry, Thuong Lo commune has a traditional handicraft village of bamboo rattan and brocade weaving. The District Culture and Information Department cooperated with Thuong Lo Commune People's Committee to open classes to teach people how to make souvenir products from bamboo and rattan. To preserve traditional crafts and create souvenirs and products with local identity to serve the shopping needs of visitors. However, the products mainly serve the needs of tourists, so the quantity consumed is very small.

The model of community tourism cooperative was built in Doi village, Thuong Lo commune. Tourism products include visiting villages, visiting stilts house (Goi's house), learning about production life, visiting fields, banana gardens, and forest gardens; Traditional dishes of the Co Tu ethnic group such as Lam rice, grilled chicken, grilled fish, grilled meat, banana flower salad, sprouts, honey biscuits, forest vegetables...

People here have been interested and supported by the local government to promote local tourism development, such as: opening traditional vocational training classes in rattan and bamboo weaving, restoring brocade weaving of the Co Tu people, and supporting building homestay for 03 households, the support level is 75 million VND/household or creates some traditional products such as Wild honey, wild honey biscuits labeled as Kazan waterfall

tourism cooperative; several souvenir products from rattan and bamboo; Brocade weaving produced by the people themselves to promote in the market.

3.4. Challenges in developing livelihood activities in Thuong Lo commune

Agricultural production activities are mainly farming activities associated with land use, and livelihoods are most vulnerable to climate change. With the prolonged drought, some households lack investment in intensive farming and care, which affects productivity and output; the restructuring of valuable crops is still slow, especially the conversion of acacia and rubber plantations. In addition, some household garden land is still tiny and narrow, not ensuring the area as prescribed when registering. Some households lack investment in care and intensive farming, so the plants grow poorly, and the effective value is not high.

Livestock production has changed but is not sustainable; cattle raising still faces many difficulties and unstable prices, and grazing cattle still occurs in some villages, affecting agro-forestry production. Vaccination for cattle and poultry has not been paid attention to, and some cattle-raising households have not taken measures to ensure environmental hygiene.

Extreme weather events such as storms, floods, and droughts are also frequent natural disasters in the commune. In the context of climate change, the weather is warmer; the drought is more severe. The increase in extreme weather events in both frequency and intensity threatens the livelihoods of the people here.

Forest resources are also one of the main livelihoods for people in Thuong Lo commune, especially those whose livelihoods depend on exploiting forest resources. But along with climate change trends and the current situation of forest exploitation, forest management is still inadequate, so forest resources tend to be exhausted. In particular, illegal hunting and deforestation are threatening biodiversity and landscape quality.

In terms of tourism, the situation is still challenging to manage and capitalize on; the initial investment for ecotourism in Doi village was relatively minimal, less than 70 million VND (primarily investing in teaching people hospitality skills, cooking, and restoring traditional cultural values). Mainly due to the impact of the Covid-19 epidemic, many domestic and foreign tours were linked with local tourism cooperatives but had to be postponed. Therefore, the cooperative's income decreased a lot compared to previous years.

3.5. Evaluation of the superiority of livelihood models in the study area

Among 20 existing economic models in Thuong Lo commune, the research team has consulted experts, including longtime farmers, local agricultural officials, and experts in the field of agroforestry, about ecological and economic models on the superiority of each model according to Formula 1). Then, use formula (2) to calculate the priority of each criterion.

$$\mathbf{Cj} = \frac{\mathbf{1}}{\boldsymbol{nj}} \sum_{\boldsymbol{k=1}}^{\boldsymbol{m}} \mathbf{Cki} \qquad (1)$$

In which: Ckj: kth "expert" score on criterion j

Nj: number of "experts" for the criterion score j

k=1,n (n: experts; n: from 1 to 40); j=1,m (m: criterion; m: from 1 to 10)

$$\mathbf{Sj} = \sum_{\boldsymbol{I=1}}^{\boldsymbol{n}} \mathbf{Cj} \qquad (2)$$

In which: Sj: total score for evaluation of criteria j

Cj: Total score from criterion i to j

i=1,n (n: rating score; n: from 0 to 10); j=1,m (m: criterion; m: from 1 to 10)

Thus, the higher the score for each criterion, the more dominant that criterion is and vice versa. Similarly, the higher the total score of 10 criteria of each model type, the greater the superiority of that model.

Table 2. Results of evaluation of types of eco-economic models from agricultural households

Models Group	Type of eco-economic model	High economic efficiency	Easy to do	Low investment	High market demand	Few diseases	Protect Environment	Low risk	Easy to find seed	Locally suitable	Do a job	**Total score**
Crops	1. Wet rice	5	7	7	6	6	6	6	8	6	6	63
	2. Corn	8	8	8	7	7	6	7	8	7	7	73
	3. Cassava	6	8	8	6	7	5	7	8	7	5	67
	4. Sweet potato	6	8	8	6	8	6	7	8	7	5	69
	5. Sugar cane	7	7	6	7	6	7	7	7	7	7	68
	6. Vegetables of all kinds	8	8	8	8	7	7	8	8	8	7	77
	7. Corn-Bean-Cassava	8	8	8	7	7	7	7	8	8	7	75
Garden economic	8. Nam Dong orange	8	7	6	8	8	8	7	7	9	8	76
	9. Cayen pineapple	8	7	7	8	8	8	7	7	8	8	76
	10. Banana	8	8	8	7	8	7	7	7	8	7	75
	11. Thai jackfruit	9	7	6	8	8	8	7	7	8	8	76
Forestry	12. Rubber	8	6	6	8	8	7	7	8	6	8	72
	13. Acacia	6	7	7	7	8	8	8	8	8	6	73
Livestock	14. Hybrid pig	9	8	6	8	8	7	8	7	8	8	77
	15. Pigs	7	8	7	7	6	6	7	8	7	5	68
	16. Breeding cows	8	7	6	8	7	6	6	7	8	7	70
	17. Bos taurus	7	7	6	7	6	6	7	8	8	7	69
	18. Chickens	7	8	7	7	6	6	7	8	7	6	69
	19. Muscovy duck	8	8	7	8	7	6	7	7	4	6	68
Aquaculture	20. Fish	7	6	7	8	7	6	7	8	6	6	68

(Source: Results from households, local officials, and experts in Thuong Lo commune)

According to the combined evaluation results from Table 2, households gave the garden economic model (average score of 75.75/100 points) the highest rating within the model group, followed by the growing model production forest (72.5/100 points), vegetable growing model (71.5/100 points), husbandry model (70.1/100 points), aquaculture model

(68/100 points), and wet rice model (63/100 points). The models of maize, vegetables of all types, corn-beans-cassava, Nam Dong oranges, Cayen pineapples, bananas, Thai jackfruits, high rubber, acacia, hybrid pigs, and breeding cows are among those that are also well regarded by the people with a score of > 70/100 points. However, the above figure is only relative and needs to be studied and analyzed further because each type of model has different outstanding advantages depending on the consideration criteria and, financial and professional capabilities, human resources of each household.3.6. Proposing a sustainable livelihood model in Thuong Lo commune

Based on the analysis of the potential and current status of livelihood activities of the people in Thuong Lo commune, we propose three livelihood models that contribute to sustainable poverty reduction, increase income for people as well as preserve and promote the natural and human resources here.

3.6.1. The model of the chain of community tourism links

Community-based tourism (CBT) exploits available resources with the participation of local communities, who directly participate in and benefit from tourism activities. Community-based tourism is considered the type of tourism that brings the most sustainable economic development benefits to indigenous people. Community-based tourism contributes to hunger eradication and poverty reduction, improving people's living standards, protecting ecology and natural resources, and preserving and promoting the unique cultural features of the locality.

Currently, in the commune, community tourism activities associated with the local cultural identity have been built in the village of Doi… However, due to many reasons, the actions of this community tourism site are still spontaneous. Has not brought tangible benefits to the people and local authorities.

Based on the existing livelihood potential, we boldly propose clarifying this community-based tourism linkage chain model with the desire to bring about expected economic, cultural, social, and environmental benefits for the community here.

Main products and tours

The community-based tourism model is developed in Thon Doi, Thuong Lo commune, with the potential of ecotourism (streams and waterfalls) and traditional cultural tourism of Ta Oi ethnic people. Planned activities in the model include:

- Visit the hamlet or the Goi house, take in a traditional Co Tu performance, and enjoy the food (grilled pig, grilled chicken, grilled stream fish, bamboo tube rice, wild veggies, a delicacy of wild honey), brocade products, knitted items, and pay a visit to and take a dip in the Kazan waterfall.

- Tour: Morning 7:30 am departure from Hue city - approximately 9:30 am to Doi Village - Lunch in Doi Village - enjoy traditional food and delicacies from the forest - Afternoon tour and soak KaZan waterfall - return to Hue. To experience a night in the highlands, guests can either stay the night in a stilt house (a "Guoi house") or at a homestay.

Based on the potential of natural and outstanding humanistic tourism resources, which are attractive to tourists and have been exploited by the local community. However, to further enhance the role and benefits of the community in participating in tourism activities, contributing to poverty reduction, and sustainable tourism development in the locality, the management Organizations, and management of the state and departments for community tourism need to be paid more attention.

- Commune government is the agency that directly manages and operates tourism activities. Responsible for actions, planning, promotion, and tourism policy, as well as monitoring and inspecting residential communities' activities and travel companies' activities.

- Residential community: this is an important component in community tourism development. Through cooperative groups or cooperatives, the community is the place to provide tourism development services: stilt houses, tourism products: cuisine, brocade, arts, etc. to attract tourists to visit.

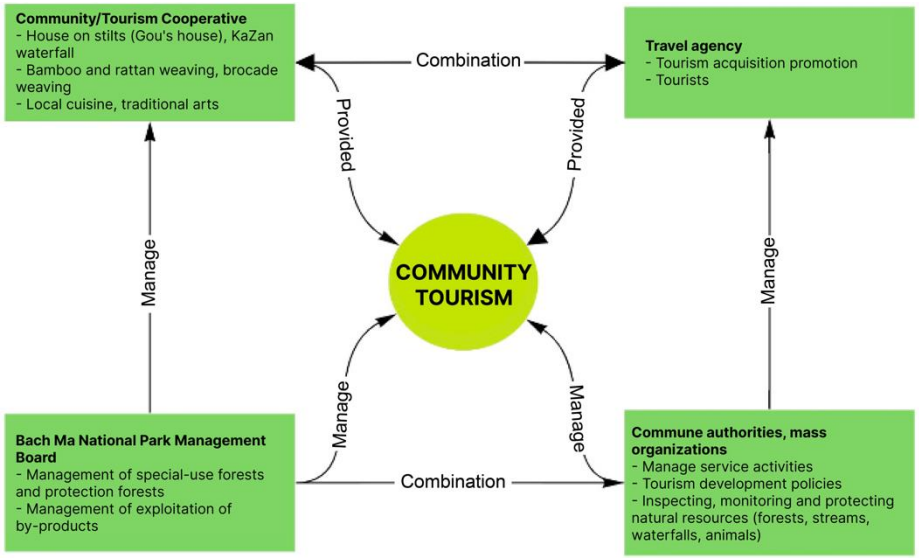


Diagram 1. Model of the chain of community tourism linkages in Thuong Lo commune

- The tour operator: is considered the focus of community tourism development, directly organizes, participates directly in the tourism business, organizes, operates, and guides tourist attractions, market access, and tourism promotion. The tour operator will associate with cooperative groups/cooperatives, coordinate with Bach Ma National Park Management Board to organize services for tourists, and be under the supervision of commune authorities in tourism activities.

- Bach Ma National Park Management Board is responsible for managing natural resources for tourism: national parks, rivers, streams, forest products, etc. The link between the parties involved in community tourism of Thuong Lo commune is shown in Diagram 1.

Develop regulations on cooperation between development stakeholders (local communities, the Bach Ma National Park Management Board, businesses, commune authorities, etc.), and regulations must be implemented thoughtfully for the model of tourism development to be effective.

3.6.2. Model of linkage and development of non-timber forest product value chain

This model is regarded as the right path because it enables individuals to sustainably increase the value of agricultural products and establishes parameters for businesses to use as a means of production, particularly in terms of human resources and land, thus establishing a material area for stable production. This is also the policy concretized in Decree 98/2018/ND-CP on encouraging the development of cooperation and association in the production and consumption of agricultural products (Tri, 2019).

Thuong Lo is located in the buffer zone of Bach Ma National Park, which is favored by nature in terms of climate and soil, and suitable for growing medicinal plants. The tree grows well and has more medicinal properties than other lands. Lien Minh Xanh Company, a member founded in 2016 with headquarters in Hue, has strengthened the development of

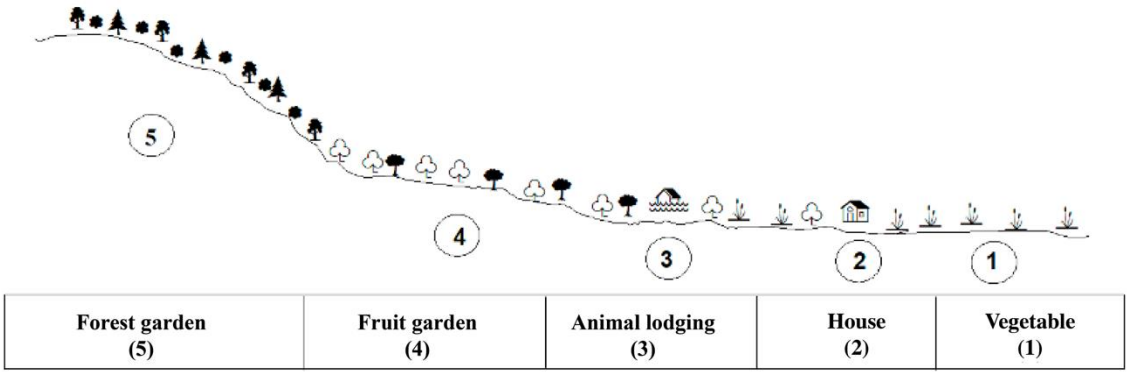
linkage models between businesses and people and communities allocated natural forests in Thuong Lo commune in the development of medicinal plants under the forest canopy after realizing the potential of medicinal plants under the canopy of natural forests in some communes in Nam Dong district, Thua Thien Hue province, especially in the buffer zone of Sao La Nature Reserve.

The goal is to create high-quality essential oil products containing the natural and cultural values typical of the Truong Son mountains. Among the many herbs in this area, Lien Minh Xanh has researched and selected the Rhizoma Homalomenae occulture species to grow under the natural forest canopy. A valuable medicinal plant called Rhizoma Homalomenae occulture is used to treat convulsions, paralysis, rheumatism, and joint discomfort. Additionally, this tree is the primary component in several goods, including Cot Thoai Vuong and Hoan Nguyen Cot. This tree is suited for growing in a natural forest environment with a brief development period.

However, to effectively implement this model, it is necessary to have appropriate development mechanisms and policies. Firstly, developing medicinal herbs under the canopy of natural forests takes a long time and requires a lot of technical impact for the tree to grow and develop well. Hence, businesses must spend a lot of time and money to build the raw material. Secondly, most people receiving forests are ethnic minorities with difficult economic conditions and limited qualifications, so at first, businesses have to spend a lot of time encouraging people. Third, there is currently only an incentive policy linking agricultural production. Still, there is no specific incentive policy for linking production in the forestry industry, so few businesses pay attention to this field. In addition, the affiliated companies must also have agreements on cooperation in procuring raw materials and technical support for planting and caring for the residential community. Only in this way will the local people have the motivation and peace of mind to produce.

3.6.3. Economic models of gardens, combined organic farming, and cottage industry

The garden economic model combined with organic farming is suitable for sustainable development. The economic development of gardens and livestock production creates products of good quality and more accessible to consume than products of the same type. Another effect is that organic production and livestock costs are lower than conventional farming because farmers do not have to spend much on fertilizers and pesticides. On the other hand, organic production also improves the quality of the living environment, farmers' health, etc. This model combines growing fruit trees, vegetables and food, spices and herbs, housing, and barns. This model requires a reasonably large area, growing fruit trees and food crops, and raising livestock, increasing people's income.



Source: Proposed Research Team

Figure 5. The economic model of the garden, combined with organic husbandry

The current economic model of the commune's garden with the main crops is Thai jackfruit, Cay pineapple, Nam Dong orange, and specialty bananas. This model will bring high efficiency if people focus on intensive farming and take care of the right technical process. However, at this time, this model in the commune has not yet produced high efficiency; the main reasons are a lack of investment capital, limited intensive care, and human investment, poor quality plant varieties, and some households have not reacted to the gardening movement because they are concerned about the market output field. Therefore, in order to increase the effectiveness of the garden economic model, it is essential to train individuals to raise public awareness of the advantages of organic farming, teach techniques for making organic fertilizers from livestock farming and cultivation, as well as promote the brand of sanitary products and locating markets for farmers' products.

Image 6: Thai jackfruit growing model

Image 7. Cayen pineapple growing model

The model of raising reproductive cows, organic pigs, and hybrid wild boar is one of the new directions for the economic development of families in mountainous areas. These are all models supported by sustainable poverty reduction programs and have the potential to bring economic benefits to the people. Through interviews, we have learned that rearing cows and wild boars are not difficult; it is more weather-resistant than the locals' preferred pig breeds, and there is a higher demand for market consumption. As an omnivorous wild animal, the hybrid pig model, in particular, can benefit from a variety of nearby food supplies such as potato leaves, mondo leaves, banana plants, water hyacinth, bran, and wort. Due to its low investment expenses and minimal risk, this strategy is ideal for impoverished households or close ones. In addition to creating economic value, livestock farming also takes advantage of the fertilizer discharged from cattle to fertilize crops.

Crafts, although not high income compared to other occupations, has created additional leisure income; bamboo and rattan trades and brocade weaving have solved many rural laborers and provided a stable income source for employees.

In addition to brocade weaving, developing bamboo and rattan craft to take advantage of raw materials from the forest and a large amount of idle human resources from agricultural labor in the village. The primary wicker materials come from the forest, including rattan, bamboo, etc. Most products are handicrafts, household goods, and production instruments (such as baskets) (flower vases, bamboo paintings, bags...). Technology is primarily used for manual labor and small-scale domestic industry.

The local government must be involved in the development of this profession. Establishing a knitting cooperative, assuming responsibilities, carrying out market research, ordering various products, and selling goods are essential. The members are responsible for raw materials and ensure the product meets technical and artistic standards. The handicraft model will create jobs for rural female workers and, at the same time, develop handicrafts in the locality, contributing to the local implementation of poverty reduction and improving living standards.

References

1. Chambers, R., & Conway, G. R. (1992). Sustainable rural livelihoods: practical concepts for the 21st century. *IDS Discussion Paper*, *296*.
2. DFID. (2001). Drought and Water Security. *Sustainable Livelihoods Guidance Sheets*, *7*(1), 1-24. papers2://publication/uuid/FC413348-5AC4-4C8D-8B63-AD3F3FE15B02
3. Hang, A. P., Thang, V. Le, Tuan, A. T., & Son, H. N. (2021). An Environmental Zoning for Sustainable Development in Thua Thien Hue Province, Vietnam. *Global Changes and Sustainable Development in Asian Emerging Market Economies*. https://doi.org/https://doi.org/10.1007/978-3-030-81443-4
4. Hao, M. B. (2017). Towards a sustainable livelihood model in Nghe An. *Science and Technology Nghe An Journal*, 10-15.
5. Hop, D. T. (2007). Khinh - Trong, a theoretical perspective in philosophical and sociological research. In *World Publishers, Hanoi*. World Publishers, Hanoi.
6. Lan, P. T. N. (2014). From rice to shrimp: risk reduction behavior and exploitation of social capital by farmers in the Mekong Delta. In *Vietnam National University Press, Ho Chi Minh City*.
7. Lang, C. P. Le, Son, H. N., Cham, D. D., Bay, N. T., Bao, Q. P., & Cuong, X. N. (2022). Cooling island effect of urban lakes in hot waves under foehn and climate change. *Theoretical and Applied Climatology*. https://doi.org/https://doi.org/10.1007/s00704-022-04085-6
8. McCracken, J. A., & Pretty, J. N. (1988). Glossary of selected terms in sustainable agriculture. *Gatekeeper Series - SA*. https://doi.org/10.3/JQUERY-UI.JS
9. Natural and socio-economic characteristics of Nam Dong district., Nam Dong district (2019).
10. Nhung, H. T. T. (2017). Livelihood and poverty study in coastal districts of Nam Dinh province. In *Thesis of PhD in Geography, Hanoi National University of Education.*
11. Report on elaboration of annual socio-economic development plan 2020, 2021., Thuong Lo Commune (2021).
12. People's Committee of Thuong Lo Commune, 2022. (2022). Results of directing agricultural production in February and tasks in March 2022. *Thuong Lo Commune*.
13. Results of implementation of production development support models funded by the National Target Program, period 2018 -2020., Thuong Lo Commune (2022).
14. Results of the implementation of the project on economic development of the garden in the period of 2017-2021., Thuong Lo Commune (2021).
15. Pho, H. D. N. (2016). Approaching the theory of sustainable livelihood framework DFID in studying the livelihood of the Ma people in Cat Tien National Park. *Scientific Journal of Dong Nai University*, *2*, 101-112.
16. Son, H. N., Cham, D. D., Mai, T. T. T., Tin, V. Le, Hang, A. P., Lang, C. P. Le, & Quan, T. N. (2017). GIS application in assessment on environmental management and natural resources of communes in Thua Thien - Hue province. *Proceeding of the International Conference on Earth Observation & Natural Hazards 2017 (Iceo 2017). ISBN: 978-604-913-650-4*.
17. Son, H. N., Mai, T. T. T., & Lang, C. P. Le. (2013). Raising Awareness Education and Response Capability with Climate Change for the Residential community in Mid-central Coastal Provinces of Vietnam. *The International*

Journal of Education Administration and Development 4(2): 812-818. Mahasarakham University, Thailand.

18. Son, H. N., Mai, T. T. T., Lang, C. P. Le, & Tin, V. Le. (2014). Raising Awareness of Environment and Resource Management Among People in The Coastal Area of Thua Thien Hue Province. *The 7th International Conference on Educational Reform (ICER 2014)*.
19. Son, H. N., & Quan, T. N. (2021). Assessing the level of vulerability due to climate change in extremely poor coastal communes in Quang Binh, Quang Tri, and Thua Thien Hue provinces, VietNam. *Prace i Studia Geograficzne*, 133-150. https://doi.org/10.48128/pisg/2021-66.2-08
20. Son, H. N., Tin, V. Le, Chan, V. M., Thinh, H. P., Tu, X. D., & Dan, N. N. (2022). Assessing the status of landslides along key transport routes in Thua Thien Hue province during the stormy season in 2020. *International Symposium HANOI GEOENGINEERING 2022 INNOVATIVE GEOSCIENCES, CIRCULAR ECONOMY AND SUSTAINABILITY*.
21. Suu, V. N. (2015). Sustainable Livelihoods Framework: A Comprehensive Analysis of Development and Poverty Reduction. *Knowledge Publishers, Hanoi*, 15-33.
22. Report on land statistics results in 2018., Thuong Lo Commune (2019).
23. Report explaining tasks and cost estimate of general construction planning of Thuong Lo commune, Nam Dong district, Thua Thien Hue province in the period of 2021 - 2030., Thuong Lo commune (2021).
24. Report on the implementation of the socio-economic plan in 2021 and socio-economic development tasks in 2022. Upper highway, 2022., Thuong Lo Commune (2022).
25. Report summarizing agricultural production tasks in 2021 and implementing the winter-spring crop in 2021-2022, agricultural production plan in 2022., Thuong Lo Commune (2022).
26. Tri, T. P. (2019). Model of linkage and development of LSNG value chain in Thua Thien Hue. *People and Nature Magazine*.
27. Trinh, M. C. (2008). Developing local livelihoods contributes to the protection and sustainable use of natural resources and the environment. *Journal of Marine Science and Technology, 1*, 81-95.

Study on the situation and solutions for ecotourism development in Bach Ma national park

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Abstract. The article uses synthetic analysis, survey methods, statistical methods, and cartographic methods to clarify the current status of ecotourism development in Bach Ma National Park. Research results show that, from 2013-2021, Bach Ma National Park welcomed 153,867 visitors with a revenue of 6.5 billion VND. Ecotourism activities have created financial resources to conserve natural and cultural resources; create livelihoods; support local communities living in buffer zones and predominantly ethnic minority communities; provide environmental education and demonstration for visitors and residents; promote socio-economic development for the locality. However, the current status of ecotourism development of Bach Ma National Park is not commensurate with its potential; ecotourism products are still poor; the infrastructure - material, and technical system have not met the needs of tourists and are degraded; the quality of tourism services is not high; The participation of local communities in ecotourism activities is still limited. Based on assessing the current status of Ecotourism, we propose solutions to improve the efficiency of ecotourism activities in Bach Ma National Park in a sustainable way.

Keywords: Situation, solutions, ecotourism, national park, Bach Ma.

1. Introduction

Tourism is one of the fastest growing economic sectors; Before the pandemic, the travel and tourism industry accounted for 10.6% of total employment and 10.4% of global GDP. Besides the positive effects, the increase in mass tourism has created various negative impacts on the socio-economic and environment. These impacts have promoted and developed the concept of sustainable tourism (Carvache-Franco et al., 2022), (Tran & Walter, 2014). Among the approaches to sustainable tourism, Ecotourism emerges as one that adheres to the basic principles of sustainable development (Walker & Moscardo, 2014). The term "ecotourism" was first used by Ceballos-Lascurain (Ceballos-Lascurain, 1987). According to the researchers, Ecotourism includes going to natural attractions for educational and recreational purposes. In Vietnam, Ecotourism has been studied since the mid-1990s the 20th century. The National Administration of Tourism has defined Ecotourism as "a type of tourism based on local nature and culture, associated with environmental education, contributing to environmental preservation, conservation and sustainable development with the active participation of local communities" (Vietnam National Administration of Tourism, 1999). The Vietnamese government has declared Ecotourism as one of the country's essential tourism products to generate income for local communities and contribute to environmental education.

According to the Ministry of Natural Resources and Environment, Vietnam has 166 protected areas, including 31 national parks, 64 nature reserves and nature protection areas, 16 habitat species conservation areas, and 55 protected areas for landscape protection (Decision

No. 1107/2015/QD-BTNMT, The List of Protected Areas, Ha Noi., 2015). Most of the conservation area's financial resources are based on the state budget. Development support capital is mainly through grant projects, partly from market-based initiatives - financial resources from ecological services and payment for environmental services. Developing Ecotourism not only enhances natural values but also contributes to socio-economic development, preserving indigenous cultural values, raising awareness of tourists and tourists' local community about responsibility and sense of protecting the natural environment. Therefore, promoting ecotourism business activities in protected areas is a development trend.

The Vietnam General Department of Forestry currently has 61 protected areas with business activities of Ecotourism, resort, and entertainment services [8], concentrated in several national parks, including Bach Ma national park. Bach Ma National Park was established in 1991 with a total natural area of 37,423.10 ha, distributed in two provinces of Thua Thien Hue and Quang Nam (Report on Management of Special-Use Forest Systems, Protection in 2019 and Sustainable Development Solutions. Ha Noi., 2019), (Vietnam Administration of Forestry, 2021). The General Department of Forestry manages Bach Ma National Park - Ministry of Agriculture and Rural Development with the main functions of management, protection, and development of special-use forests; preserving and promoting particular values of nature, standard samples of ecosystems, biodiversity, biological, genetic resources, historical, cultural and landscape relics; scientific research; providing forest environment services and Ecotourism within the scope of management and prescribed by law.

Bach Ma National Park is located in a favorable geographical position, near famous tourist areas such as Hue Ancient Capital, Lang Co Beach, Da Nang City, and Hoi An Ancient Town. Bach Ma National Park contains excellent biodiversity values with 2,421 species of fungi and plants and 1,728 species of animals, including many endemic and rare species. Bach Ma National Park is an area with natural, cultural, and historical values. The buffer zone of Bach Ma National Park is home to communities of ethnic minorities such as Co Tu, Ta Oi, Van Kieu, and Muong, with many unique cultures (Dung & Son, 2017). Therefore, the research and assessment of the current status of Ecotourism have theoretical and practical significance in proposing solutions to develop Ecotourism in Bach Ma National Park more effectively and sustainably.

2. Research methods

2.1. The method of data collection

Primary and secondary data were collected during different stages of the research process. Primary data sources have been collected through field surveys to supplement, edit and update collected data and secondary information to help objectively assess ecotourism activities in Bach Ma National Park. Secondary data sources include books, magazines, websites; legal documents (Law, Decision, Decree, Circular); documents collected from the General Statistics Office of Vietnam, the General Department of Forestry, the Department of Statistics of Thua Thien Hue province; especially the reports of the Department of Tourism of Thua Thien Hue province, Bach Ma National Park Management Board related to tourism activities in general and Ecotourism in particular. After collected, data were analyzed using specialized software (Excel, SPSS).

2.2. Methods of investigation and survey

The research team conducted three surveys at attractions at Bach Ma Peak Ecotourism Area (Hai Vong Dai Trail, Do Quyen Trail, Five Lake, Cho Den Forest Trail, Truoi Lake - Truc Lam Bach Ma Zen Monastery) and villages in the buffer zone at the foot of Bach Ma mountain. Through questionnaires and open-ended questions with different forms (direct, online, telephone, social network). Survey subjects are tourists, the management team, Bach

Ma National Park staff, the local community, and ecotourism business units in Bach Ma National Park.

3. Research results and discussion

3.1. Potential for ecotourism development in Bach Ma National Park

* Located from $15^0$59'28" to $16^0$16'02" N and from $107^0$37'22" to $107^0$54'58" E (Vietnam Administration of Forestry, 2021), the geographical boundary between Northern and Southern Vietnam, between the Truong Son mountain range and the coastal plain (Vu & Son, 2004). Bach Ma National Park contains many ecological types and landscapes, from coastal lagoons to mountainous forests. Bach Ma National Park is located between two central economic centers, Hue city and Da Nang city, 30km from Phu Bai airport and 80 km from Da Nang airport, with a convenient transportation system. The favorable location has created good conditions for Bach Ma National Park to develop tourism activities, especially Ecotourism (Dung & Son, 2020).

Figure 1. Location of Bach Ma National Park

* Topography: Bach Ma National Park is the end of the North Truong Son range, with many mountain ranges with peaks over 1,000m high running horizontally in the West-East direction. The terrain is rugged, strongly dissected, and very steep (the average slope is 15^0-25^0, and many places have a steep slope above 40^0). Several wide and relatively flat peaks are suitable for developing Ecotourism on the high mountain, especially for sports, adventure, and resort activities.

* Climate: Bach Ma National Park is located at the intersection between two tropical monsoon climates and typical tropical climates (Tham & Son, 2011). The average annual temperature is 20-25^0C (with an average humidity of 80-90%), while the average temperature in Hue and Da Nang is above 25^0C (Vietnam Administration of Forestry, 2021).

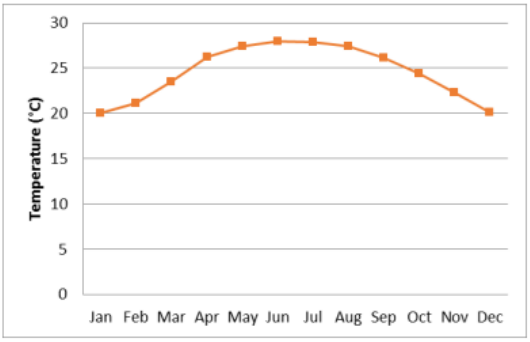

Figure 2. The average monthly temperature at Nam Dong station
(Source: Hydrometeorological Center of Thua Thien Hue Province)

When Hue city and Da Nang city had the highest average monthly temperature of over 28^0C, the highest temperature in Bach Ma did not exceed 23^0C. This is one of the strengths of the Ecotourism of Bach Ma National Park compared to neighboring tourist destinations. However, due to high rainfall (average monthly rainfall is 1,500-3,000mm) and an increased number of days with bad weather (183 days), seasonality in ecotourism activities is caused.

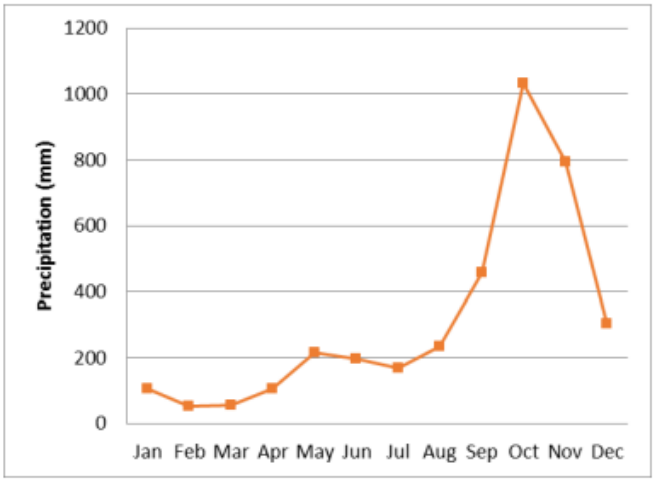

Figure 3. Average monthly rainfall at Nam Dong station

(Source: Hydrometeorological Center of Thua Thien Hue Province)

* Hydrology: Bach Ma National Park has an abundant water source, the source of many main rivers in the region, such as Ta Trach River, Truoi River, Khe Su River, and Cu De River [29]. At an altitude of over 900m, many streams, waterfalls, and water flow all year round, creating attractive attractions such as Silver Waterfall, Do Quyen Waterfall, and Ngu Ho (Five Lakes).

* Biodiversity: Forests in Bach Ma National Park are almost primitive, with 02 main types: tropical rain evergreen closed forest (at altitudes below 900m), and subtropical evergreen closed evergreen forest (at an altitude above 900m). Bach Ma National Park has a high level of biodiversity with a total of 2,421 species of fungi and plants (accounting for nearly 17% of the total number of plant species in the country), including 74 species listed in the Red Book of Vietnam in 2007, 20 species were listed on the 2016 IUCN List and 204 endemic species (Vietnam Administration of Forestry, 2021).

Table 1. Number of species of fungi and plants in Bach Ma National Park [29]

Flora	**Total species**	**Number of species in the Red Book of Vietnam** (2007)	**IUCN** (2016)	**Number of endemic species**
Fungus	332	4	-	-
Moss	89	-	-	11
Pteridophyta	182	1		19
Gymnospermatophyta	22	6	6	1
Basal angiosperms	1,796	66	14	173
Eudicots	*1,329*	*41*	*13*	*147*
Monocots	*467*	*22*	*1*	*26*

Total	**2,421**	**74**	**20**	**204**

Source:(Vietnam Administration of Forestry, 2021)

In terms of fauna, Bach Ma National Park has 1,728 species; there are 70 species listed in the Red Book of Vietnam in 2007, 52 in the 2016 IUCN List, and 15 endemic species.

Table 2. Number of animal species in Bach Ma National Park [29]

fauna	Total species	Number of species in the Red Book of Vietnam (2007)	IUCN (2016)	Number of endemic species
Mammalia	133	39	32	-
Aves	363	16	13	13
Fish	58	2	2	-
Amphibia, Reptilia	134	12	5	2
Insects	1,036	1	-	-
Araneae	3	-	-	-
Gastropoda	1	-	-	-
Total	**1,728**	**70**	**52**	**15**

Source:(Vietnam Administration of Forestry, 2021)

* Cultural resources: The buffer zone of Bach Ma National Park has many ethnic communities, including Kinh, Co Tu, Van Kieu, Muong, Ta Oi, and Pa Ko ethnic communities. Each ethnic community has its unique cultural characteristics. The Katu people attract visitors with their unique village structure, paintings with primitive colors, and sculptures with rudimentary features, reflected in architectural works such as the Guol house, graves, poles, stab buffalo... Van Kieu people also have their own unique cultural identity, which is reflected in festivals such as PuPo (going down to the field), Chac Vat (opening the forest door), the new rice ceremony, and Chan vi ang festival (offering to heaven), the ceremony to share the grain to the storehouse, and the ceremony to worship the water trough. These are traditional rituals very typical of ethnic communities.

3.2. Legal basis of ecotourism development in Bach Ma National Park

The development orientations of Ecotourism have been confirmed through many documents such as the Strategy for the development of tourism products in Vietnam to 2025, exposure to 2030 (Decision No. 2522/QD-BVHTTDL Approving the Strategy for the Development of Vietnam's Tourism Brand to 2025, Orientation to the Year 2030, Ha Noi., 2016); Strategy for developing Vietnam's tourism brand to 2025, orientation to 2030 (Decision No. 2714/QD-BVHTTDL Approves the Strategic Project on the Development of Vietnam's Tourism Products to 2025, with an Orientation to 2030, Ha Noi., 2016); Some solutions to promote tourism development in Vietnam in the doi moi period (Decision No. 2522/QD-BVHTTDL Approving the Strategy for the Development of Vietnam's Tourism Brand to 2025, Orientation to the Year 2030, Ha Noi., 2016); Master plan on tourism development in Vietnam to 2020, vision to 2030. Accordingly, tourism is identified as a critical economic

sector to create a driving force for stability and socio-economic development, contributing to hunger eradication and poverty alleviation.

Vietnam has a legal framework and specific regulations on ecotourism development in protected areas. Ecotourism activities in reserves are interdisciplinary, governed by specialized laws such as the Law on Forest Protection and Development 2004, the Law on Tourism No. 09/2017/QH14: Article 5, tourism development policies, Forest Law No 16/2016/QH14: Articles 53 and 56 present ecotourism activities in protected areas (protection forests and special-use forests); Law on Biodiversity No. 32/VBHN-VPQH: Article 5, regulations on conservation and sustainable development of biodiversity and sub-law documents promulgated by the Government and Ministries such as Decision No. 24/2012 /QD-TTg on investment policy on the development of special-use forests for the period 2011-2020, Decision No. 1633 QD/BNN-TCLN, Planning, conservation and sustainable development of Bach Ma national park in the period 2010-2020 (Decision No. 1633 QD/BNN-TCLN, Planning, Conservation and Sustainable Development of Bach Ma National Park for the Period 2010-2020, Ha Noi., 2011), Decree No. 117/2010/ND-CP on organization and management of special-use forest system.

Based on the issued legal framework and regulations, ecotourism activities in Bach Ma National Park have been organized in different forms (Decision No. 2958/QD-BNN-TCLN on the Scheme of Renting a Special-Use Forest Environment for Ecotourism Business in Bach Ma National Park. Ha Noi., 2017), (Decision No. 1633 QD/BNN-TCLN, Planning, Conservation and Sustainable Development of Bach Ma National Park for the Period 2010-2020, Ha Noi., 2011).

* Self-organized ecotourism business: Center for Environmental Education and Service is responsible for managing tourism activities in Bach Ma National Park. The organization center provides entrance ticket services, guide explanations at tourist routes and spots, selling souvenirs, camping service in the forest, and transportation service from the foot of the mountain to Bach Ma ecotourism area.

* Cooperation in ecotourism business: To operate the ecotourism business professionally, since 2014, Bach Ma National Park has signed an economic contract and allows Thanh Tam Tourism and Service Company to use the premises to organize food and beverage services for tourists.

* Leasing special-use forest environment for ecotourism business: Bach Ma National Park has allowed business units to lease forest environment in Sub-Area 214 (9.14ha) and Sub-Area 227 (90.27ha) belonging to the service-administrative subdivision (total area of 99.41ha). The typical forest status is a poor forest with the main trees being Jamblon, Barringtonia racemose, and Khoeo discolors; The bare land is mainly bamboo and vines interspersed with regenerated timber trees. The area allowed for the construction of the works is 02%, without changing the purpose of using special-use forest land.

3.3. Current status of ecotourism development in Bach Ma National Park

3.3.1. Tourists

With its unique landscape and high level of biodiversity, Bach Ma National Park has attracted many domestic and international tourists. Table 3 shows that since opening to welcome guests in 2013, the number of tourist arrivals has increased continuously (from 13,280 in 2013 to 29,250 in 2019). Notably, in 2020 and 2021, the number of visitors decreased significantly due to the impact of the Covid-19 epidemic. From 2022 to April 2022, Bach Ma National Park has temporarily stopped welcoming tourists (due to the effects of the Covid-19 outbreak, and the route to the top of Bach Ma was eroded). From 4/2022 until now,

Bach Ma National Park welcomes visitors back at 2 points (Tri Sao Waterfall and Truoi Lake) with 911 visitors.

The number of visitors on the day accounted for nearly 80%; the proportion of international visitors accounts for 30% of the total number of tourists and tends to increase rapidly (from 13,380 arrivals in 2016 to 24,014 arrivals in 2019). This proves that the ecotourism model in Bach Ma is beautiful to international tourists due to its pristine natural resources and natural environment, especially well-preserved flora and fauna.

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Table 3. Number of tourists in Bach Ma National Park in the period of 2013-2021 (visitors)

Year	Total	Domestic Visitors	International visitors
2016	18.200	13.380	4.820
2017	18.652	12.433	6.219
2018	23.200	14.898	8.302
2019	29.250	24.014	5.236
2020	16.170	13.668	2.502
2021	6.113	5.981	132

Source: Department of Tourism of Thua Thien Hue province, 2022

The number of visitors at Bach Ma National Park is divided by time and space, causing an overload on the natural environment.

+ Due to weather and climate conditions, the number of visitors mainly concentrates from March to August (concentrating to 88.3% of the total number of visitors for the whole year). Tourists are primarily workers, officials, students, and students traveling in large numbers. Especially on festivals and weekends, it often causes overload at tourist routes and destinations. Specifically, at the Hai Vong Dai trail, at peak times, the number of visitors is twice as large as the allowed capacity (117 compared to 49 visitors/day) or the route to Ngu Ho (five lakes) (92 compared to 88 visitors/day).

+ Ecotourism activities focus on several routes and attractions, such as the Hai Vong Dai route, Ngu Ho trail, and Do Quyen trail. These are areas adjacent to the intact protection zone, where ecosystems need to be protected and limited human impact.

3.3.2. Revenue

Currently, the tourism revenue of Bach Ma National Park mainly comes from collecting entrance fees and accompanying services (guides, campfires, planting trees, porters). Bach Ma National Park is allowed to leave 90% of the total cost collected to cover expenses; the rest is paid into the state budget.

Table 4. Tourism revenue in Bach Ma National Park 2013-2021

Year	Number of visitors (visitors)	Revenue (million VND)
2013	13,280	380
2014	14,150	450
2015	14,852	480

2016	18,200	622
2017	18,652	862
2018	23,200	1,156
2019	29,250	1,428
2020	16,170	878
2021	6,113	342

Table 4 shows that the revenue from ecotourism activities of Bach Ma National Park from 2013-2021 continuously increased (from 380 million VND in 2013 to 1,428 million VND in 2019). Notably, revenue decreased in 2020 and 2021 due to the heavy influence of the Covid 19 pandemic.

3.3.3. Routes, attractions

Bach Ma National Park has built many routes and tourist attractions with attractive tours.

(1) Routes, attractions

+ Hai Vong Dai Trail: The most convenient sightseeing route for visitors with a length of 800m, paved with granite, leading to Hai Vong Dai observatory (at an altitude of 1,430m). Visitors can visit the natural landscape of the mountains, the sea, and the lagoon.

+ Do Quyen Trail: About 1.5km long, leading to Do Quyen waterfall (over 300m high). On the edge of the cliffs and streams, there are many red Rhododendron flowers in spring.

+ Ngu Ho Trail: About 1.5km long, taking visitors to beautiful waterfalls with clear blue lakes. Visitors can swim in lakes 4 and 5.

+ Trail of Cho Den Forest: The trail leads visitors to the majestic Black Chop forest (with the black cypress trees over 1m in diameter and over 30m in height).

+ Tri Sao (Rheinardia ocellata) Trail

+ Truoi Lake - Truc Lam Bach Ma Zen Monastery: Truoi Lake has an area of about 400 ha, and Truc Lam Bach Ma Zen Monastery was built on a high mountain. Here, visitors can learn about the Zen line Truc Lam Yen Tu; about the origin of national Buddhism.

In addition, Bach Ma National Park has many other potential routes and attractions, such as Ngu Ho Trail; MIA Trail; Route Km 8 - Tri Sao - Truoi Lake; Huong Loc ecological village, and Thuong Nhat environmental village.

+ Tour mở "Khám phá thế giới hoang dã về đêm"

(2) Tours

+ Biking tour to conquer Bach Ma peak: With a total length of 15.2 km and an altitude of 1,260m, the average slope is 8.3m, and trees cover 90% of the road. This is one of the tours that attract many visitors.

+ Open tour "Explore the wild world at night."

+ Open tour "Call the birds to watch the sunrise": With a diversity of bird fauna (with 363 species, of which 16 species were listed in the Vietnam Red Book in 2007, 13 species listed in the IUCN List in 2016 and 2016), 13 endemic species) [29], Bach Ma National Park has developed a type of bird-watching tourism. This is a tour with great potential for future development.

+ Camping in the forest: The capacity of the Thong Nang area is about 50 visitors/time with 11 campsites (10 campsites and 01 center camp). The campground has an electric lighting

system, self-flowing water faucets and accompanying services such as a campfire area and a charcoal stove for barbecue.

3.3.4. Infrastructure - facilities for Ecotourism

By 2022, all communes in the buffer zone of Bach Ma National Park will have roads for cars, and roads to villages have been concreted to serve people's travel and create favorable conditions for tourism development ecological calendar. However, the investment in the transportation system has also increased the number of tourists and motor vehicles entering Bach Ma National Park, which has significantly affected the wildlife here. In addition, it also increases the erosion process, prevents flow, and puts great pressure on the natural environment.

Bach Ma National Park's accommodation and food establishments are basically satisfying in terms of quantity. Table 5 shows that Bach Ma National Park has more than 39 rooms (including villas, motels, and homestays) with prices ranging from 300,000-1,050,000 VND to serve the accommodation needs of tourists. However, the quality of accommodation facilities is low because most villas and motels were built long ago and are being degraded.

Table 5. Number of accommodation facilities in Bach Ma National Park

Accommodation	**Quantity (Room)**	**Price (VND/room)**
The area at the foot of Bach Ma Mountain	13	300,000
An area on the top of Bach Ma Mountain		
Villa Do Quyen I, II	08	750,000 - 1,000,000
Villa Phong Lan	06	1,050,000
Villa Kim Giao	09	750,000 - 950,000
Bao An's House	03	750,000

Source: Bach Ma National Park Management Board

In addition, Bach Ma National Park also has transportation services by 16-seat car; guide services at tourist attractions; food and beverage services; camping services.

3.3.5. The degree of assurance of the role of environmental education and presentation

One of the criteria to distinguish Ecotourism from other types of tourism is to uphold the role of environmental education and presentations as a basis for forming attitudes and behaviors towards the natural environment course. Specifically, tourists must have complete and realistic information before visiting; presented about Bach Ma National Park's natural environment and values upon arrival and during the visit.

Environmental education activities have been carried out through Green clubs established in schools in the buffer zone. From 2015 up to now, Bach Ma National Park has coordinated with school clubs to organize 80 educational activities on environmental protection; 08 marches to promote forest protection, 01 round of "cycling for the environment,"; 06 trips to visit and experience Bach Ma National Park; Organized a painting and speaking contest.

For tourists, the Visitor Center is a place to welcome guests, provide information about Bach Ma National Park, and organize environmental education activities for guests. However, the research shows that the percentage of tourists who collect data from this source is relatively small, the number of tourist groups that require a guide is low, and most tourists often visit by themselves according to the guide map. On the other hand, due to limited time to visit, the desire to learn about Bach Ma National Park is not the real need of many visitors. Therefore, most tourists do not know much about Bach Ma National Park before and after the end of the tour.

In addition, most of the guides of Bach Ma National Park are mainly trained in forestry and pedagogy; have not undergone formal training courses in tourism. Therefore, the level of instruction, explanation, foreign language, and knowledge about biodiversity and the ecological environment is still limited. These limitations have significantly reduced the role of tour guides, especially for Ecotourism.

3.3.6. The relationship between ecotourism development and the local community

Ecotourism activities in Bach Ma National Park have contributed to economic improvement for the people in the buffer zone. From 2013-2020, 180 villages in the buffer zone were supported for livelihood development with a total amount of 7.2 billion VND (each model/project is 40 million VND). The livelihood support programs of Bach Ma National Park have been positively responded to by the local community, contributing to improving rural infrastructure, meeting necessary needs, serving long-term benefits for the entire community communities and enhancing livelihoods for local people; contributing to strengthening the cohesion and coordination between the national park, local authorities, and communities in the buffer zone of Bach Ma.

In addition, through ecotourism activities, cultural features (festivals, food, costumes, and music) of ethnic minority communities are preserved and developed. However, the participation of local people in ecotourism activities is still limited; tourism is relatively isolated from the community. Therefore, in the coming time, it is necessary to create conditions for local communities in the buffer zone to participate in and benefit from ecotourism activities.

* General assessment

Bach Ma National Park has great potential for ecotourism development and has achieved positive results. The story of ecotourism activities has created a financial source for conservation work, creating jobs and stabilizing incomes for communities in the buffer zone, contributing to economic restructuring towards tourism - services, and promoting socio-economic development for the locality. Besides, the story of Ecotourism in Bach Ma National Park still has many challenges and difficulties. Specifically:

+ Although there are many potentials to develop Ecotourism, in reality, these potentials have not been synchronously planned, invested, and exploited; current ecotourism products are still monotonous, the exploitation of tourism resources only stops at sightseeing and interpretation, and little investment is invested in upgrading, embellishing or creating their highlights; Tourism promotion is still limited.

+ Investment in infrastructure construction is still slow; accommodation, dining, amusement, and entertainment facilities have not met the demand for quality service tourists (especially international guests).

+ Many areas of Bach Ma National Park lease forest environment for ecotourism business, but there are no investors (because most of these sites are small in area, there are no roads; it is difficult to connect with their link with other routes and tourist attractions).

+ The harsh climate with heavy rainfall, low number of business days (less than 100 days/year), and high number of bad weather days affect the ecotourism business.

3.4. Solutions to develop ecotourism activities in Bach Ma National Park

Based on the legal framework and specific regulations on ecotourism development in national parks, nature reserves, and the current status of ecotourism development in Bach Ma National Park, we propose the following: solutions to develop ecotourism activities more effectively and sustainably.

+ Policy solutions

Bach Ma National Park needs to create favorable conditions to attract domestic and foreign organizations and individuals to invest in the construction and development of ecotourism services through joint ventures and investment linkages, leasing forest environmental services for ecotourism business to create a breakthrough in stabilizing revenue. Diversify and build specific ecotourism products for Bach Ma National Park. In addition to sightseeing tours and experiencing nature and culture, Ecotourism needs to combine conferences, seminars and research, training, and event organization.

+ Capital solutions

In the context of limited financial resources and the constraints of current mechanisms and policies, the attraction and selection of business cooperation forms in the form of Public-Private Partnerships, leasing of business forest environment ecotourism to contribute to solving difficulties in infrastructure investment - material. In the long term, Bach Ma National Park needs to strengthen the mobilization of all social resources and capital sources in enterprises of all economic sectors for investment in many forms (contribution of construction capital, joint ventures, and joint ventures), direct construction investment, construction investment loan...).

+ Human resource solutions

Training a team of managers, and eco-tour guides with high professionalism, with a sense of protection and sustainable development of the tourism environment. Pay attention to teaching local guides to exploit local resources and create jobs and income for local communities, and strengthening training to improve foreign language skills for officials, staff, and guides to facilitate the reception and service of international visitors to the reserve to visit study and research.

+ Solutions for propaganda and promotion

Increase the participation of local people living in and near ecotourism sites in tourism planning and management. Strengthen the organization of tourism promotion through movies, websites (Tripadvisor, Trivago, Booking), and social networks (Facebook, Youtube, Instagram, Tweeter).

+ Solutions for awareness education and environmental protection

Ecotourism resources are often susceptible to impacts. Therefore, it is necessary to increase awareness among guides, staff, local people, and tourists about preserving and conserving resources and avoiding environmental damage.

+ Solutions to improve the lives of people in the buffer zone

The support level of 40 million VND/village/year is low and unsuitable for actual conditions. Therefore, in terms of short-term solutions, Bach Ma National Park needs to increase the level of support for buffer zone development, prioritize local communities to participate in ecotourism activities, create jobs, raise incomes, and stabilize local people's lives. In the long term, Bach Ma National Park needs to develop a mechanism to share benefits with people in forest management and protection. The Bach Ma National Forest Management Board should have policies and regulations for tourism business organizations to ensure that there is a sharing of material profits for local communities and for resource conservation environment where these organizations exploit ecotourism development.

4. Conclusion

Bach Ma National Park has the potential to develop Ecotourism with diverse natural and humanistic tourism resources, especially the distinct ecosystems and endemic plant and animal species, which are well preserved.

Ecotourism activities in Bach Ma National Park have been organized and achieved some results. The number of tourists and the revenue of Bach Ma National Park has increased over the years, from 13,280 visitors with an income of 380 million VND in 2013 increased to 29,250 visitors with a revenue of 1,428 million VND in 2019. Notably, in 2020 and 2021, due to the impact of the Covid-19 epidemic, the number of visitors and revenue decreased significantly. Bach Ma National Park has built attractive tourist routes and attractions such as Hai Vong Dai Trail; Do Quyen Trail; The Five Lakes Trail; Cho Den (Parashorea stellata Kurz) Forest Trail; Tri Sao Trail; Truoi Lake - Truc Lam Bach Ma Zen Monastery with tours to visit, explore, adventure, experience walking, climbing, staying. Infrastructure - facilities for Ecotourism have been invested in and built. Environmental education and demonstration for tourists and locals have been carried out through the Center for Environmental Education and Services of Bach Ma National Park. Ecotourism activities have created financial resources for conserving natural and cultural resources, created livelihoods, supported local communities in the buffer zone and predominantly ethnic minority communities, and contributed to promoting the locality's socio-economic development.

The current state of ecotourism development is not in line with its potential; ecotourism products are still subpar; the infrastructure - material, and technical system have not met the needs of tourists and are degraded; the quality of tourism services (accommodation, transportation, entertainment, and entertainment services) is not high; and despite the results achieved, ecotourism activities of Bach Ma National Park still face numerous challenges and difficulties. In addition, the harsh climate (heavy rainfall, high humidity, prolonged rainy and cold periods) has also affected the ecotourism business in Bach Ma National Park.

Based on the orientations of ecotourism development in Vietnam in general and the current status of ecotourism development in Bach Ma National Park, we have proposed solutions to improve the efficiency of tourism activities ecological calendar in Bach Ma National Park. The solutions system includes policy solutions, funds; human resource solutions; propaganda and promotion solutions; solutions for awareness education and environmental protection; and solutions to improve people's lives in the buffer zone. The implementation of solutions needs to be carried out synchronously, paying particular attention to implementing the principles of sustainable tourism development, avoiding harm to natural resources and the environment.

References

1. Carvache-Franco, M., Carvache-Franco, W., Carvache-Franco, O., & Borja-Morán, J. (2022). Motivations as a predictor of satisfaction and loyalty in ecotourism. *Journal of Outdoor Recreation and Tourism*, *37*(October 2021). https://doi.org/10.1016/j.jort.2021.100478
2. Ceballos-Lascurain, H. (1987). The future of 'ecotourism.' *Mexico Journal*, 13–14.
3. Dung, T. D., & Son, H. N. (2017). Current satus and solutión to developing tourism in highland districts of Thua Thien Hue province. *Hue University Journal of Science*, *126*, 5–14.
4. Dung, T. D., & Son, H. N. (2020). Orientation of links to develop tourism products in the mountain districts of Tri - Thien area. *Review of Regional Sustainable Development. Vietnam Academy of Social Science*, *2*.
5. Report on management of special-use forest systems, protection in 2019 and sustainable development solutions. Ha Noi., (2019).

6. Decision No. 1633 QD/BNN-TCLN, Planning, conservation and sustainable development of Bach Ma national park for the period 2010-2020, Ha Noi., (2011).
7. Decision No. 2958/QD-BNN-TCLN on the Scheme of renting a special-use forest environment for ecotourism business in Bach Ma National Park. Ha Noi., (2017).
8. Decision No. 2522/QD-BVHTTDL approving the Strategy for the development of Vietnam's tourism brand to 2025, orientation to the year 2030, Ha Noi., (2016).
9. Decision No. 2714/QD-BVHTTDL approves the Strategic Project on the development of Vietnam's tourism products to 2025, with an orientation to 2030, Ha Noi., (2016).
10. Decision No. 1107/2015/QD-BTNMT, The list of protected areas, Ha Noi., (2015).
11. Tham, N., & Son, H. N. (2011). Bioclimatic resource assessment for the development of tourism in Thua Thien - Hue province. *Ho Chi Minh City University of Education Journal of Science - Special Issue: Social Sciences and Huamanities*, *26*, 94–104.
12. Tran, L., & Walter, P. (2014). Ecotourism, gender and development in northern Vietnam. In *Annals of Tourism Research* (Vol. 44, Issue 1, pp. 116–130). https://doi.org/10.1016/j.annals.2013.09.005
13. Vietnam Administration of Forestry, 2021. (2021). *Management, conservation and sustainable development of Bach Ma National park, period 2021-2030*.
14. Vietnam National Administration of Tourism, 1999. (1999). *Developing strategies for ecotourism development in Vietnam, National Workshop.*
15. Vu, D. N., & Son, H. N. (2004). The effects of climate on ecotourism in Thua Thien - Hue province. *Journal of Sciences of the Earth, 26(2)*, 181–187.
16. Walker, K., & Moscardo, G. (2014). Encouraging sustainability beyond the tourist experience: Ecotourism, interpretation and values. *Journal of Sustainable Tourism*, *22*(8), 1175–1196. https://doi.org/10.1080/09669582.2014.918134

Study on the procedure of UAV-based flight and image processing for forest mapping: experimental result from industrial park of Ha Hoa, Phu Tho province

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Abstract. The use of unmanned aerial vehicles (UAVs) in mapping the status of forest coverage is widely implemented and provides a superior solution due to its precision, mobility and cost-effectiveness. However, the application and implementation procedure of such technique in Vietnam is not yet consolidated in terms of operation framework, methodology and product standard, also depending on the expertise and availability of the operator agency. In this study, we establish a forest status map for 400 hectares of the industrial park in Ha Hoa district, Phu Tho province by deploying a UAV (DJI MavicPro 2) at an altitude of 150m to acquire multispectral optical imagery at a very-high-resolution of 5.4cm and traditional field survey. The software eCognition Developer v9.1 by Trimble Geospatial was used to perform object-based image multiresolution segmentation, then labelled using field-based key samples to correlate forest cover types and classify using the Random Forest algorithm. The forest cover map was established at the scale of 1:2000, consisting of 2180 condition plots in total, with the area of forest (mainly afforested) and unforested cover being 171ha and 229ha, respectively. Study outcomes provide a reliable dataset of location, and area of land use/forest cover types to support local administrators in forest evaluation and propose proper forest protection and promotion.

Keywords: drone, land cover, forest status map, random forest, multiresolution segmentation

1. Introduction

Applied remote sensing and GIS techniques in studying forest cover status and coverage, as well as other surface problems, are one of the most well-known research approaches worldwide. Recently, the emergence of Unmanned Aerial Vehicles (UAVs) has brought numerous changes to remote sensing applications. In particular, UAVs are able to obtain very high spatial resolution data with absolute management of operation time (Wyard et al., 2022). Globally, UAV applications can be performed extensively and intensively in the field of agriculture and forestry (Norasma et al., 2019) to collect geospatial data, especially for forestry work and afforestation operation, besides providing reliable data and manoeuvrability for other forestry tasks (Suab and Avtar, 2020). One of the UAVs' advantages is the accessibility to difficult terrain, hence they are capable to use as an inspection tool to evaluate the accuracy of other land cover mapping methods using different remote sensing datasets (Gao et al, 2022).

The usage of UAVs in forestry is no longer a new concept in Vietnam, but it retains difficulties in proper deployment. For dense jungles, remote sensing studies using satellite imagery with spatial resolution greater than 2m per pixel might not be appropriate due to error and low accuracy. In forestry and forest management, UAVs are extensively employed thanks to their highlighted features of high spatial resolution, versatility in temporal data acquisition

and cost-effectiveness (Hoi and Dung, 2021). UAVs can capture multispectral imagery with a higher spatial resolution (less than 2m per pixel), therefore they are a better solution which is convenient for intensive study in the field of forestry.

Alternatively, the practical requirement of local forest management requests a forest cover map scaled at 1:2000, which is a high precision, updated and reliable data for administration purposes. The application of UAV-borne imagery has been expected to settle the requirement in terms of accuracy, manoeuvrability and practicality. In this paper, the large-scaled forest cover map is experimentally implemented by combining high-precision multispectral imagery from the DJI Mavic 2 Pro device and automatically object-based image classification using the eCognition Developer software at the test site of the industrial park of Ha Hoa district, Phu Tho province.

2. Methodology

2.1. Study area

The study was implemented in the industrial park in the northwest of Phu Tho province, in the geographical area of Ha Hoa district, which has served as a commodity hub among Phu Tho and other provinces of the Northwestern Vietnam region. The area has convenient traffic routes which include highways, and waterways, close to the crossroad of TransAsia expressway CT05 (Noi Bai – Lao Cai Expressway), and approximately 4km away from the 32C national highway.

Local terrain in the projected industrial park is relatively flat, hilly, and dissected by a few narrow, dry gullies. The topology is declined to the east downstream to the Red River, with the average slope of 8-20^{o}, relative elevation of 40-55m a.s.l with the highest peak of 70m on the southwest borderline of the park. Such terrain is favourable for agro-forestry production, especially large-scale, concentrated industrial parks.

The total area of the projected site is 400 hectares, lies on the territory of 2 communes (Xuan Ang and Vo Tranh communes), and is divided by the CT05 expressway into 2 sections - A to the north and B to the south with a respective area of 158 hectares and 242 hectares. The site is projected to be a concentrated and multipurpose, hi-tech and eco-friendly industrial park, for clean manufacturing to reduce industrial wastewater (i.e. inhibit sectors that generate toxic, environmentally hazardous wastewater).

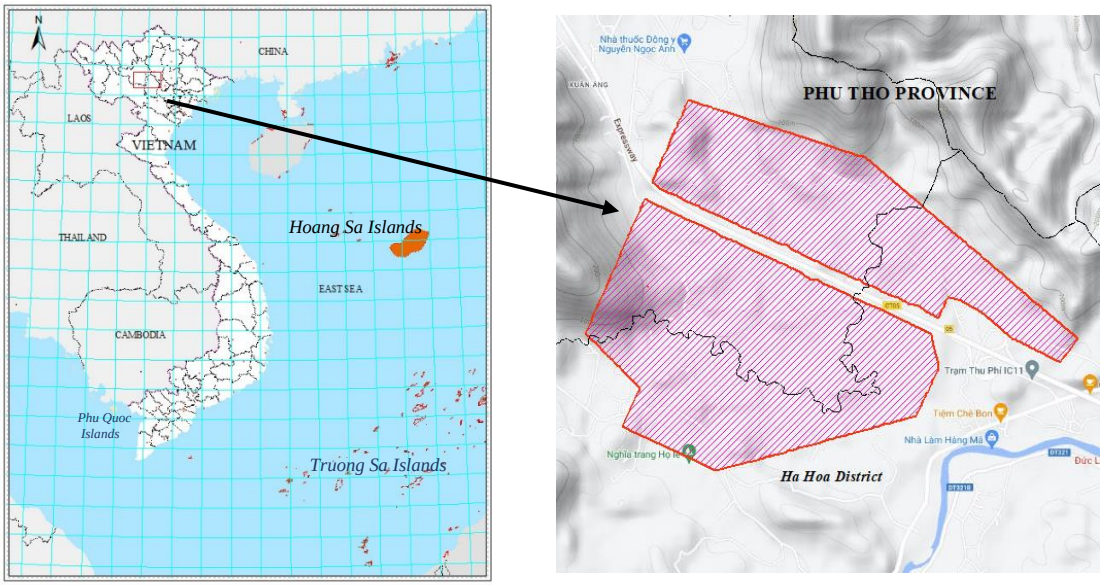

Figure 1: Location of the study area

In terms of forestry, forest plantation is a notable practice on gentle slope hills and multiple transportation routes, which is a favourable condition for manoeuvring small UAVs. Principal plants in the study area are Acacia sp., Eucalyptus sp., and Dendrocalamus sp., cultured in household size and interstitials.

2.2. Data acquisition and processing

To obtain multispectral imagery in the study site, one UAV DJI Mavic 2 Pro was deployed. UAV configuration included one gimbal camera Hasselblad L1D-20c with 1" CMOS sensor at the resolution of 20MP, aperture f/2.8-11, colour profile Dlog-M 10-bit. The UAV is configured by the manufacturer for easy manoeuvrability and usage, with compatibility with multiple flight route design applications. In this study, a Pix4D application was implemented to perform flight route design. Then, a raw UAV-borne photo was imported and processed by the Agisoft Metashape software to produce an orthophoto for later multiresolution image segmentation and classification using a key sample set on eCognition Developer software.

UAV imagery and orthophoto specification in the Agisoft Metashape software was described as follows:

Table 1: Orthophoto specifications for UAV-borne imagery

Specification	
Visible band	The natural visible spectrum of Red, Blue, Green
Spatial resolution	
Geometry correction	Accuracy improvement using Ground Control Points (GCPs)
Colour improvement	For visual use and sun elevation correction
Image coordinates	WGS 84/UTM zone 48N

2.3. UAV-borne image interpretation and forest cover mapping procedure

This study used the classification scheme for forest cover status and forestland according to Circular No.33/2018/TT-BNNPTNT dated 2018, November 16th by the Vietnam Ministry of Agriculture and Rural Development (MARD) on the regulations of forest surveillance, inventory and monitoring.

Orthophoto processing was described in Fig.2 and used as the primary input for interpretation and forest cover mapping.

Jalbuena and other scientists, such as Jilliane Rae, used a multiresolution segmentation algorithm on the LiDAR dataset using eCognition (Jalbuena et al., 2015; Jilliane Rae, 2018).

In this study, eCognition Developer v9.1 was performed on image segmentation and classification for forest cover mapping on the projected site for the industrial park of Ha Hoa district, Phu Tho province based on a UAV-borne composed multispectral image acquired in November 2021.

Interpreted sample key set in the study was obtained and examined on-site. Then, 70% of the set (280 samples) was labelled to the segmented image to product forest cover map, and the remaining 30% (120 samples) was allocated for later on-site verification and accuracy assessment.

The land-use map of Xuan Ang and Vo Tranh communes (established by the People Committee of Ha Hoa district in the year 2020) scaled at 1:2000 was re-organized into similar land-use purpose groups to produce a reference layer used for the segmentation operation to

minimize computerized error happens during processing. The processing also ensured the segmentation operation produces forest plots closed to land-use parcels, hence favours land-use information association and layering into the final map.

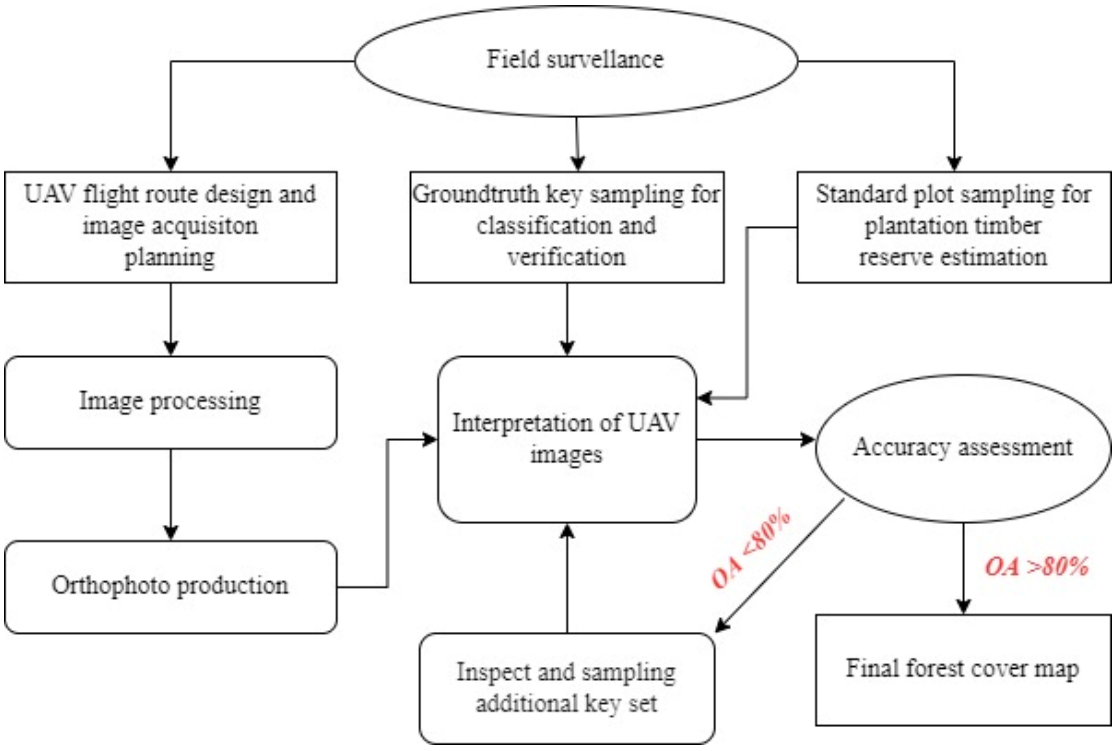

Figure 2: Workflow of forest cover mapping in the study area.

The sample key set was used for multiresolution segmentation in the eCognition Developer software. Baat (2000) firsthand proposed and performed the image multiresolution segmentation as an integrated technique to group pixel-based homogeneity region and its neighbour pixel into an object by considering the homogeneity criteria of pixels or current image object. (Baatz, 2000; Baatz and Schape, 2000). Kavzoglu (2014) assumed that image segmentation creates objects by grouping spectral homogeneity features on images. The multiresolution segmentation algorithm is bottom-up grouping, beginning with a 1-pixel object to separate an image into meaningful segments which closely relate to real-world objects or regions represented in the image. Segmentation is used to identify an object's location and its boundary with neighbouring ones (Kavzoglu and Yildiz, 2014). In the following steps, smaller image objects would be fused into larger ones, continuously. During coupled clustering, the basic optimization process minimizes heterogeneity with a weight factor defined by n*h, of which n is segment size, and h is the randomness definition of heterogeneity. In each step, the neighbouring coupled image objects would be fused. The fusion operation will stop when the minimum growth surpasses the threshold calculated by the scale parameter (eCognition, 2004). The spectral/colour heterogeneity was defined as formula (1).

$$h = \sum_c w_c \sigma_c \qquad (1)$$

The heterogeneity (h) due to deviation is described by the ratio between the total length of the reality perimeter of the segment and the square root of the pixel quantity it contains, after Karakis et al, 2006, as in (2) $h = \frac{l}{\sqrt{n}}$ (2)

** Random Forest classification algorithm*

According to Genuer (2020), the segment labelling using Random Forest (RF) algorithm in the eCognition Developer software was a considerably novel and comprehensive machine learning technique for classification, regression and other tasks by aggregating a collection of decision trees in a learned period to seek for a method of classified layers or estimate regressive median of each tree (Genuer and Poggi, 2020).

2.4. Classification result assessment

For accuracy assessment, a minimum number of 10 pixels for each classified status is randomly selected, and then compared to ground-truth data collected on-site. If the accuracy rate was under 80%, the classification operation and key sampling would be revised to improve the accuracy of the classified map (Mai Trong Thinh and Nguyen Hai Hoa, 2017). The procedure requires the following steps:

Confusion matrix building for the classified outcome and verification samples to evaluate the Kappa coefficient (K). According to Congalton (1999), the confusion matrix is the best method for accurate assessment (Congalton and Green, 1999).

-– Overall accuracy assessment

-– User accuracy assessment

-– Producer accuracy assessment

The Kappa coefficient is used as a measure of classification accuracy. This is the unifying factor of all the primes from the confusion matrix. The Kappa efficiency is explained as the fundamental difference between the actual skewness error of a matrix and the total number of changes indicated by rows and columns (McGrath, 2010). The determining formula for the Kappa coefficient is as follows:

$$K = \frac{N\sum_{i=1}^{r} X_{ii} - \sum_{i=1}^{r}(X_{i+} - X_{+i})}{N^2 - \sum_{i=1}^{r}(X_{i+} - X_{+i})} \qquad (3)$$

Where: r = number of columns in the image matrix; X_{ii} = number of observed pixels at row i and column i (on the main diagonal), X_{i+} = Total observed pixels at row i, X = total observed pixels at column i and N = total number of pixels observed in the image matrix.

The Kappa coefficient is normally between 0 and 1, i.e. if the score in this range is acceptable for the accuracy of the classification. According to the USGS, the score has been divided into 3 groups: $K \geq 0.8$: high accuracy; $0.4 \leq K < 0.8$: moderate accuracy; and $K < 0.4$: low accuracy

3. Result and discussion

3.1. Key sample set

In this study, the classification scheme according to the Circular No.33/2018/TT-BNNPTNT dated November 16th, 2018 by the MARD on the regulations of forest surveillance, inventory and monitoring. Field surveillance for key sample collecting and standard plot survey for forest plantation had determined 9 types of land-use and forest as follows.

The key sample set included 400 samples, which were timber plantation (RTG, 81 samples), bamboo plantation (RTTN, 18 samples), palm plantation (RTCD, 4 samples), new plantation (DTR, 26 samples), fruit trees and non-aquatic vegetation (DNN, 95 samples), water body (MN, 57 samples), build-up area and other land-use (DK, 59 samples), bare land (DT1, 47 samples), rice paddy (NNP, 13 samples). There were 280 samples (accounted for 70% of the set) used as key samples for classification operation and the rest of 120 samples (30% of the set) for verification and accuracy assessment.

1. Bamboo plantations (RTTN)	2. Timber plantations (RTG)	3. Palm Plantations (RTCD)

4. Rice (NNP)	5. Water surface (NNP)	6. New Plantations (NNP)

7. Bare soil (DT1)	8. Fruit trees (DNN)	9. Build up (DK)

Figure 3: Classification scheme and key samples

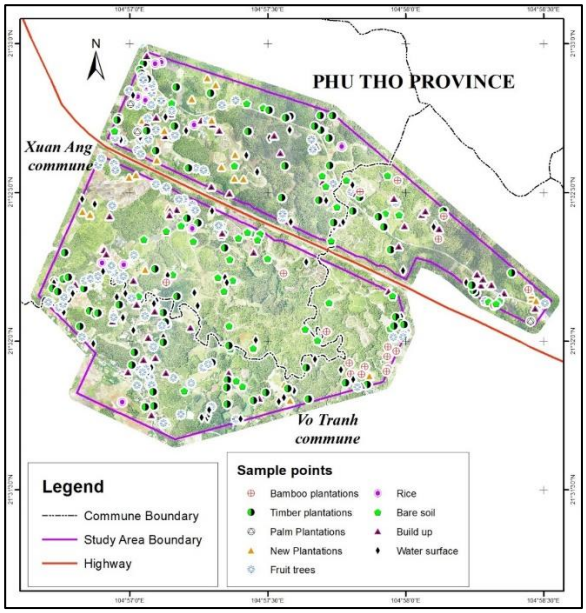

Figure 4: Position of image key sampling for classification and verification

3.2. Classification accuracy assessment

The overall accuracy of the interpretation results was 95% with the Kappa coefficient scored 0.93. Deviation emerged the most for NNP, MN, DK, DT1 where accuracy range at 90%-92% (Table 2). These were non-forest status codes and difficult to decipher states. Accuracy for plantation forest statuses were absolute (100%), which implied the 5.4cm spatial resolution UAV-based images clearly made sharply distinction between objects.

Table 2: Confusion matrix between classified results and verified key samples.

FCM		**Ground Reference**									**Total**
		DK	DNN	DT1	DTR	MN	NNP	RTCD	RTG	RTTN	
Classification	DK	9		1							10
	DNN		13		1						14
	DT1	1		9							10
	DTR				20						20
	MN					9	1				10
	NNP					1	12				13
	RTCD							4			4
	RTG								24		24
	RTTN									15	15
Total		10	13	10	21	10	13	4	24	15	120
User Accuracy (%)		90.00	100.00	90.00	95.24	90.00	92.31	100.00	100.00	100.00	95.28
Producer Accuracy (%)		90.00	92.86	90.00	100.00	90.00	92.31	100.00	100.00	100.00	95.02
Overall Accuracy (%)											**95.15**

3.3. Forest cover map and statistics

The forest cover map was successfully established at the scale of 1:2000 with additional information on administrative boundaries, land parcels, projected land-use, and plantation timber reserves into each forest plot as follows:

Table 3: Forest cover and landuse statistics in the study area

No	**Landuse/Forest type**	**Alias**	**Total area**	**Commune**	
				Vô Tranh	**Xuân Áng**
	Projected industrial park		**400.00**	**176.45**	**223.55**
1	**Forest land**		**171.11**	**78.92**	**92.19**

No	Landuse/Forest type	Alias	Total area	Commune	
				Vô Tranh	Xuân Áng
1.1	Plantation on hilly terrain	RTG	123.79	48.88	74.91
1.2	Bamboo plantation on hilly terrain	RTTN	30.35	22.43	7.92
1.3	Palm plantation on hilly terrain	RTCD	0.14	0.02	0.12
1.4	New plantation on hilly terrain	DTR	16.83	7.59	9.24
2	**Non-forest land**		**228.89**	**97.53**	**131.36**
2.1	Hills	DT1	88.90	29.44	59.46
2.2	Fruit orchard/farmland on hilly terrain	DNN	54.88	26.59	28.29
2.3	Freshwater farm	NNP	28.13	13.17	14.96
2.4	Water bodies	MN	35.07	15.70	19.37
2.5	Build-up area and other landuse	DK	21.91	12.63	9.28

Forest covers 171.11 hectares, and accounts for 43% of the projected industrial park. The entire forest cover within the projected site is plantations, while the natural forest is absent. In the forestland group, there are 123.79 hectares (72%) of timber plantation (RTG) on hilly terrain, of which Acacia sp. appears on 102.08 hectares (accounted for 82% of timber plantation area) and the rest is Eucalyptus sp planted in the 2015-2018 period. Bamboo plantation on hilly terrain (RTTN) occurs on 30.35 hectares (18% of forestland), mostly *Schizostachyum aciculare* species for food (bamboo shoots) and other common uses (furniture, weaving goods…). Palm plantation occurs on only 0.14 hectares, and consists of *Tracycarpus sp.* which is cultivated to harvest leaves used in common uses (house roofing, brooms). New plantation on hilly terrain (DTR – underdeveloped forestland) occurs on 16.83 hectares. DTR land-use is mainly *Acacia sp.* (15.43 hectares, accounts for 92% of DTR) planted since 2019 with a density of 1400-1600 trees per hectare, underdeveloped reserve (or insignificant reserve) due to unmeasurable tree diameter.Non-forest land in the study area is 228.89ha, accounts for 57% of the projected industrial park, including hills (DT1, 88.90 hectares, accounts for 39%) – mostly freshly harvested timber plantation; fruit orchard and cropland on hilly terrain (DNN, 54.88 hectares, accounts for 24%) consist of projected forestland and mainly household cropland with annual and perennial plants (cassava, pineapple, tea…), fruit orchards… Freshwater aquatic cropland occurs on 23.18 hectares (12% of non-forest land), where is rice paddies. Water bodies take 35.07 hectares (15%), and serving as reservoirs for cultivation and streams. Build-up land and other landuses occur on 21.91 hectares where are non-cultivated land, including residential land, workshops, farmland, traffic routes…

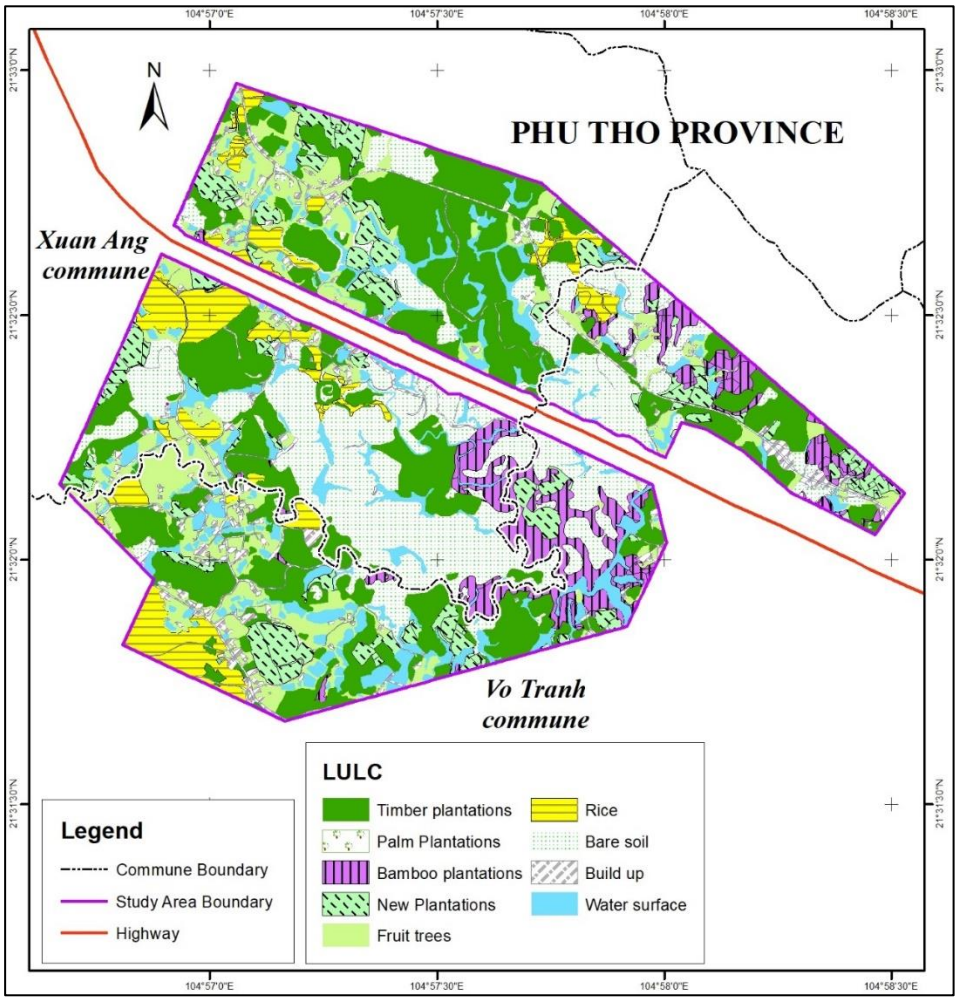

Figure 4: UAV-based forest cover map of the industrial park of Ha Hoa district

4. Conclusion

In this study, we present the performance of a small UAV device to establish a large-scale forest cover map (1:2000) from raw multispectral photo acquisition using a DJI Mavic 2 Pro, orthophoto production and interpretation using multiresolution segmentation and Random Forest classification approaches on the eCognition Developer software. The key sample set included 400 samples of the projected industrial park of Ha Hoa district, of which 280 samples were used for imagery interpretation and 120 samples for verification purposes. The key sample set represented 9 types of land-use, of which forestland (plantation) and non-forest land were 4 and 5 types, respectively. Based on the types of the key sample set, UAV-borne images of the study area had been segmented into 2184 plots and labelled with accordance types. The final forest cover map of the projected industrial map of Ha Hoa district shows 171 hectares of the total 400 hectares were planted forest. Accuracy assessment for interpretation result had been carried out by a confusion matrix of classified outcomes and verified key samples, with an overall accuracy of 95% and Kappa efficient scored at 0.93.

The high accuracy (95%) and Kappa coefficient (0.93) imply the feasibility and applicability of the study. These outcomes could be used to improve the application of remote sensing in general and especially UAV in the establishment of forest cover maps on small area regions. UAV-borne image is easy to access and provides a better cost-effective solution for mapping forest cover, which is essential in forest management, preservation and development.

References

1. Baatz, M. (2000). Multi resolution segmentation: an optimum approach for high quality multi scale image segmentation. Beutrage zum AGIT-Symposium. Salzburg, Heidelberg, 2000,
2. Baatz, M., & Schape, A. (2000). Multiresolution segmentation: an optimization approach for high quality multi-scale image segmentation. *Angew. Geogr. Info. verarbeitung, Wichmann-Verlag, Heidelberg*, 12-23.
3. Congalton, R. G., & Green, K. (1999). *Assessing the accuracy of remotely sensed data: Principles and practices* Boca Raton, FL, USA.
4. eCognition. (2004). User Guide 4, Definiens Imaging GmbH.
5. Gao, W., Wang, G., Li, H., Mao, W., Yin, S., & Yao, B. (2022). Research on the key technology of uav in the accuracy assessment of land cover classification. *The International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences*, *43*, 1203-1208.
6. Genuer, R., & Poggi, J.-M. (2020). Random forests. In *Random Forests with R* (pp. 33-55). Springer.
7. Hoi, N. D., & Dung, N. T. (2021). Seasonal Dynamics of Tropical Forest Vegetation in Ngoc Linh Nature Reserve, Vietnam Based on UAV Data. *Forest and Society*, *5*(2), 376-389.
8. Jalbuena, R., Peralta, R. V., & Tamondong, A. M. (2015). Object-based image analysis for mangroves extraction using Lidar datasets and orthophoto. *ACRS Proceedings, Asian Association on Remote Sensing, Manila, Philippines*.
9. Jilliane Rae, C. C. (2018). Object-based image analysis for extraction of mangrove forests in rehabilitated areas of Bacolod, Lanao Del Norte, Philippines using lidar data and GIS. *Journal of Applied Sciences Research*, *14*(4), 6-10.
10. Karakış, S., Marangoz, A., & Büyüksalih, G. (2006). Analysis of segmentation parameters in ecognition software using high resolution quickbird ms imagery. ISPRS Workshop on Topographic Mapping from Space,
11. Kavzoglu, T., & Yildiz, M. (2014). Parameter-based performance analysis of object-based image analysis using aerial and Quikbird-2 images. *ISPRS Annals of Photogrammetry, Remote Sensing & Spatial Information Sciences*, *2*(7).
12. Mai Trong Thinh, & Nguyen Hai Hoa. (2017). Using multi-time remote sensing images in assessing changes in mangrove area in Quang Yen town, Quang Ninh province. *Journal of Science and Technology*, *3*.
13. McGrath, R. (2010). Kappa Coefficient. In. https://doi.org/10.1002/9780470479216.corpsy0484
14. Norasma, C., Fadzilah, M., Roslin, N., Zanariah, Z., Tarmidi, Z., & Candra, F. (2019). Unmanned aerial vehicle applications in agriculture. IOP Conference Series: Materials Science and Engineering,
15. Suab, S. A., & Avtar, R. (2020). Unmanned aerial vehicle system (UAVS) applications in forestry and plantation operations: experiences in sabah and sarawak, Malaysian borneo. In *Unmanned Aerial Vehicle: Applications in Agriculture and Environment* (pp. 101-118). Springer.
16. Wyard, C., Beaumont, B., Grippa, T., & Hallot, E. (2022). UAV-Based Landfill Land Cover Mapping: Optimizing Data Acquisition and Open-Source Processing Protocols. *Drones*, *6*(5), 123.

Cultural geography research in Vietnam

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Abstract. As a sub-discipline of human geography, cultural geography studies the relationship between cultural subjects and the geographical space where cultural processes, phenomena, and evolution arise. In the world, cultural geography has received a lot of academic attention, which is reflected in a multitude of scientists' research with diverse schools, models and theories as well as research subjects and topics. In Vietnam, cultural geography is recognized as a major sub-discipline of human geography and a part of geographical science. Cultural geography research in Vietnam is becoming increasingly popular. The approach and methodology, scope and research subjects of cultural geography are increasingly enhanced. In order to gain an overview of cultural geography, this article outlines the situation of cultural geography research in Vietnam; then suggesting some appropriate directions for cultural geography research in order to implement and concretize Vietnam's socio-economic development strategies in the upcoming time.

Keyword: cultural geography research

1. INTRODUCTION

As a sub-discipline of human geography, cultural geography studies the relationship between cultural subjects and the geographical space where cultural processes, phenomena, and evolution arise.

In the world, cultural geography has received a lot of academic attention, which is reflected in a multitude of scientists' research with diverse schools, models and theories as well as research subjects and topics. The comprehensive development of cultural geography together with many specific research topics of this sub-discipline often stem from scholarly debates about the approach, content, subjects and methods of cultural geography research. Compared with classical cultural geography research, state-of-the-art ones have transcended cultural geographical boundaries and approached closer to other fields such as politics, economics, history, environment and so forth to strengthen the interdisciplinary relationship of geography in humanities and social science research, linking with other social theories and approaches. In other words, modern cultural geographers have studied almost every aspect of human geography, thereby reinforcing its role in geoscience.

However, there has not been a comprehensive hermeneutical study of how cultural geography research in Vietnam has developed so far. Therefore, in order to gain an overview of cultural geography, the article will summarize the situation of cultural geography research in Vietnam; then suggesting some appropriate directions for cultural geography research in order to implement and concretize Vietnam's socio-economic development strategies in the upcoming time.

2. LITERATURE REVIEW

2.1. Approach and method

The article applies a *systematic approach* to the cultural geography research as a sub-discipline of human geography. In addition, the *historical geography approach* is also used

through an overview of the historical formation and development of the sub-discipline as well as a review of some typical theoretical schools in the world and in Vietnam.

The authors utilize the *method of collecting and processing information through secondary document* as the main research method. The documents collected and cited hereunder include research works in the field of cultural geography of established foreign and domestic research institutes and academic institutions.

2.2. Findings and discussion

2.2.1. Cultural geography research in Vietnam

a. Theories of cultural geography in the world and approaches in Vietnam

The Berkeley school in North America dated back to the 1920s and was the starting point of classical schools of cultural geography. The original, traditional and dominant view of this school was raised by the American geographer, Carl Ortwin Sauer (1889 - 1975). In the article *The Morphology of Landscape* (1925) published in the *University of California Publications in Geography 2*, he introduced ideas of cultural landscapes, codes of conduct in geography and set that code of conduct based on phenomenology. According to Sauer, "in each landscape, there are phenomena that are not physically present but interrelated or independent of each other". Therefore, the task of geographers is to discover regional links to phenomena: "The task of geography is conceived as the establishment of a decisive system of phenomena, including landscape, in order to capture all its meaning and color the diverse landscape on the ground". Sauer was also fiercely critical of environmental determinism and proposed an alternative approach called "morphology of landscape" or "cultural history". He focused on the cultural landscape research and offered an approach to cultural geography based on the view: Culture is associated with the natural and cultural landscape, when a group of people with diverse characteristics in population size, density, social customs, agricultural production practices, etc. or in other words, culture, has impacted and changed the natural landscape by creating and developing cultural landscapes. The cultural landscape then acts as an intermediary and as human environmental landscape.

This approach involved collecting data on the human impact on the landscape over time. Sauer also believed that agriculture and the domestication of plants and animals had an effect on the natural environment, and expressed concern about the way that modern capitalism was destroying the cultural diversity and the world's environment.

Carl Ortwin Sauer's theory was strongly influential both in North America and in Europe. In the following decades, Sauer's approach remained popular with cultural geographers as they focused on generalizing the origin and diffusion of culture from culture cradles across the world. Despite the empirical controversy about these processes of cultural diffusion, Berkeley school-based cultural geography research tends to study a single cultural landscape of a particular group of people. Common themes include diffusion of farming practices, agricultural life paradigms, distribution and patterns of material cultural products, and land use practices influenced by culture.

Carl Ortwin Sauer's theory of "morphology of landscape" has been widely applied by Vietnamese scientists in their research to find out the organic relationship between nature and human, especially human behavior towards the natural environment reflected in the cultural values of the area, region, and nation. Accordingly, geographers consider the natural landscape as a subject, and culture as an influencing factor to form the cultural landscape.

Julian Haynes Stewart with "Methodology of Multilinear Evolution"

Julian Haynes Stewart (1902 - 1972), the American anthropologist who contributed to the development of the concepts and methods of cultural ecology, was influential among

anthropologists in the mid-twentieth century. Stewart envisioned cultural ecology as a methodology for understanding how human adapt to environment. With his work *Theory of Culture Change: The Methodology of Multilinear Evolution* (1955), he argued that ecology was the science that described the way in which the adaptation to the environment caused cultural change. Human adaptation was partly inherited from history, including technology, practices, and knowledge that enabled human to live in certain environment. That is, while the environment influences human adaptation, it cannot determine itself. Stewart separated the fickleness of the environment from the inner working of the culture that took the former's place. In the long run, this means environment and culture are more or less on separate evolutionary paths, and the ability to interact between environment and culture depends on the structure of each element.

Steward's method is a demonstration of the technologies and methods used by people to exploit the environment and make a living, to observe cultural-behavioral patterns of human in relation to the use of environment, and finally to evaluate how these behavioral patterns affect other aspects of culture [16].

The theory of "The methodology of multilinear evolution" has been applied by many Vietnamese scientists in cultural research; carried out in small communities where there is greater unity of environmental knowledge and the range of environmental diversity is also within the capacity of human perception and adjustment. At the same time, the theory emphasizes the role of culture in the process of adapting to the natural environment and calls for a change in lifestyle, leading people to a friendlier attitude towards the environment.

Joel Bonnemaison with "New Cultural Geography"

An important contributor to the development of the theory of cultural geography was the French cultural geographer, Joel Bonnemaison (1940 - 1997). Joel Bonnemaison argued that culture was built and located in a certain space, and there was an interrelationship between culture and its space. Joel Bonnemaison inherited the previous views of cultural geography and built a "New cultural geography" school. In his paper, *Cultural and Space: Conceiving a New Cultural Geography* (2005), Joel Bonnemaison explained that "The term cultural geography" is new, but the concept of it is not new. The concept of cultural geography first appeared in Germany, where geographers were less "naturalistic" than in France. In the nineteenth century, Friedrich Ratzel referred to anthropological geography, and then the concept of cultural geography came to France through the influence of American anthropology with the important contribution in terms of cultural geography by Carl Sauer – Ratzel's student and the founder of the Berkeley School. For France, this was more of a comeback than a new arrival. With their emphasis on the importance of culture, prominent French geographers in Quebec were instrumental in the renaissance of the geo-cultural approach in the 1980s. The return of the geo-cultural approach was associated with the French school of geography through its typical approach to cultural geography. "The renaissance of cultural geography is associated with the extension of the term "culture". In my generation it is often said that "everything is political" but now "everything is culture". It can be seen that talking about culture is becoming a fashion. Nowadays, we often talk about company culture, political party culture and so on. Each activity, each group of people has their own culture. We even see the Ministry of Culture in the French Government. Along with geography, culture penetrated into most fields of social science. In fact, social scientists used to identify cultural factors as qualitative, non-quantifiable factors, and this viewpoint more or less restricted an in-depth insight of many things and phenomena. The three dimensions of landscape space in cultural geography include:

Territory: Concerning landmarks and territorial boundaries; the political structure with key, central and peripheral regions.

Geographical environment: A geographical and ecological structure - soil, vegetation, water, climate, population density, communication system. Human are completely dependent on this ecological system because the entire geographical environment is anthropomorphized to a smaller or larger scale.

Geographic symbol: The structure that represents a geographical environment and its meaning. This concept is similar to the concept of "médiance" which was introduced by Augustin Berque in 1990 to refer to the impacts and values that people bring to the world. Meaningful geographical symbols are related to ethics and metaphysics. They represent the spiritual value of the country which we call the soul of the country"[12].

According to Bonnemaison, culture was built and located in a corresponding space, so cultural systems all include spatial element. In his work, *Lag géographie culturelle* (Cultural Geography, 2004), he stated that the cultural system consisted of four elements, considered as four poles or four pillars, which were: architectural heritage, technical legacy, beliefs, and space.

The new theory of cultural geography focusing on determining cultural and environmental values in a specific territory can radically change the conception of sustainable environmental system with a holistic approach which states "territory is a measure of a territory's adaptability to changes and its resilience".

Theory of cultural regions of the Soviet Union (former)

From the 1950s to the 1970s, based on the results of the study of indigenous cultures in Siberia, a number of Soviet ethnographers such as Maxim Grigorievich Levin (1904-1963) and Nikolai Nikolaevich Cheboksarov (1907-1980) developed the theory of the economic-cultural type and of the historical-ethnographic area, also known as the historical-cultural area. Accordingly, historical-ethnographic areas were formed due to the impact of factors such as: the relative homogeneity of landscape geography; the level of socio-economic development, the process of close and long-term exchange and interactions between residents of ethnic groups in the region; common historical origin of the peoples in the region. That impact formed common cultural characteristics in the areas of material and spiritual life of the inhabitants. With this finding, the theory of historical-ethnographic area has had a high practical effect in identifying regional culture and cultural zoning (Левин, М.Г. & Чебоксаров, Н.Н. 1955. ; оксаров, Н.Н. & Чебоксарова, И.А. 1971) [18].

This fundamental scientific theory has great influence on human geography research in general and cultural geography research in particular on cultural zoning in Vietnam. Vietnamese cultural geographers often utilize the method of overlaying geographical and landscape maps, ethnic distribution maps to determine the boundaries of cultural areas.

b. Some directions of cultural geography research in Vietnam

Cultural zoning

In Vietnam, many cultural geography studies approach culture from a spatial perspective through studying the interaction between culture and natural geographical conditions, highlighting the relationship between living environment and cultural features. Cultural identification means not only clarifying the essential features but also determining the presence of that culture in space [1]. All cultural phenomena are affected by two basic factors: space and time; in which, the spatial element shows that a cultural phenomenon is born and exists in a certain geographical space. Cultural space is a defined geographical space in which a phenomenon or combination of cultural phenomena arises, exists, changes and connects to form a system [8]. The basic cultural zoning research directions are based on two main criteria: natural geographical areas and residence areas of ethnic groups. Typical for this method of cultural zoning is the zoning of Vietnam's territory into 07 cultural regions by scholar Ngo

Duc Thinh (1984, 1993, 2009), including: the Northern Delta, Viet Bac (North East of the North), North West and North Central mountainous area, North Central Coast (Thanh Hoa to Thua Thien - Hue), Central and South Central Coast (Da Nang to Binh Thuan), the South (Gia Dinh – the South), Truong Son - Central Highlands.

Research on the urban-rural territorial cultural landscape and the change of the landscape due to the change of the natural system and human activities in accordance with each different development stage of Vietnam.

Typically, the process of industrialization and modernization of Vietnam has resulted in many industrial zones. The formation of industrial zones has created new migration flows from rural areas to urban areas. Along with the socio-economic transformations are the cultural changes experienced by the rural communities with industrial zones. It is the change in lifestyle, from the way of eating, living, and dressing up to cultural activities such as customs and practices in funerals, weddings, death anniversary, the system of belief and religion, etc. A process of cultural and spiritual restructuring is taking place due to socio-economic changes. The change is most evident in cultural consumption, at the individual level and to some extent, at the family level. This transformation process also has consequences, that is, the deviation of standard among a part of the population [4].

The change in production and consumer culture

Production culture is a system of relatively stable requirements for the quality and development level of a production mode and is maintained and reproduced in the community through space and time. Production culture is expressed in the way of dealing with the basic elements of the production process, including labor, objects of labor, means of labor and the evolving nature of production relations.

The change of production culture originates from two key factors: natural geographical conditions and cultural exchange conditions through the influence of internal and external factors of production.

A typical study on the change of production culture is the study “Change in production culture of people in Dong Trieu town, Quang Ninh province in the OCOP program” by Dinh Trong Thu and Dinh Thi Lam (2022). According to the research, under the influence of the Program “One Commune, One Product” (OCOP), the production culture of the people of Dong Trieu (Quang Ninh province) has undergone many changes, namely changes in behavior to input resources; production scale adjustment and production re-organization; strict compliance with the standards set forth by OCOP for the production process; enhanced knowledge in product quality management; application of 4.0 technology in promotion, marketing and story-telling for each product. The change in production culture has transformed the thinking, perception and action in production of each person in the community, thereby bringing about economic benefits [9].

Studying livelihood culture change in the process of economic development. The author believes that the change in livelihood culture is reflected in the behavior to livelihood resources, including: natural resources (land, forest, water, flora and fauna, etc.); physical resources (infrastructure, commodities, tangible heritages); social resources (relationships, networks, group members, trust, social channels, etc.); human resources (skills, knowledge, work experience, capability and health, etc.); financial resources (methods of using financial resources). Livelihood culture change is reflected in livelihood activities such as occupations, jobs, livelihood methods; tools, qualifications and skills for a living; experience. Livelihood culture change is also reflected in the rituals associated with livelihood such as community livelihood rituals (spiritual rites practiced by group of the same trade) or family livelihood rituals (the way of worshiping livelihood) [10].

In consumer culture, there is more attention to the design, quality, origin, brand, environmental impact, etc. of the products used; more attention is paid to the spiritual life of oneself and one's families, especially eating and living habits to stay healthy. There is a significant difference in the degree of consumer cultural change in communities with different levels of urbanization [2].

Sea and island culture

Sea and island culture is a topic that attracts the attention of many research disciplines such as anthropology, history, cultural geography, sociology, literature, etc. For cultural geography, sea and island culture is located in the marine space, where the marine environment affects human life and work, spiritual values and material production capacity of the society. The study of islanders' *behavior towards the sea* has attracted a large number of researchers. Among them are:

The first work on sea and island culture from the perspective of cultural geography was conducted during the French colonial period, namely the "*Peasants of the Tonkin Delta"* [27] by geographer Pièrre Gourou (1936). The study mentioned fishing in estuaries such as Do Son, Van Uc river, Kien Thuy, Thuy Nguyen (Hai Phong city), Yen Hung (Quang Yen province, now Quang Ninh province), Thuy Anh (Thai Binh province), Giao Thuy, Hai Hau (Nam Dinh province), Kim Son (Ninh Binh province). He affirmed that the Northern coast was not favorable for seafaring activities because there was no proper shelter for ships, the entire southern part of the delta, the recently formed coastline and the land reclaimed from the sea was very unfavorable, even adverse, to activities at sea; fishermen who were supposed to fish at sea actually avoided the offshore waves and fish only at estuaries (Pièrre Gourou, 1936, pp. 401-404).

Environment is an important factor affecting the formation of culture and lifestyle of each community. The environment of Vietnam's sea and islands plays a very important role in the formation of the Vietnamese people's "mariculture".

Behaviors towards the sea are reflected in the livelihood culture and the lifestyle culture of fishermen associated with the marine environment. Livelihood culture shows most clearly the mode of production, the way of living, and reflects fishermen's economic life. The knowledge, understanding and values in the livelihood culture are often expressed through the skills of crafting tools for seafaring activities, in the fishing techniques and experience of shipbuilding for fisheries and maritime traffic; in aquaculture and exploitation of aquatic products; in the processing of products obtained from the seas and oceans; through skills to adapt to the marine environment. In their daily life which is associated with the marine and island environment, the owners of sea and island culture have created many great values, namely the habits, behaviors, ways of living as expressed through eating, dressing, residing, traveling, etc. that are adapted to the marine environment. Fishermen in the sea and islands live in houses of different architecture depending on their location: houses in coastal fishing villages; houses in towns, houses on islands and rafts or boats in fishing villages. For coastal villages, fishermen know how to adapt to and withstand storms by not building tall and permanent houses. Meanwhile, in coastal towns, high-rise buildings flank the village road, forming streets and blocks, but always in harmony with nature. In some fishing villages,

[27] Pièrre Gourou (1936), *Les paysans du delta Tonkinois* (*Peasants of the Tonkin Delta),* translated version, the Vietnam Historical Sciences Association, École française d'Extrême-Orient, Youth Publishing House, Ho Chi Minh City, 2003.

people mainly live on rafts and houseboats, their everyday, economic and cultural life is attached to the boat.

The unique imprint of Vietnam's sea and island culture is also reflected in the DK rig in the East Sea. The DK rig in the East Sea is a unique invention marking the surviving power of Vietnamese people in the East Sea. The DK rig in the East Sea is a combination of architectural works that carries cultural - historical values, marking the scientific and creative labor and resilience of Vietnamese generations. The DK rig in the East Sea is the culmination of the maritime defense strategy, safeguarding the country's sea border.

c. Some comments and directions for future research

In Vietnam, *cultural geography* is recognized as a major sub-discipline of human geography and a part of geographical science. This sub-discipline has connections not only with other sub-disciplines of human geography but also other fields such as anthropology or ethnology, etc.

Studies of cultural geography are constantly expanding their focuses and subjects, research topics from traditional cultural landscapes to all aspects of human life and interaction with their natural habitats.

Currently, the cultural geography approach is also used by some culturists and anthropologists when studying marine and island culture. However, the presence of geographical factors, including the characteristics of geographical factors, the relationship between geographical factors and cultural factors, the influence of geographical factors remains vague in marine and island cultural studies. These contents need further elucidation in terms of theory.

From the perspective of cultural geography, the cultural studies on people's behavior to the environment are mainly through folk knowledge. Only studies on small localities are available and there is a lack of basic cultural geography studies on geographical regions and sub-regions. The studies are mainly descriptive while proper analytical ones are still missing.

Cultural geography research in Vietnam is becoming increasingly popular, the approach and methodology, scope and research subject of cultural geography are increasingly enhanced. This is the premise for the cultural geography sub-sector to continue to develop more comprehensively in the future, especially in terms of applying and highlighting the aspect of space and territory in proposing solutions for realizing national development goals and socio-cultural development policies.

The cultural geography research on specific territories is considered to be the optimal basis for decisions because the results of cultural geography research provide a solid framework for territorial geography research and the most objective view about the territory; especially, the study emphasizes human values, cultural values and human behaviors in the face of a rapidly changing world and is the basis for solving complex ongoing problems.

The results of cultural geography research together with other sub-disciplines of human geography will provide a comprehensive and in-depth geographic scientific basis for spatial organization of economic-population activities. Step by step, appropriate economic sectors will be formed on the basis of promoting the territory-specific cultural values in combination with modern cultural values to contribute to the effective implementation of socio-economic development goals while ensuring environmental values.

Cultural geography will make an important contribution to promoting cultural values in rational territorial organization, the optimal management and control of those development processes in relationship with human life. The production territory systems are constantly changing and demonstrated in a closed chain: nature - production - population - consumption

- population - nature. A new perspective on the new human-nature relationship is formed, focusing on sustainable development. Human being needs to resolve fundamental conflicts with the natural environment on the basis of geoscientific arguments and the principle of limiting and excluding negative impacts of development activities, especially economic ones, work towards the goal of harmonious development in economic, social and environmental aspects.

3. CONCLUSION

It can be affirmed that cultural geography has been recognized as a main and fundamental sub-discipline of human geography and a part of geographical science. This sub-discipline has connections not only with other sub-disciplines of human geography such as political geography, economic geography, population geography, and so on, but also other fields such as culturology, anthropology and ethnology, etc.

Throughout its history from late nineteenth century, early twentieth century to the present, cultural geography has constantly developed with many schools, models and theories from classical to modern; constantly expanded its focus and subjects, research topics range from traditional cultural landscapes to all aspects of human life and interaction with their natural habitat.

Although it is an increasingly popular field, in the world and even in Vietnam, there are still scholarly debates about the approach and methodology, scope and subject of cultural geography research. This is the premise for the cultural geography sub-discipline to continue to develop more comprehensively in the future and open up many research opportunities in human geography for Vietnamese geographers.

REFERENCES

1. Huynh Cong Ba, 2015. Characteristics and cultural nuances of regions - sub-regions in Vietnam. Thuan Hoa Publishing House. Thanh Hoa.
2. Nguyen Thi Hoa and Dinh Trong Thu, 2018. Changing consumer culture in the suburbs of Hanoi. Journal of Human Geographical Research. No. 3(26), pp. 41-46.
3. Vu Tu Lap, 2004. The development of geographical science in the twentieth century. Giao duc (Education) Publishing House. Hanoi.
4. Nguyen Van Quyet (2013). Research on cultural change of agricultural - rural communities in the process of industrial zone development. PhD thesis of Culturology, Hanoi.
5. Ngo Dat Tam & Nguyen Quy Thao (2010). Viet Nam Atlas. Used in schools (editor), the first edition with corrections, Giao duc (Education) Publishing House. Vietnam.
6. Ho Kim Thi, 2015. An overview of human geography. Department of Geography, University of Social Sciences and Humanities. Ho Chi Minh City.
7. Ngo Duc Thinh, 2015. Regional and cultural zoning in Vietnam. Social Science Publishing House. Hanoi.
8. Dinh Trong Thu and Le Hong Ngoc, 2018. Some basic theoretical issues in the cultural geography research. Journal of Human Geographical Research. No. 1 (24), pp. 46-52.
9. Dinh Trong Thu and Dinh Thi Lam, 2022. Changing production culture of the people of Dong Trieu in the OCOP Program. Journal of Museums and Anthropology. No. 2 (38), pp. 70-83.
10. Tran Quoc Vuong, 2009. Vietnamese cultural foundations. 11th Edition. Giao duc (Education) Publishing House. Hanoi.
11. Do Thi Hai Yen (2018). Changing livelihood culture of residents of Huong Son commune, My Duc district, Hanoi city in the context of tourism development. PhD Thesis of Culturology. Hanoi.

12. Joel Bonnemaison (2009), "Cultural and Space: Conceiving a New Cultural Geography, New York, 2005, translated by Nguyen Thanh Tung, edited by Nguyen Van Hieu.
13. Johnson N.C. et al, 2013. The Wiley - Blackwell Companion to Cultural Geography. John Wiley & Sons Ltd. UK.
14. Johnson R. et al, 2000. The dictionary of human geography. Oxford: Blackwell. UK.
15. Myga-Piatek U., 2005. History, methods and recourses of cultural landscape. Problems of landscape ecology. 17, page 71-77.
16. Sauer C.O., 1963. The morphology of landscapes. Reprinted in: Leighly J., ed., Land and life: Selections from the writings of Cart Ortwin Sauer. University of California Press. US.
17. Julian Haynes Steward (1972), Theory of Culture Change: The Methodology of Multilinear Evolution, University of Illinois Press.
18. Левин, М. Г. & Чебоксаров, Н. Н. (1955), "Хозяйственно-культурные типы и историко-этнографические области" (Các loại hình kinh tế - văn hóa và các khu vực lịch sử - dân tộc học), СЭ (Dan toc hoc Xo Viet), 1955, No.4; https://arheologija.ru.

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5th ACG Travel Grants Winners Announcement

August 5th, 2022

As announced earlier on AGA website, the AGA will provide a limited number of travel grants to participants from developing countries, to enable their participation in the 5th Asian Conference on Geography, to be held in Thai Nguyen, Vietnam from September 5th -9th, 2022.

As of August 1st, the AGA Secretariat received over 20 applications from 10 countries. Due to limited budget and financial policy, the AGA will be able to provide financial assistance to a total of 6 applicants. After review by awarding committee of the AGA, we are pleased to announce that the 5th ACG travel grants will be provided to following six recipients:

Prof. Safdar Ali Shirazi, Pakistan
Prof. Md. Nurul Islam, Bangladesh
Prof. Bipin Kumar Acharya, Nepal
Prof. Prabuddh Kumar Mishra, India
Dr. Emil Jabrayilov, Azerbaijan
Dr. Sokunthea Hay, Cambodia

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