Volker Wohlgemuth,
Stefan Naumann,
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Grit Behrens (eds.)

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Environmental Informatics – A bogeyman or saviour to achieve the UN Sustainable Development Goals?

Adjunct Proceedings of the 35th
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German Informatics Society

FACHAUSSCHUSS UMWELTINFORMATIK

Volker Wohlgemuth · Stefan Naumann · Hans-Knud Arndt
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Editors

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Preface

This book presents the main research results of the 35th edition of the long-standing and established international and interdisciplinary conference series on environmental information and communication technologies (EnviroInfo 2021).

The conference was held from 27 to 29 of September 2021. It was organized by the Berlin University of Applied Sciences under the patronage of the Technical Committee on Environmental Informatics of the Gesellschaft für Informatik e.V. (German Informatics Society - GI)

This book presents a selection of peer-reviewed research papers that describe innovative scientific approaches and ongoing research in environmental informatics and the emerging field of environmental sustainability. Combining and shaping national and international activities in the field of applied informatics and Environmental Informatics, the EnviroInfo conference series aims at presenting and discussing the latest state-of-the-art development on information and communication technology (ICT) and environmental-related fields. A special focus of the conference was on the question whether Environmental Informatics is a bogeyman or a savior to achieve the UN Sustainable Development Goals.

The respective articles cover a broad range of scientific aspects including advances in core environmental informatics-related technologies, such as Sustainable Mobility Digital Sharing Economy and Sustainability, Sustainable Usability and User Experience, Earth System Observation and Computational Analysis for Sustainable Development, Modelling and Simulation in the Environmental and Earth Sciences Artificial Intelligence and Sustainability, Environmental Health Informatics, and other relevant topics in the field of Environmental Informatics.

We would like to thank all contributors for their submissions. Special thanks also go to the members of the program and organizing committees, for reviewing all submissions and Franziska Mai for layouting and organizing the submissions in this book. In particular, we like to thank our local organizers at the GIU Berlin for the local organizing support.

Last but not least, a warm thank you to our sponsors that supported the conference.

Berlin	Volker Wohlgemuth
Magdeburg	Hans-Knud Arndt
Bielefeld	Grit Behrens
Birkenfeld	Stefan Naumann

Berlin, September 2021

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APPLIED ENVIRONMENTAL INFORMATICS

Cost-benefit analysis of the exploitation of natural resources for master planning to the coastal zone of Quang Binh province, Vietnam

Le Nam[1], Tran Nghi[2], Hoang Phan Hai Yen[3], Do Thi Ngoc Thuy[4], Trinh Hoai Thu[5], Tran Thi Thuy Huong[5], Nguyen Dinh Thai[2], Luong Thi Thanh Vinh[3], Nguyen Thi Hoai[3], Mai Phuong Ngoc[3]

1. Introduction

The coastal zone of Vietnam is defined to include coastal land and coastal submarine areas. The defined coastal land includes the administrative boundaries of the communes and cities directly under the province [22][25][26]. The coastal zone is defined to be in the limit of 0–30 m of water, which is the limit of the ancient shoreline zone (25–30 m deep) rich in heavy minerals. The coastal zones support the livelihoods of 65% of our country's population living in coastal areas, so they have a very important meaning in socio-economic development [13][22][23][27]. However, several studies show that the process of exploiting natural resources in coastal socio-economic development is not very reasonable and causes serious conflicts between resource exploitation and environmental degradation [26][24][29]. Research and assessment of environmental resources serving the orientation of coastal master planning towards sustainable development is a systematic new approach based on analysis of the correlation matrix interaction of conflict problems and economic costs and benefits. The orientation of coastal master planning towards sustainable development must be one step ahead before implementing branch planning. Currently, a common irregular phenomenon is that branch planning is ahead of master planning [5][7]. The simple reason is that branch planning satisfies the immediate needs of people and society [19][9][18]. Meanwhile, the conflict between the exploitation of different resource types and environmental protection has not been given adequate attention. To find the optimal plan in exploiting and using resources for economic development, it is necessary to solve the cost-benefit problem. The results of cost analysis give a positive result of net present value greater than 0 (NPV value > 0); therefore, the project is feasible and brings economic benefits while the opposite result should not be implemented [1][4][6][15][11][14][30].

The coastal zone of Quang Binh province is within the limits of 105°15'0"–107°0'0" E and 17°0'0"–18°0'0" N, including coastal communes and the coastal submarine area (0–30m water) in the districts of Quang Trach, Bo Trach, Quang Ninh, Le Thuy, and Dong Hoi city. Coastal communes are both administrative units and within the scope of the continental-marine interaction in the Quaternary, including two coastal ecosystems: the lagoon-lagoon ecosystem of the Late Holocene and the sand dune ecosystem. Within the

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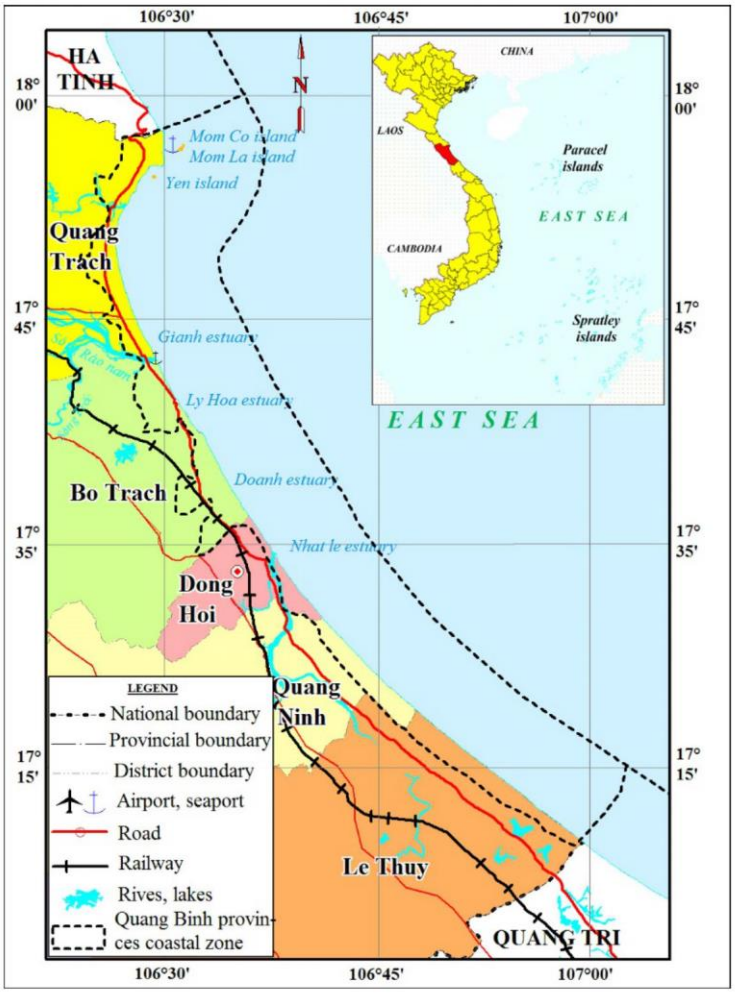
coastal zone of Quang Binh Province, there are three important resources of economic value, namely tourism, fisheries, and glass sand [8][33].

Exploiting glass sand mining will deplete groundwater in the sand dune and cause depletion/pollution of surface water resources, rendering them unrecoverable in the short term. Forest cover on the sand was cut down, and the originally excavated sand dune terrain was deformed and never recovered [2][21][32].



In advanced countries, research on integrated coastal zone planning and management was conducted very early on. In New Zealand, the Resource Management Law enacted in 1991 directed the coastal planning of that area towards the sustainable development of natural resources [17]. The Venezuelan coast has had many serious problems related to land use and natural resource use stemming from governmental policy

and control capacity. Based on analyzing the current situation, [20] proposed a model linking territorial planning with coastal zone planning for the sustainable development of Tasmania's coastal zone. The research was conducted by [10] on the assessment of coastal ecosystems and infrastructure planning in Switzerland and Cambridge. In terms of cost-benefit analysis, there has been a series of studies and important contributions. [16] performed a cost-benefit analysis of the exploitation, planning, and management of water resources in the coastal zone.

1.1 Natural conditions and coastal zone resources

The coastal zone of Quang Binh province is the product of endogenous and exogenous geological processes. The endogenous geological process has created a differentiated geological structure including four zones from the mainland to the sea. The weak subsidence zone creates low-lying river-lagoon plains aged from the early Pleistocene to the present (from 1.9 million BP) between the foot of the Truong Son mountain range and coastal sand dunes. The thickness of Quaternary sediments in this zone ranges from 50 to 150 m and can be divided into five formations corresponding to five sedimentary cycles. These sedimentary cycles are closely related to five cycles of global sea-level change due to the influence of five glacial and interglacial cycles (20): (1) cycle 1: early Pleistocene (Q_1^1) due to the Gunz glacial/G-M interglacial cycle; (2) cycle 2: early middle Pleistocene (Q_1^{2a}) due to the influence of the Mindel glacial/M-R interglacial cycle; (3) cycle 3: late middle Pleistocene ($Q1^{2b}$) due to the influence of the Riss glacial/R-W1 interglacial cycle; (4) cycle 4: early-late Pleistocene (Q_1^{3a}) due to the influence of the Wurm1 glacial/W1-W2; and (5) cycle 5: late Pleistocene to Holocene (Q_1^{3b}-Q^2).

1.2 Important resources of the coastal zone

Tourism resources

Presently, Quang Binh is planning to build community beaches and entertainment spots-large-scale beaches ranging from 2 to 17 km in length with sandy beach widths of 27 to 290 m-while at the same time building a community beach with a location suitable for a residential area, the potential for sustainable development of community tourism, and services for domestic and international tourists.

Quang Binh tourism in 2017 has seen a remarkable change. The number of tourists to Quang Binh in 2017 reached more than 3.3 million, an increase of 70.9% over the same period, of which international visitors constituted about 130,000, an increase of nearly 120% over the same period. Total tourism revenue reached about 160.6 million USD, up 64.7% over the same period, of which revenue from tourism was about 269.2 million USD, up 53.6% over the same period, and state budget payments reached 6.3 million USD, up 33% over the same period. This is considered a good sign after nearly two years of Quang Binh tourism suffering from the marine environmental pollution caused by Formosa.

Fishery resources

Fishery resources are the second most important resource in Quang Binh province. Seafood export turnover increased more than four times from nearly 1.5 billion USD in 2000 to 7.8 billion USD in 2014. Seafood export turnover in 2016 reached 7.05 billion USD, up by 7.3% compared to 2015. In 2017, despite facing

many challenges from markets such as the impact of the catfish inspection program and the EU's warning of yellow cards for Vietnamese seafood, seafood exports for the whole of 2017 still reached over 8.3 billion USD, an increase of 18% compared to 2016. The fishing industry has benefited from the world's most advanced technologies, from using plant polyphenols as preservation products on fishing vessels to replacing banned antibiotics to ensure good food safety and hygiene, to implementing Cells Alive System (CAS) technology for efficient postharvest preservation. Onboard product preservation technology has made use of new materials such as polyurethane (PU) to create seafood storage cellars on fishing boats. Seawater cooling equipment helps preserve seafood, as does the use of insulation tunnels and refrigeration equipment in compartments to help ice keep longer. Such measures increase product storage time, enable longer ship operations at sea, and prevent microorganisms from proliferating, resulting in less odor and higher product quality.

Glass sand

The coastal sandy barrier bar of Q_2^2 (6–5 ka BP) is found in many places in the coastal sand dunes of Quang Binh where there are also high-quality glass sand minerals. The sand is white, and the mineral composition is mainly quartz mixed with very little feldspar and some other minerals. Chemical composition (average %) is SiO_2: 98.51, Fe_2O_3: 0.33, and TiO_2: 0.0–0.03%. The total level P1 reserve has been calculated to be over 10 million tons.

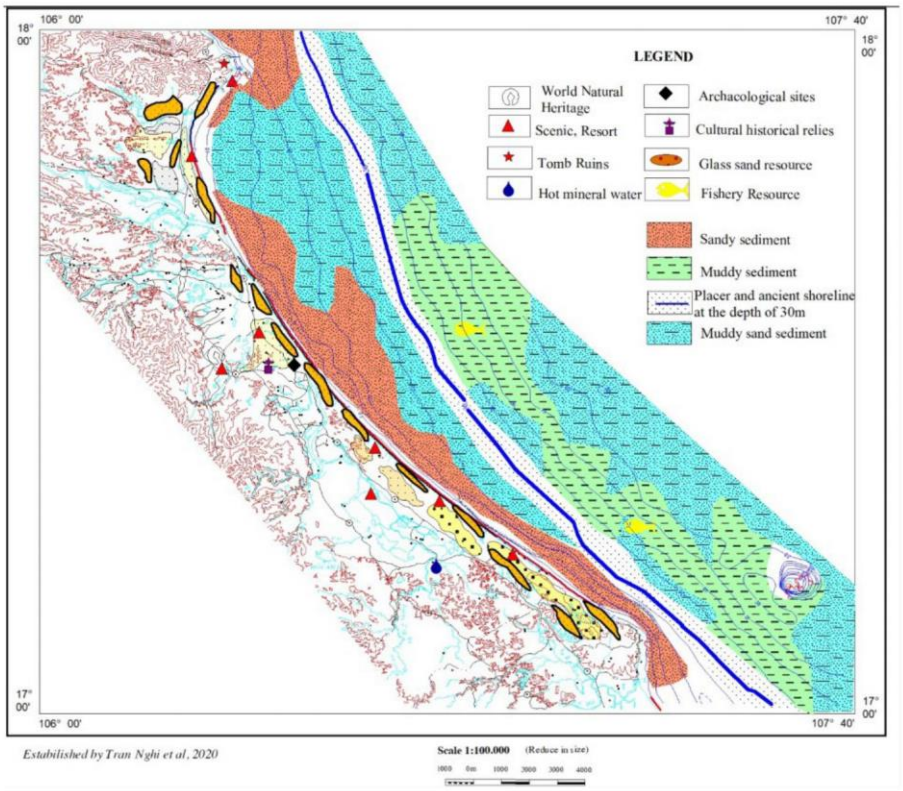


Fig.2. Map of resource distribution in the coastal zone of Quang Binh Province

2. Methods and materials

2.1 The theoretical basis for cost-benefit analysis in resource exploitation

CBA is a method of determining and comparing the costs and benefits of a program, policy, or project to evaluate the project's potential to increase or decrease economic benefits to society [2][6][10]. The CBA's purpose is (1) to provide information to help decide whether to invest in a project or not and (2) to provide a basis for comparing options for a project.

2.2. GIS method

The Kriging interpolation method examines the relationship between data variability in space to predict the value of interpolation data at locations where actual survey data is not available.

2.3 Selected resource extraction scenarios

The underlying cost and benefit streams are identified for each scenario under the following assumptions: (1) the discount rate for the present monetary value calculation is called the social discount rate; (2) the research plan uses the bank interest rate for loans of r = 7% per year; and (3) expenses and benefits over the years are assumed to increase equal to the forecasted inflation rate for the period 2016–2020 of 6% per year. With a selection of the base year 2016, the development scenarios are described as follows:

No.	Name of plan	Description
Scenario 1	Tourism development planning	A project planning to build and upgrade investment coastal zone tourist site of Quang Binh.
Scenario 2	Planning for glass sand exploitation development	Carrying out projects to exploit glass sand at explored sites and apply for mining licenses.
Scenario 3	Planning for development of fisheries exploitation	Taking advantage of natural conditions, upwelling waters with diversified fisheries resource projects to exploit aquatic resources.

Tab.1. The scenario of resources exploitation in the coastal zone of Quang Binh Province

3. Results

3.1 Cost-benefit analysis of tourism development

High-end tourism development is possible in the coastal zone of Quang Binh province where there is a coastline of nearly 100 km with beautiful beaches, casuarina forests, and sand dunes. Possible tourism types include hill climbing, fishing, swimming, surfing sports, and picnicking. At the same time, there are tourist festivals, resorts, Dong Hoi with swimming tourism, and the International Sailing Festival. Expenses and benefits over the years are assumed to increase equal to the forecasted inflation rate for the 2016–2020 period of 6% per year. The uptime series used to compute this scenario is 15 years. Tab. 2 lists the costs and benefits of the project.

	Costs, Benefits	Monetary value (Unit: USD)
About cost		
Initial investment	- C (1) Initial investment in infrastructure (motels, hotels, restaurants, roads) using 82,432 m2 of seawater and 509,228 m2 of land.	89,866,000
Annual cost	- C (2) Annual operating costs (labor, cleaning, laundry, hotel management, kitchen, security)	133,411,689
	- C (3) Expenses for modification, warranty, and replacement of additional materials and tools.	37,777.8
	- C (4) Expenses for treating and cleaning garbage of tourists (1kg/person/day) = number of passengers x amount of trash x number of days. Average x cost = 1,361,000 x 1kg x 4.5 x 0.0007.	190,540
	-C (5) Electricity costs, water costs (underground water for tourism).	156,577.8
	- C (6) Cost of environmental stress = cost of wastewater treatment + cost of damage to air quality = 3,851 + 1,325.	230,044.4
Other expenses	- C (8) Annual cost of coastal erosion repair (construction of bank protection).	3,555.5
	- C (9) Cost of oil spill treatment.	888.9
Total costs		**135,762,820**
About benefit		
Total revenue for 1 year = **Total benefit B**		212,998,159(*)

Tab.2. Cost-benefit analysis for tourism development

(*) At the Quang Binh coastal zone tourist destination, there are 1,204,000 domestic tourists and 157,000 international tourists. The expenses of an average tourist per day including room rent, meals, travel expenses, sightseeing expenses, purchase of goods, souvenirs, cultural and sports services, medical expenses, and other expenses reached 1.301.000 VND, with international visitors 2.730.000 VND. International visitors combine tourism with business, training, trade, visiting friends. Thus, the total revenue per year (1.82x1.301.000x1.204.000 + 4.53x 2.730.000 x157.000) exchanged into USD comes to 212,998,159 USD.

No	Index	Estimate Value (million USD)
1	Net present value (NPV)	1,161,793,240
2	B/C ratio >1	1.51

Tab.3. Calculated result of cost-benefit analysis for scenarios of tourism exploitation

Recommendation: From a social perspective, the manager should agree to the implication of the project.

3.2 Analyzing the costs versus benefits of exploiting glass sand

Quang Binh Province has three projects to exploit glass sand mines. The reserve of glass sand is 444,617 m^3, and the exploiting capacity is 3,186.9 m^3 in 15 years, with an area of 64.5 ha. The expiration date is 2025. The exploitation capacity of glass sand is 7,800 tons of crude filtered raw sand/year, equivalent to 3.120 m^3/year. The time of the project is t = 15 years. Expenses and benefits over the years are assumed to increase equal to the forecasted inflation rate for the period of 2020–2024 of 6% per year. Based on ore mining and sorting technology, assessing the negative impacts on economic life, environmental quality, and human health, the author provides a table of costs and benefits from titanium mining activities as follows (Tab. 4).

	Costs, Benefits	**Monetary value (Unit: USD)**
Cost		
Initial Cost	- C (1) Costs of construction and equipment purchase	Initial Cost
Annual cost	- C (3) Direct production cost	461,622,000
	- C (4) Costs affecting the landscape, diversity of forest ecosystems	
	- C (5) Health costs of people in polluted areas	
	10,900	
	- C (6) Annual cost of environmental remediation and improvement done by making a one-time deposit	4,900
Total annual cost C = C (3) + C (4) + C (5) + C (6) + C (7)		**725,466.7**
Benefit		
The revenue from selling glass sand is B = **Total benefit (B)**		**693,333(**)**

Tab.4. The cost-benefit table from the exploitation of glass sand

(**) *The average cost of glass sand consumption is 2.000.000 VND/ton. The annual yield is for simplicity in the calculation and assumes constant other factors so that the mining output is 7,800 tons/year. Particularly for the first year of exploitation, the output was 4,800 tons. So, the revenue from the sale of glass sand is: B (1) = 2,000,000 * 7,800 = 15,600 million dong/year, which is equal to 693,333 USD. Extraction of glass sand has some costs that have not been calculated due to the long-term effects. First, glass sand mining exploits coastal sandy barrier bars and sand dunes, so it will break up the landscape of large and beautiful sand dunes that are valuable for aesthetic tourism. Second, when mineral sorting is carried out, wastewater from the sorting process will seep into groundwater, and radioactive substances will be dispersed and seep from surface water into groundwater, causing serious pollution. These consequences greatly affect agriculture, people's health, and ecosystems. It is really difficult to accurately and fully assess the damages that mineral mining causes.*

No	Index	Estimate Value (million USD)
1	Net present value of NPV	-1,502,133 <0
2	B / C	0.80 <1

Tab.5. Result of calculating the cost versus benefit of the glass sand exploitation scenario of the Quang Binh coastal zone

Recommendation: From the perspective of society, the project should not be implemented because the cost is greater than the benefits that the project brings.

3.3 Fishing cost-benefit analysis

Aquaculture development must be in line with and comply with local socio-economic planning. The project lasted 15 years (t = 15) exploiting the fisheries in the sea area of Quang Binh province. The annual fishing market is generally favorable, with an increase of 3.0% in production compared to the previous year. The protection of aquatic resources is regularly maintained, maximizing efficiency. In addition, aquaculture has developed diversely.

	Costs and Benefits	Monetary value (Unit: USD)
Cost		
Initial investment	- C (0) Expenses for the purchase of boats, fishing boats, fishing tools, and tools	424,890
Annual costs	- (C1) Production costs: gasoline costs, electricity costs, labor costs	201,200
	- (C2) The protection of aquatic resources	28,900
Other expenses	- (C4) Cost of remediation for seawater pollution caused by oil spill	30,090
	Total cost (C) = C (1) + C (2) + C (3) + C (4)	9,416
Benefit		
Revenue from fishing and aquatic products annually (means as a total benefit [B])		622,890

Tab.6. Table of costs and benefits of fishing in Quang Binh province

The project implements fishing in a long-term sustainable direction, so it is assumed that the catch is unchanged over the years. Costs and benefits are assumed to increase equal to the inflation rate of the 2016–2020 period of 6% per year.

No	Index	Estimate value (million USD)
1	Net present value of NPV > 0	1,554,888
2	B / C >1	1.35

Tab.7. Result of calculating the costs versus benefits of the fishing scenario

Recommendation: Based on the above-calculated criteria, from a social perspective the manager should allow the project to be implemented.

4. Conclusions and discussions

1. Important resources of the coastal zone of Quang Binh are tourism resources, aquatic resources, and energy resources. Of these, energy resources are in the initial stage.
2. Regarding the cost-benefit analysis for resource exploitation activities in Quang Binh province, the calculated results show that tourism resources and fisheries resources give NPV >0 and B/C >1, and mineral resources give NPV <0 and B/C <1. From a social perspective, the government should not allow the implementation of mineral exploitation projects and only implement tourism development and fishing projects. Considering the time factor and the goal of sustainable development, tourism and fisheries resources are more feasible.
3. Cost-benefit analysis is a scientific basis for managers to make decisions on granting permits to investors to rationally exploit coastal resources in the direction of sustainable development.

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