

ENVIRONMENTAL AND NATURAL RESOURCES FUNCTION ZONING FOR SUSTAINABLE USE OF VAN DON ISLAND DISTRICT, QUANG NINH PROVINCE

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Abstract. Van Don district has many favorable conditions in terms of geographical location, economic and political position, and diversity in natural resources for developing marine economic zone. The strength of the district is to develop eco-tourism, conservation of valuable marine ecosystems as well as exploitation of minerals and construction materials. At the present, Van Don is facing negative impacts from urbanization and economic development, environmental degradation, and reduction of biodiversity. Therefore, the purpose of this study aims to determine the zoning criteria and application for the functional zoning for sustainable use of environment and natural resources in Van Don island district. Based on the zoning criteria and natural and socio-economic characteristics, Van Don island district can be divided into two main environmental and natural resources function zones, consisting of Cai Bau island zone (with 3 sub-zones) and Van Hai zone (with 4 sub-zones). Each sub-region has its own unique characteristics that are scientific foundations for orienting sustainable development.

Keywords: Zoning, sustainable development, natural resources, environment, Van Don island district.

INTRODUCTION

Environmental and natural resources function zoning is defined as the division of definite region into smaller units (sub-regions or zones) according to conformity criteria for orientation of the efficient and sustainable use of resources [1–6]. The general objective of the zoning is to increase the compatibility and reduce conflicts in the use of natural resources and environment. The results of the zonation of the area will contribute to minimizing the dispute of interest and conflicts and also provide guidelines for exploitation, use and compliance requirements for each unit. Thus, zoning of the environmental and natural resources is a scientific basis to regulate the development of three systems: Environment,

economics and society systems to ensure that the development of these systems is compatible with the carrying capacity of the natural system, protection of the environment and sustainable development.

Van Don is an island district of Quang Ninh province (fig. 1), which has a geographic location and an important geopolitical position in the Gulf of Tonkin [5, 7]. It is also an island complex with the most complicated terrain and many of islands. The rapid and strong development of the region in the past and present has had a strong impact on the natural resources and environment. In order to build Van Don into an administrative-economic zone, it is necessary to have a suitable functional zonation area to increase the

compatibility, potential strengths and reduce the negative impacts on exploitation of resources and environmental degradation.

The objective of this paper is to clarify the

scientific and practical basis for the zonation of the Van Don island district to serve the planning orientation and management for sustainable development.

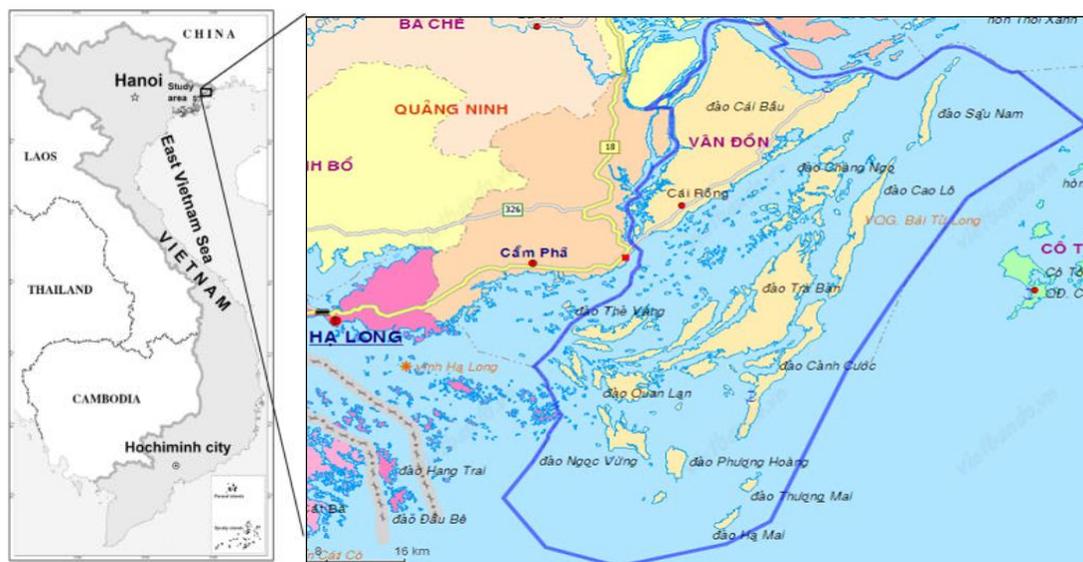


Fig. 1. Location map of Van Don district

DOCUMENTATION AND RESEARCH METHODOLOGY

Document. The material used for this article is based on survey results of the authors' collective between June and August 2017 in Van Don island district on landscape, topography, socio-economy and natural resource exploitation,...

In addition, the secondary materials were referenced including:

“Master plan for construction of Van Don economic zone”, report of People’s Committee of Van Don district, 2014.

“Land use planning to 2020 and five-year land use plan (2011–2015) in Van Don district”, report of Van Don district People’s Committee, 2010.

“Environmental planning of Quang Ninh province to 2020, vision to 2030”, report of Quang Ninh province People’s Committee, 2014.

“Master plan for environmental protection in Quang Ninh province up to 2020”, report on Quang Ninh province, Nguyen Cao Huan (Ed.), 2010.

“Tourism development planning of Quang Ninh province to 2020, vision to 2030” by Department of Culture, Sports and Tourism of Quang Ninh province, 2015.

“The state of environment in Quang Ninh province in the years 2005–2010, 2010–2015”, report of the Department of Natural Resources and Environment of Quang Ninh province.

Approach and methodology. Functional zoning in Vietnam in particular has been implemented from a variety of approaches and serves different purposes: Shore-land geomorphology, ecological landscape, coastal function, geo-environment,... These types of zoning are based on different criteria and characteristics. The Canadian Environmental Cooperation Agency is based on three categories of natural, biological and human impact criteria to divide into 15 different ecoregions [8]. In Vietnam, Le Huy Ba (2010) uses 6 criteria (terrain-geomorphism, inundation, salinity, soil, rainfall, fauna and flora) for aquaculture ecological zoning in the Mekong Delta [1]. There are 15 international regulars and regional guidelines for zoning, but there is not yet a

common “template” for functional zoning of sustainable use in Vietnam.

System approach and ecosystem approach are used to study the functional zonation of areas and to ensure the harmony between the benefits of the system’s resources and the maintenance of core values. The system approach clarifies the interactions of the nature-society-human system in the area as well as in relation to the surrounding area. With the ecological approach each territory is considered as a large ecosystem, consisting of many sub-regions, each sub-region is a smaller ecosystem with different characteristics. This approach aims to promote the conservation and sustainable use of resources against the adverse effects of the environment. With these approaches, the main methods used are:

Based on the characteristics of the area, the criteria used include: Natural factors (terrain, flow, soil, natural resources, ecosystem service value); human factors (human activities, status of exploitation, utilization of resources) and development policy, planning system. Each criterion must reflect the core features of the study area, be clear on the method of collection and calculation, to ensure comparability.

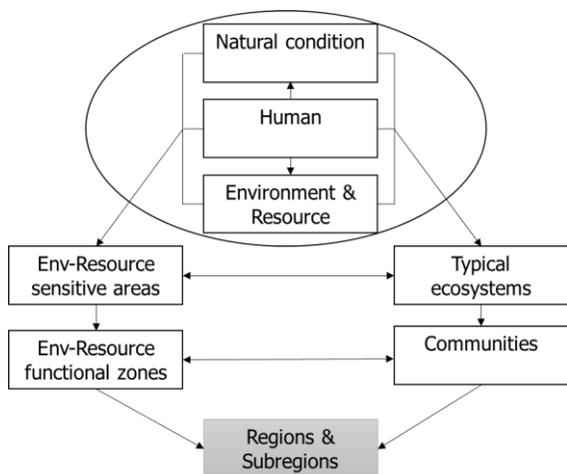


Fig. 2. Principles of resource-environment zoning

In order to ensure the feasibility of the zoning results and in line with the locality

master plan, the zoning should ensure the benefits of the parties, their socio-economic development and resources management orientation. Principles of zoning include: i) Respecting the objectivity of the region: The territory is an objective entity, formed by the long-term interplay of natural elements, in accordance with the natural law on the flow of energy and material transfer, ii) Accepting the relative uniformity of the region: Each territorial region is defined by the uniformity of all zoning criteria in a relative manner. At each level the dominant feature is selected as the basis for partitioning. It may be terrain, geographic location, soil, vegetation cover,... iii) In accordance with the function of the area: The zoning should respect the integrity of the ecosystem or the observance of natural laws, preserve the ecological and environmental functions of the area, iv) Compliance with management criteria: To be objective, to ensure the planning, management, exploitation and use of resources as a scientific basis to regulate the development of the load capacity of the system.

Mapping method: The partition data is used to represent the spatial characteristics of the study object. Based on the inheritance of the topographic map of 1/25,000 issued by the Department of Survey, Mapping and Geographic Information (Ministry of Natural Resources and Environment), the thematic maps should show the distribution status and fluctuations of the natural resources and environment. The results are shown in spatial units on the integrated zoning map of the district.

RESULT AND DISCUSSION

Characteristics of nature, population and natural resources

Natural conditions. Van Don island district covers an area of 217,133 ha, in which 55,320 ha is land and the remaining area is sea with more than 600 islands in Bai Tu Long bay.

Topography has a distinct distribution from hills to coast and coastal islands. Depending on the topography, the terrain can be divided into the following types: i) Mountainous terrain with an average elevation of over 25 m is strongly divided in Cai Bau island; ii) Coastal

terrain with an average height of 1–3 m is newly formed, often submerged; iii) Coastal islands include rock and land islands [4, 9–11].

The region has a tropical monsoon climate with coastal features, hot and humid in summer, cold in winter. Average annual values: Temperature 23.3°C, radiation 105 kcal/km², air humidity 84%, rainfall 1,700–2,200 mm. One to two storms directly affect the region, usually occurring from June to October with a wind speed of 20–40 m/s, often accompanied by prolonged heavy rain, affecting local production and livelihoods.

River network and stream flow are relatively thin, short and sloping in the direction of northwest-southeast to the sea. Besides the Voi river (18 km longest), there are also small streams such as Cai Bau river, Khe Ngai stream, Dai Van,...

Tide regime is uniform tide, the tide is highest in the country from 3.5–4.0 m. The tide crests are usually 25 hours apart. The strongest tide occurs in January, June, July, December and the weak one occurs in March, April, August, September. Waves are not large because there are many islands shielding. The highest waves occur only in the south and south-west, with low frequencies, mainly wind waves.

Van Don has the following main groups of land: sandy soil (5,552.1 ha) including sand along the river bank, dunes, and from marine; saline soil (4,533.1 ha) in the mangrove area; the gray soil (443.1 ha) and yellow red soil (34,081.3 ha) are distributed in hilly areas at over 25 m height; acidic soils (85.7 ha) are distributed along the district; the alluvial soil (76.2 ha) forms narrow stripes along the rivers and streams.

Population and labor. Total population in Van Don district in 2014 is 43,400 people, in which urban population accounts for 18.5% and rural population is the rest [12]. From 2010 to 2015, the population tends to increase slowly, the average natural growth rate is about 1.5–1.55% per year and fluctuates unevenly over the years. Population growth is mainly due to the formation of industrial zones. The average population density is 79 people/km², unevenly distributed. The density is highest in Cai Rong

town, 2,222 people/km², and very low in Van Yen commune with only 14 people/km². There are 9 different ethnic groups living in the district including Kinh, San Diu, Hoa, Dao, Tay, Muong, Cao Lan (San Chay), Thai and Nung. The Kinh majority and San Diu ethnic groups are 84.74% and 12.95% of the total population respectively.

In 2014, the district has 23,740 workers in the age group, accounting for 54.7% of the population. Employment structure in the economic sectors tends to reduce the proportion of agriculture-forestry-fishery labor, increase the proportion of trade-service labor, especially in the field of tourism services. The average income per capita in 2015 is 36.7 million VND, increasing 2.3 times compared to 2010. The rate of poor households decreases rapidly from 12.7% in 2010 to 2% in 2015. Some poor communes of Van Don district are mentioned: Van Yen, Dai Xuyen, ThangLoi,...

Status of exploitation and use of natural resources. The main economic activity is agriculture, with aquaculture being the spearhead, along with the tourism industry which is on the upward trend. In general, Van Don district is full of natural conditions and natural resources favorable for socio-economic development, most important ones are marine and forest resources.

Van Don island district has several kinds of minerals of high economic value such as crystal sand which can be able to produce crystal, distributed in Quan Lan and Ngoc Vung; coal (Ke Bao mine) has been exploited since previous period with the remaining reserves of about 107 million tons; iron ore discovered on Cai Bau island has a reserve of about 154 thousand tons; titanium-zirconium is found in the Quaternary formations in Quan Lan, gold mineral is distributed along Cai Bau island [12, 13]. In addition, there are many types of construction materials in the area, such as limestone, clay, gravel, sea sand,... in Dong Xa, Ha Long serving the needs of local people.

Van Don island has 26 artificial reservoirs for the needs of production and living. In particular, Mui Rong lake provides fresh water for Cai Rong town, other lakes supply water for agricultural production and domestic use in

other places. Total volume of exploited water in the district is about 19.72 million m³/year (in which, surface water is 19.35 million m³/year,

underground water is 0.37 million m³/year) (table 1).

Table 1. Water use in Van Don district [12]

Unit: mil.m ³ /year											
Total volume of exploited water			Exploited water for domestic and tourism			Exploited water for industrial activity			Exploited water for agricultural activity		
Total	Surface water	Underground water	Total	Surface water	Underground water	Total	Surface water	Underground water	Total	Surface water	Underground water*
19.72	19.35	0.37	1.37	1.05	0.32	0.02	0.02	-	18.33	18.28	0.05

Note: *: In agriculture, groundwater is almost used for livestock purposes.

Van Don has the rich marine resources with many kinds of high economic value such as squid, shrimp, crab, fish, mollusk (sea snail, pearl). Fishery resources are concentrated in the Van Hai archipelago, with annual capacity of 10–15 thousand tons; in which, surface fish is about 7–9 thousand tons/year.

There are 40,291.3 ha of forest land in the district. Natural forests are mainly mixed broadleaved evergreen forests, intercropping bamboo forest is classified as poor forest. Plantation forests tend to decrease in the period 2010–2014, from 1,255 ha to 800 ha.

Van Don district has hundreds of large and small islands with unique shapes such as Hon Dong Trong, Soi Nhu cave, Dua and Cai De caves, creating magical beauty to attract tourists. Besides, there are natural long sandy beaches which are suitable for tourism such as Quan Lan, Minh Chau, Ngoc Vung, Tra Ban, Ban Sen, Long beach, ... The coral reefs along the coast of Ba Mun, Sau Nam, Sau Dong, Bai Tu Long National Park are the ideal points for visitors. Besides, there are also typical tourism resources such as Van Don trading port, Van Don and Ngoc Vung trade festivals, which also create diversities in tourism activities [7, 14].

Van Hoa port is being built and planned as an important seaport in the seaport system of Quang Ninh province, which is a favorable condition for sea transport activities [9, 10, 15, 16].

Result zoning. Based on the above principles and criteria, Van Don island district is divided into two zones: The area of natural resources and environment on Cai Bau island consists of three sub-zones: (I.1). Cai Rong-Van Yen (Cai

Rong town, Dong Xa commune, Ha Long, part of Van Yen commune); (I.2). Doan Ket-Binh Dan-Dai Xuyen; (I.3). Van Hoa (part of Van Yen commune and part of Dai Xuyen commune); the Van Hai archipelago has 4 sub-regions: (II.1). Bai Tu Long National Park; (II.2). Sub-zone of the Bai Tu Long National Park buffer zone; (II.3). Quan Lan-Minh Chau-Ngoc Vung; (II.4). Ban Sen-Thang Loi (fig. 3).

Sub-zone Cai Rong-Van Yen (I.1):

It is distributed along the hillsides of southeast Cai Bau from Dong Xa commune to the south of Van Yen commune, including inland and coastal wetland. The area is composed mainly of sedimentary rocks: Upper Holocene mQ₂³ (sand, silt, clay, plant monument 1–2 m thick), Middle Holocene apQ₂²⁻³ (gravel, sand, clay, thick 2–6 m). The eastern part of Ha Long commune is covered by D_{3bp} sediments of Pho Han formation: limestone clay, siliceous rock, stale gray, 450–650 m thick.

The low mountainous terrain, the mountain ranges have direction along the northeast-southwest from Van Yen to Dong Xa commune, hydrological system is short and steep, and often dry in dry season. Water reservoirs are small and provide water for domestic use and production.

The main soils of this sub-region are sandy soils along the coastal zone and river, and yellow-red soil on the clay and metamorphic. The sub-region is an administrative center, a trade center for services, a high-class resort, a culture, health and education center of the district (fig. 4).

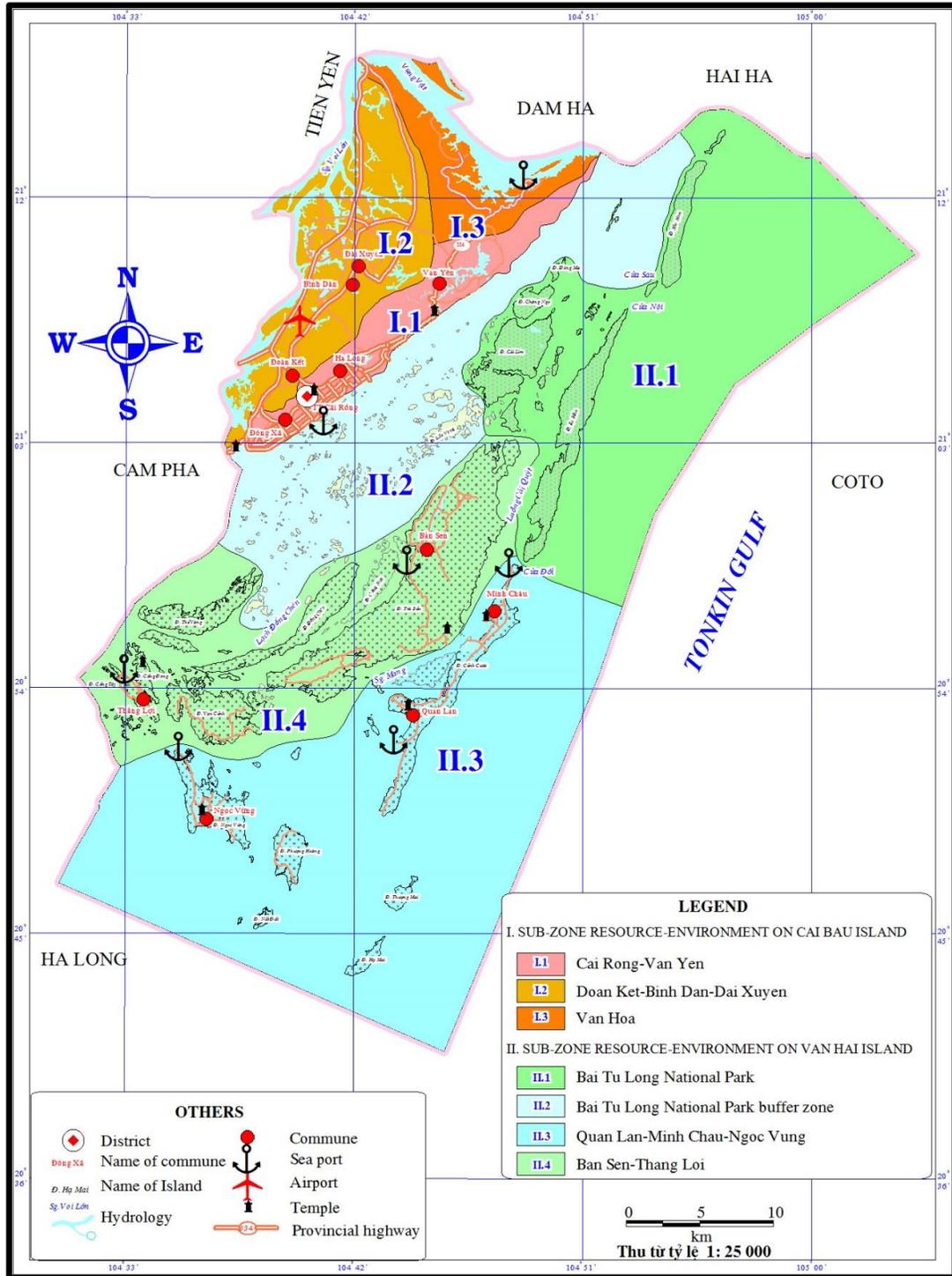


Fig. 3. Map of resource-environment zonation in Van Don island district

Cai Rong port is both a passenger port and a fishing harbor. It is also a boat shelter when there are thunderstorms or storms. The

orientation of the area is to take advantage of the natural conditions to develop sustainable tourism.



Fig. 4. Bai Dai landscape: Natural beach (a) and artificial beach (b)

Sub-zone Doan Ket-Binh Dan-Dai Xuyen:

This sub-region is located in the west of Cai Bau island, occupying the area of Doan Ket, Binh Dan and part of Dai Xuyen commune. The area is composed mainly of rocks: Ha Coi formation, upper layer ($J_{1-2}hc2$), including sandstone, siltstone, shale, quartzitic sandstone yellowish brown, light gray, thickness 700–800 m; the lower layer ($J_{1-2}hc1$) consists of sandstone, siltstone, claystone, quartzitic sandstone, limestone, lime clay 300–750 m; Upper Holocene (mQ_2^3) includes sand, silt, clay, plant monuments 1–2 m thick.

The residential area is located along the west coast, northwest, across from the Voi Lon river. The main economic activity here is rice

and shrimp farming. Lower elevation is below sea level with coastal mangroves.

The main soils of the sub-region are saltwater, reddish yellow soil on shale and metamorphic, and yellowish soil on sandstone. The sub-region has the potential to develop population, develop mangroves and agroforests in hilly areas, and develop industry and airport.

Currently, the main road connecting the functional areas of Van Don Economic Zone and Van Don Airport are being deployed in Doan Ket commune. In the future, the district's expressway will be built and will run along this sub-region and serve as a driving force for socio-economic development.



Fig. 5. Backfilling of administrative centers (a) and Van Don Airport (b)

Sub-zone Van Hoa (I.3):

This sub-region is located in the northern part of Cai Bau island, covering part of the area of Van Yen and Dai Xuyen communes, located in the basin of Van Hoa and adjacent wetlands.

The area is composed mainly of rocks: Ha Coi formation, upper layer ($J_{1-2}hc2$), thickness 700–800 m; the lower ($J_{1-2}hc1$) thickness 300–750 m; Middle-Upper Holocene (mQ_2^{2-3}) includes pebbles, sand, clay, thick 2–6 m.

There are two main types of soils in this sub-region: Yellowish soil on sandstone and alkaline soils in estuaries.

The main resources are fisheries and wet-rice cultivation. Road 334 from Cai Rong town to Van Hoa port was expanded and asphalted (fig. 6).



Fig. 6. Coastal filling of Chua cape (a) and mangrove forest outside Van Hoa port (b)

Bai Tu Long National Park (II.1):

This sub-region covers the core zone of Bai Tu Long National Park, which consists of many islands and coastal wetlands.

This area consists of main rocks: P_3bc Bai Chay formation is composed of silica, sand slabs of dark gray color with thin layer or silica lime, thickness of 250–300 m. Pho Han formation (D_3bp) is composed of limestone, limestone clay, siliceous rock, dark gray slate with longitudinal section of 450–650 m.

The land is mainly light yellow soil on sand and saline rock. These islands have high biodiversity with many endemic species that make this area a high conservation value. According to the plan, the cable system will be built to connect the complex resort on Cai Bau island with Tra Ban island through national park in Cai Lim. Through this journey you can enjoy the wonderful beauty of the national park and the sea.

Buffer zone of Bai Tu Long National Park (II.2):

This sub-region is distributed between Cai Bau island and the core zone of Bai Tu Long National Park, including water surface area and coastal island. This is an area where fishing, aquaculture and especially commercial activities are concentrated.

Quan Lan-Minh Chau-Ngoc Vung (II.3):

The sub-region includes the Canh Cuoc, Ngoc Vung, Phuong Hoang, Thuong Mai, Ha Mai and surrounding wetlands, distributed in the buffer zone between Bai Tu Long National Park and Ha Long bay World Heritage Site.

Quan Lan is the richest commune in Van Don district, the tourism and services sector is developing strongly, aquatic farming is also focused. This is the current and future sub-region for tourism and resort development.

Ban Sen-Thang Loi (II.4):

The sub-region includes the islands of Tra Ban, Cong Nua, Dong Chen, Van Canh, The Vang, Cong Dong-Cong Tay, Van Duoi and surrounding wetlands.

Ban Sen and Thang Loi are poor communes of Van Don district, the main productions are timber harvesting, forestation, hunting and trapping of forest animals. This area also has low productivity agriculture and underdeveloped aquatic culture.

Aquaculture in Ban Sen commune is dominated by mollusks such as Tu Hai, Vau, Ngoc Trai,... The strength in aquaculture in Thang Loi commune is the traditional cage fish culture. However, in recent years, the farming of the species (*Matridae*) has been cultivated by local people. On the island of Van Canh there is a white sand beach suitable for the development of tourism.

Table 2. Characteristics of natural resources and environment function in Van Don island district

	Sub-zone I.1	Sub-zone I.2	Sub-zone I.3	Sub-zone II.1	Sub-zone II.2	Sub-zone II.3	Sub-zone II.4
Topography	Plant, coastal sandy tidal flat	Low hilly terrain, mountain ranges running along the direction of NE	River mouth estuary	Island and wetland surround	Small islands and canals	Island and wetland surround	Offshore islands and wetland surround
Current flow	Hydrological system is short, steep and often dry in dry season	Flow network is thin, Voi Lon river flows through	Flow network is thin, toward Van Hoa river mouth	Diurnal tidal, NE-SW direction	Diurnal tidal, NE-SW direction	Diurnal tidal, NE-SW direction	Diurnal tidal, NE-SW direction
Soil	Sandy soil along riverside, coast; yellowish red soil on claystone and metamorphic rock	Salt soil, yellowish red soil on claystone and metamorphic rock, yellowish soil	Yellowish soil on sandstone and alum soil in the river mouth	Yellowish soil on sandstone and salt soil	Sand sediment, gravel sand	Yellowish soil on sandstone and salt soil	Limestone island, poor humid
Human activities	Centre of culture, health, education	Rice and shrimp farming	Aquaculture and rice	The core zone of Bai Tu Long National Park	Fishing, aquaculture	Marine tourism	Wood gathering, reforestation, fish farming
Resources	Tourism, mineral, material	Material, coal	Mineral, mangrove	Biodiversity with endemic species	Ecotourism, crystal sand, aquatic resource	Ecotourism, crystal sand	Tourism, aquatic resource, limestone island geosite
Zoning	High quality tourism development	Urban development, centre of administration, economics,...	Protection of aquatic resources and plantations	Conservation of marine biodiversity and islands, ecotourism activities in the national park	Conservation of marine biodiversity, marine tourism	Conservation of special-use forests, aquatic resource	Forest protection, aquatic resource and geological heritage
Recommendation	Construction and development in the direction of sustainable ecological urban	Construction and development in the direction of sustainable ecological urban	Planning mangrove forest and seaports	Strictly managing tourism activities and other activities in BTL bay, prioritizing conservation	Ensuring coastal environment not affect the core zone and also development of eco-tourism	Managing and improving the international standard tourism for environment, biodiversity conservation	Protection of nature, biodiversity, and disaster prevention

CONCLUSION

The results show that the natural resources in Van Don island district are diverse, rich and unique. Van Don is characterized by landscape, favorable economic and political position as well as valuable natural resources in the promotion and construction of marine economic zones. The strength of the region is the development of services, ecotourism, aquaculture and the conservation of valuable marine ecosystems, and simultaneously the reasonable exploitation of minerals, materials.

Based on the criteria for zoning of natural conditions and natural resources-environment, Van Don island has been divided into two major areas: The area of Cai Bau island (with three sub-zones) with sustainable development potential in urban ecology and services, and island of Van Hai (with four sub-zones) with the potential for sustainable development of marine ecological tourism, aquaculture and marine natural preservation. This is a scientific basis for policy makers to make strategic development for Van Don island district.

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