POLICY BRIEF
Vietnam Ocean account
Case study in Quang Ninh province
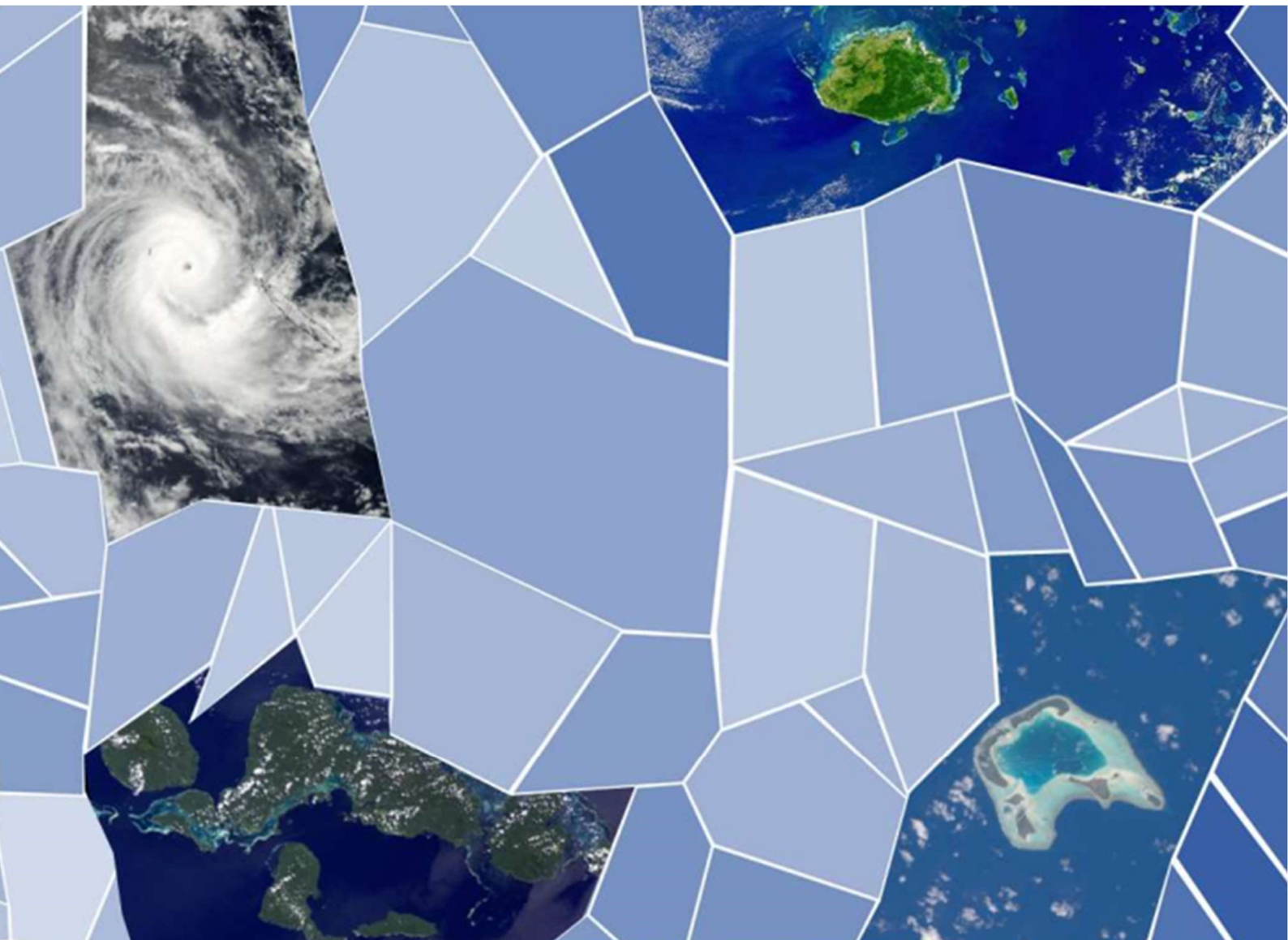
List of Acronym

ATC	Atmospheric correction
ESCAP	Economic and Social Commission for Asia and the Pacific
FRMS	Forest Resources Monitoring Data
GDP	Gross Domestic Product
GRDP	Gross Regional Domestic Product
LEP	Law on Environmental Protection
MONRE	Ministry of Natural Resources and Environment
MVI	Mangrove Vegetation index
ISPONRE	Institute of Strategy and Policy on Natural Resources and Environment
SEDS	Socio-Economic Development Strategy
SEDP	Socio-Economic Development Plan
SEEA	System of Environmental Economic Accounting
SNA	System of National Accounts
STI	Space Technology Institute
VGGS	Viet Nam Green Growth Strategy
VNFOREST	Viet Nam Administration of Forestry
WWF	World Wide Fund for Nature

1   EXECUTIVE SUMMARY

Vietnam's sea has great potential for socio-economic development. Over the years, the marine economy has made important contributions to the national economy (about 49.5% of the country's total GDP from coastal province, direct contribution from marine contributes to 13% in 2013), but the scale of development is not commensurate with the potential. The marine natural resources and environment is being depleted at an alarming rate.

The Central Party in October 2018 adopted the Resolution on national Strategy on sustainable development of Viet Nam's marine economy to 2030 with vision towards 2045 (Party Resolution No. 36-NQ/TW, dated 22 October 2018. This has an overarching goal of enhancing the sustainable socio-economic development and environmental protection in marine and coastal areas and islands with the direction of development of a society with the transition to the sea. MONRE is currently developing proposal on development of Blue Economy modes towards marine sustainable development to implement the strategy of sustainable development of Vietnam's marine economy to 2030, with a vision to 2045 which supposed to submit to Prime Minister for approval by 2022.

Ocean accounts organize ocean data (social, environmental, economic) into a common framework using the same structure as national accounts maintained by the National Statistical Offices or Finance Ministries. These provide the means to measure progress towards growth and sustainability of the ocean economy beyond Gross Domestic Product (GDP), in line with Sustainable Development Goals 14, 15.9 and 17.19 as well as international statistical standards. A comprehensive sequence of ocean accounts enables countries to monitor three critical trends: (1) changes in ocean wealth, including produced assets (e.g., ports) and non-produced assets (e.g., mangroves, coral reefs); (2) ocean-related income and welfare for different groups of people (e.g., income from fisheries for local communities); (3) ocean-based economic production (e.g., GDP from ocean-related sectors).

The pilot study "**Vietnam Ocean account: Case study in Quang Ninh province**" aims to test an ocean account approach for estimating contribution of ocean to provincial economy, assess the changes in ocean wealth (e.g., mangroves, coral reefs) and identify the land-based pollution source. The compilation of ocean account follows the guidance from GOAP. The study has highlighted to great contribution from the ocean-related sectors to GRDP of Quang Ninh. Change of ecosystem assets (i.e., mangrove and seagrass) over periods of time (i.e., 2015 – 2019) was analyzed to assess the change of ecosystem asses. Land based pollution sources (i.e., wastewater) from different sectors were studied to understand the flow to environment from economic sectors.

Calculation results of the added value contribution of ocean economy activities shows that on average in the period 2018-2020, **the total scale of added value at current prices of ocean economy sectors reached 16,178.7 billion VND/year (704.1 million USD),** equivalent to **8.4%/year** of the Gross Domestic Product (GRDP) in Quang Ninh province.

The economic sectors have significant contributed to GRDP of the provinces, but it is also a source of pollution. In the last 10 years (2011-2020), **the main contribution** of wastewater flows from registered sources in Quang Ninh are (i) **industrial activities** (of which coal minings and thermal power generations are contributing the major share) and (ii) **domestic wastewater.**

Mangrove forest is stable and slightly increased (1.9%) interm of area, however, there is a **clear trend of reclassification of function zonning toward production forest**. From 2015 to 2020 **there are 10.4% of protection forest and 46% of special use forest was reclassifed as produciton forest**.

This is a clear indication of Quang Ninh to use mangrove forest more extensively for economic development

Evaluation of data on the quality of seagrass beds shows that, in fact, **seagrass beds are seriously degraded**. As shown by the data on species composition, the area and density of distribution is very sparse in most of the study areas. Seagrass ecosystems are degraded especially seriously in Ha Coi and Hoang Tan due to recent activities of water surface reclamation for aquaculture and massive land reclamation to build economic zones and urban areas.

In recent years, **corals in the coastal area of Quang Ninh have declined sharply**. The largest decrease is in the Co To archipelago, which has decreased by 90% in area and coverage, followed by the Ha Long Bay area, which has decreased by about 30% compared to 1995. The main reasons for the decline are increased turbidity in the water. high in coastal areas and destructive fishing (cyanide) in Co To. Currently, there are no coral reefs of very good type (coverage of living corals over 75%), only 1 reef of good type (coverage between 51-75%) in Bai Tu Long, and the poor and the average. Tran and Co To islands have only poor reefs.

The results of the Ocean Account could be used as input for the development of provincial Socio-economic Development Plan 2026 – 2030, including optimizing spatial planning and natural capital resource allocation.

2 METHODS

2.1 Study area

The pilot study was conducted in Quang Ninh province, following the ocean accounting development process supported by ESCAP in 2019 – 2020, Located in the North-East of the country, Quang Ninh Province has an onshore area more than 6.000 km^2 and sea area more than 6.000 km^2, along with the 120 km coastal line, and more than 2.000 islands. It has forests plains and sea and an international border gate of Mong Cai to the People's Republic of China. Quang Ninh has access to many lands and river-going transport ways including the Cai Lan the only deep-sea port in northern Vietnam.

Quang Ninh province is an economic center of the northern key economic region. This place converges favorable conditions for socio-economic development in the process of industrialization and modernization. As a province with mineral resources, Quang Ninh provides raw materials to produce building materials, domestic and export industries, making an important contribution to economic development and GRDP of Quang Ninh province. Besides, Quang Ninh is also a potential tourism place, and a top of the tourism growth triangle in the North of Vietnam. The average population of Quang Ninh province in 2020 reaches 1,337.6 thousand people, equivalent to an increase of 1% compared to 2019, of which the urban population is 901.1 thousand people, accounting for 67.4%; rural population is 436.5 thousand people, accounting for 32.6%.
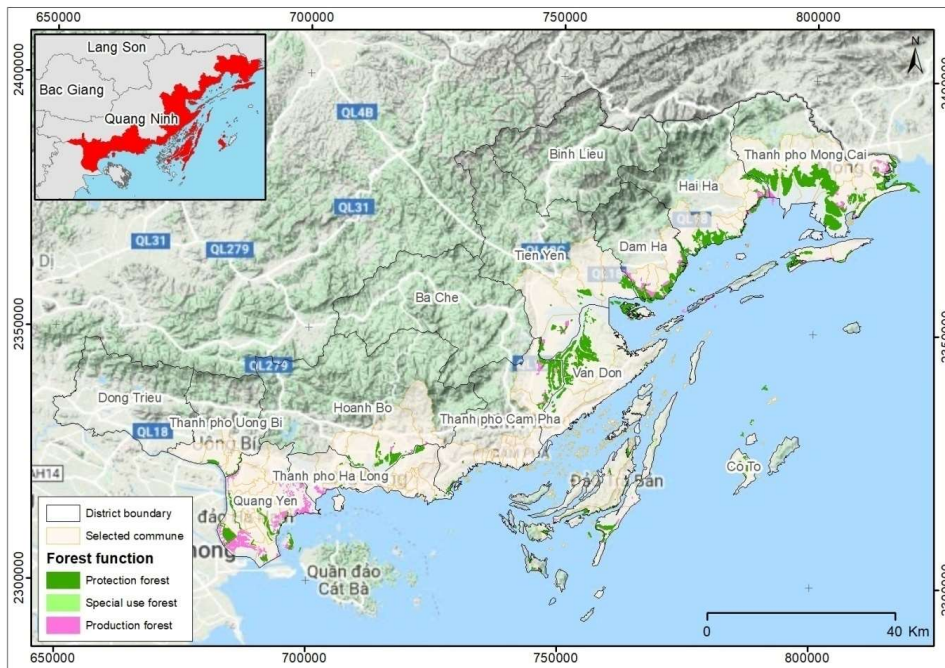
Figure 1. Administrative boundary map for Quang Ninh Province

2.2 Account calculation and data sources

The compilation of ocean account follows the guidance from GOAP (See Figure 1). Main accounts were calculated are the ocean assets (mangrove, coral reef and sea grass); flows to economy (supply and use of ocean services) and flows to environment (water emissions, and impacts on ecosystems).
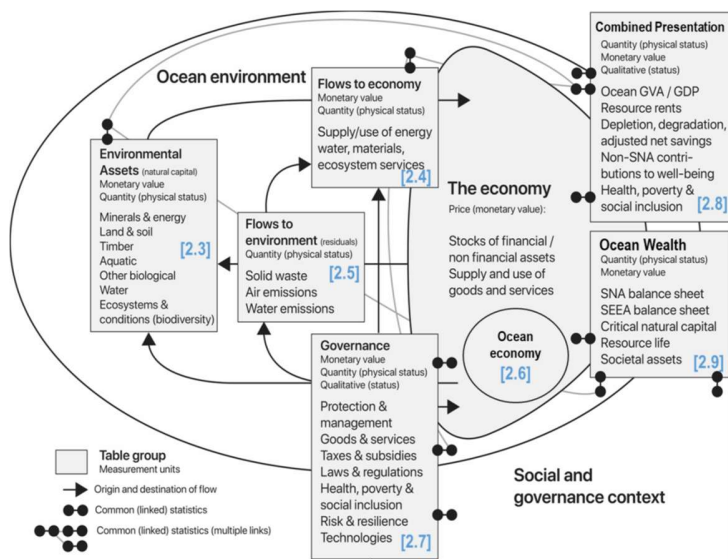
Figure 2. Detailed table structure of Ocean Accounts Framework

Table 1 describes the account information and data sources for ocean-related account

Table 1. Source of data for calculation

Data	Source
Socio-economic data	• Quang Ninh Statistical Yearbook for the period 2016-2020 • Mid-term Rural, Agricultural and Fishery Census 2020 • Annual tourism survey data (period 2016-2020) • Annual Fisheries Survey of the General Statistics Office • Annual corporate and individual surveys
Environment pollution	• Published researches/official reports of Quang Ninh. • Wastewater discharge permits data in Quang Ninh province (2009-2020), issued by Quang Ninh PPCs and the Ministry of Natural Resource and Environment (MONRE).
Ecosystem (mangrove, seagrass)	• Vietnam NFI Map 2010,2018 • Seagrass map IUCN • Published researches
Sea surface temperature and Chlorophyll-a	• Satellite image MODIS Aqua • Level 1 processing: level 1B (https://oceancolor.gsfc.nasa.gov/products/) • source: OBPG (NASA's Ocean-Color, Ocean Biology Processing Group-OBPG). • Time resolution: daily images • Spatial resolution 250 m (bands 1-2), 500 m (bands 3-7), 1000 m (bands 8-36). (details: table 1) • Image collection period: 2010 – 2020. • Quantity: 6100 images.

2.3 Define terrestrial basin and marine unit

From ESCAP funded study in 2019-2020[1] the terrestrial drainage basins and marine units of Quang Ninh were already defined. On the land the draingage basin is generated from watershed model, on the ocean the marine unit is adapted from Quang Ninh environmental protection plan to 2020 with vision to 2030. In this study we take this drainage basins and marine units and use them to spatially group account data.

---

[1] Vietnam Ocean account: Case study in Quang Ninh province (ISPONRE 2020)

Figure 1. Basin and marine unit of Quang Ninh

On the land, Quang Ninh is divided into 3 basins.

- Drange Basin 1 (DB1): cover the Ha Long city area.
- Drange Basin 2 (DB2): cover the middle part of Quang Ninh province.
- Drainage Basin 3 (DB3): cover the Dam Ha area.

On the ocean Quang Ninh has 7 marine units which can also be grouped in 3 larger unit, each corresponding to one land drainage basins. For simplification in the accounting process, in this study we used the grouped 3 marine unit for all analysis.

Table 2. Marine unit of Quang Ninh and its corresponding drainage basin

| #	Marine unit name	Marine unit combined	Drainage basin	Area (ha)
1	A.1. Tuan Chau Island	Marine Unit 1	Basin1	23,935
2	C.1. Ha Long Bay	Marine Unit 1	Basin1	48,945
3	A.2. Bai Tu Long Bay	Marine Unit 2	Basin2	89,339
4	A.4 Ba Nui Island	Marine Unit 2	Basin2	19,613
5	C.2 Bai Tu Long National Park	Marine Unit 2	Basin2	20,843
6	C.3 Co To island and Tran island	Marine Unit 2	Basin2	13,275
7	A.4 Ba Nui Island	Marine Unit 3	Basin3	86,026
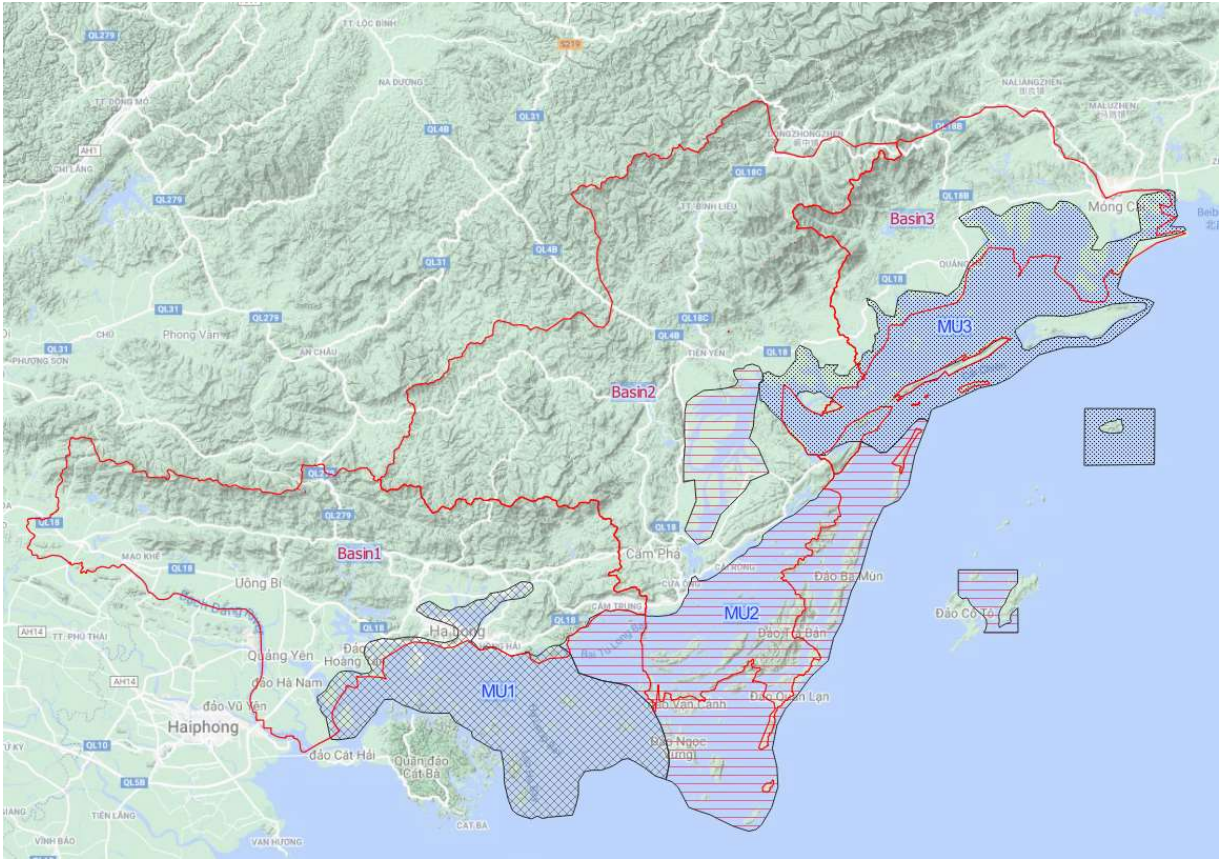
Figure 2. Quang Ninh 3 marine units

3 STUDY RESULTS

3.1 Contribution of ocean economy to Quang Ninh's GPD

With the goal of developing Quang Ninh province to become a strong marine economic center of the country, associated with a system of deep-water seaports; focusing on localities including Ha Long, Cam Pha, Mong Cai, Quang Yen, Van Don, Co To, Hai Ha associated with marine economic sectors; become a national tourism center connecting with major international tourist centers of the region and the world via sea. The marine economy has made extremely important contributions to the economic growth of Quang Ninh province in recent years. Calculation results of the added value contribution of ocean economy activities through Table 3 shows that on average in the period 2018-2020, the total scale of added value at current prices of ocean economy sectors **reached 16178.7 billion VND/year** (704.1 million USD), equivalent to 8.4%/year of the Gross Domestic Product (GRDP) in Quang Ninh province. In the period 2018-2020, Year 2019 the added value of ocean economy activities made the largest contribution with 8.6%, equivalent to 16.7 trillion VND. In 2020, due to the impact of the Covid-19 epidemic, the value-added ratio of marine economic sectors accounted for only 8.08% of the GRDP of Quang Ninh province and reached a value of **17.7 trillion VND** (774.4 million USD). Of the total added value of marine economic sectors, in the period 2018-2020, product tax accounts for an average of 8.1%/year

Table 3. Contribution of ocean economy to economic growth

STT	Criteria	Unit	2018	2019	2020
1	Total added value of ocean economy	Billions VND	12,985	15,323	16,272
2	Product tax	Billions VND	1,132	1,367	1,458
3	Direct contribution to the ocean economy	Billions VND	14,117	16,690	17,730
4	Gross domestic product in Quang Ninh province (GRDP)	Billions VND	166,271	194,132	219,378
5	Direct contribution of ocean economy to Gross Domestic Product (GRDP) in Quang Ninh province (%)	%	8.49	8.60	8.08

3.2 Ecosystem Assets
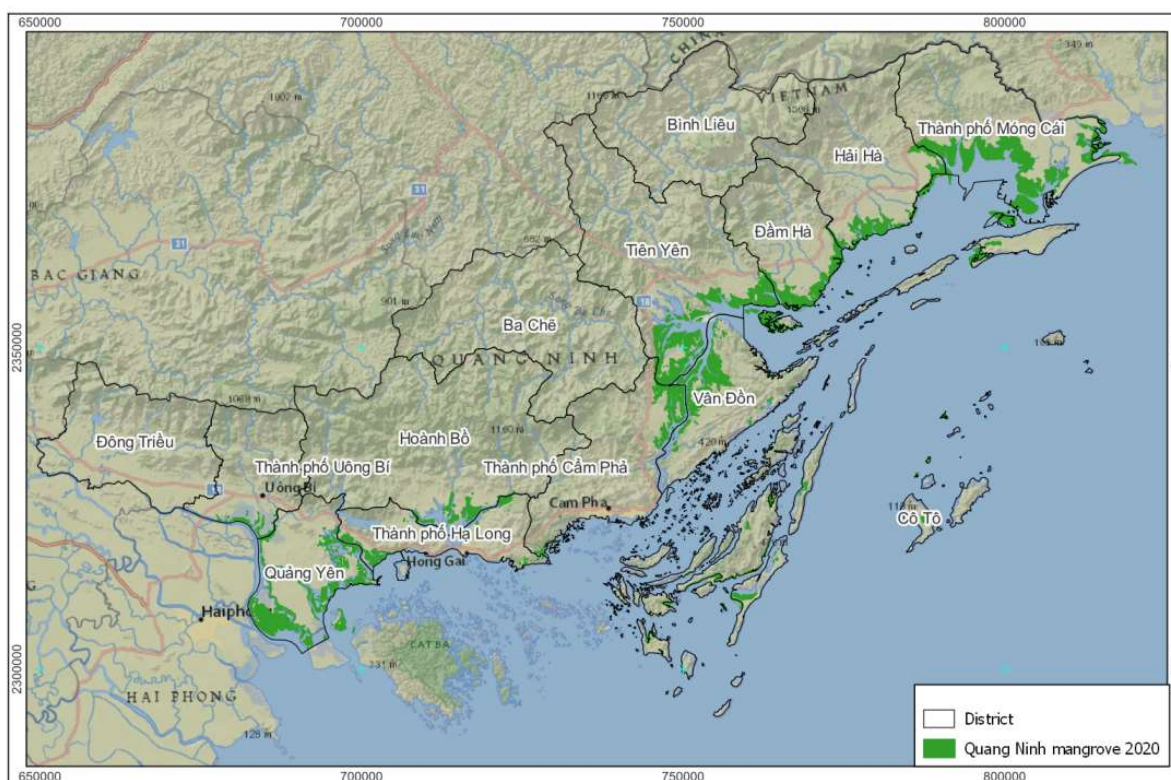
3.2.1 Mangrove forest

Figure 3. Quang Ninh mangrove forest 2020

From the forest status map obtained from FRMS database (2015–2020), the area of the mangrove forests increased by 388 ha from 19,372.53 ha in 2015 to 19,761.40 ha in 2020 (+2%).

Table 4. Mangrove forest area 2015 and 2020 (Source FRMS data)

Basin	mangrorve 2015	mangrove 2020	Change 2015 2020
basin 1	2,022.27	1,839.81	(182.45)
basin 2	7,025.59	7,717.65	692.06
basin 3	10,324.67	10,203.94	(120.73)
Total	19,372.53	19,761.40	388.87

Mangove forest by function zonning

Although the total mangrove area is slightly increased, there was a significant change in forest function zoning. From 2015 to 2020 there was 2,550 ha of mangrove forest changed from protection to production function, that was a reduction of 10,4%. Special use forest[2] that are mangrove forest was reduced by 24 ha that equivalent to 46% compared to 2015.

Table 1. Quang Ninh mangrove forest area reported by forest function at province level (Source. FRMS data)

Forest type	2015	2020	Change 2015 – 2020
Special use	49.39	27.60	(21.80)
Protection	17,491.78	15,697.52	(1,794.26)
Production	398.52	2,853.77	2,455.25
Outside designated forest land	1,432.84	1,182.51	(250.33)
Total mangrove forest	**19,372.53**	**19,761.40**	388.87

This change in forest function is reflected in the national level Decision 15/NQ-CP regarding the administration of land use planning to 2020 and the last land use planning (2016 – 2020) of Quang Ninh province. In this plan the area of protection forest is planned to be reduced by 1,714 ha and production forest reduced by 20,207 ha. In the same plan, 21,168 ha of un-used land is allocated to forest land that makes the total planned forest area reduced by only 839 ha. The plan did not provide specific area where this change occurred, or it's inland forest or mangrove forest but it provides clear evidence that at least 20,207 ha of forest will be converted to other land use for economic development purposed.

*Table 2. Change in forest land to other land use in the Quang Ninh 2016–2020 land use planning (Source Decision 15/NQ-CP)*

Change type	Protection	Special use	Production	Total

---

[2] Special use forest as defined in Vietnam Forest Law is forest reserved for biodiversity protection (national park, protected area), culture/historical and research.

1. Forest land to non-agriculture land (1)	1,259	86	18,779	20,124
2. Forest land to agriculture land (2)	455		1,428	1,883
Total (1+2)	1,714	86	20,207	22,007
3. Un-use land to forest land	15,792	839	4,537	21,168
Change after adjustment	14,078	753	-15,670	-839

To access the mangrove forest change in more detail, a 2015-2020 change matrix and change map was. In general, most mangrove is stable (96.4%), there are 1.1% of mangove forest resoration and reforestation, 1.4% mangrove forest loss and 1.1% of forest degradation. This result showed that although the total mangrove area is slightedly incease (1.9%) there are still area with mangrove forest loss and degradation.
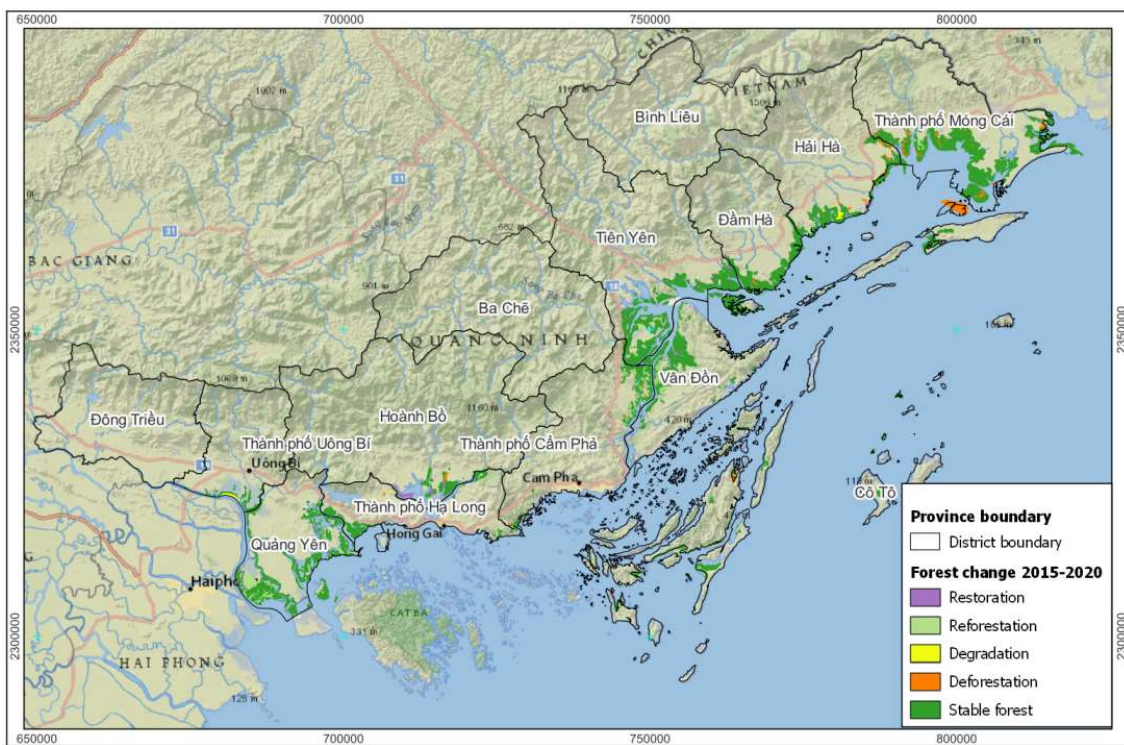
Change type	Area (ha)	%
Restoration: new mangrove forest by natural extend	123.3	0.6
Reforestation: new mangrove forest by plantation	96.8	0.5
Degradation: change from mangrove forest to regrowth mangrove forest	219.7	1.1
Deforestation: mangrove forest loss	273.31	1.4
Stable mangrove forest	19,085.80	96.4

Figure 4. Forest change map 2015 – 2020

To access the mangrove forest quality the image-based mangroved forest was classified in 3 classes: poor, medium, and good. The result (table) showed that from 2015 to 2020 the poor mangrove reduced by 2,997 ha, medium mangrove reduced by 1,998 ha and good forest increased by 6,010 ha. This suggests a general trend of improvement in mangrove forest quality in the study period. However as mentioned in the method sections, this is only a result of quick image classification exercise without field verification. We suggest treating this result as indicative and further field investitation need to be conducted to verify the level of accrurcy.

Table 3. Mangrove foret as classifed from Sentinel 2 by forest quality

Basin	2015				2020			
	poor	medium	good	Total	poor	medium	good	Total
basin 1	354.28	236.18	1,251.80	1,842.26	161.49	107.66	1,297.15	1,566.30
basin 2	2,236.00	1,490.67	2,082.43	5,809.11	774.04	516.02	4,986.59	6,276.66
basin 3	4,639.97	3,093.31	2,438.92	10,172.20	3,116.27	2,077.52	5,354.68	10,548.46
Total	7,230.24	4,820.16	5,773.16	17,823.57	4,051.79	2,701.20	11,638.43	18,391.41

Changes in Seagrass in recent year

The surveyed area of seagrass is inceasing from 930 ha in 2004 to 1,470 ha in 2015 and 1,825 ha in 2017. However, the increase does not reflect the rehabilitaion of seagrass but due to the incompleteness of the survey taken in the past.

For site with consistent survey result from 2002 to 2020 the result showed that seagrass was significantly reduced both in term of area and coverage: Ha Long Bay decreased by 75%, Dam Nha Mac lagoon by 60%, Quan Lan decreased by 50%.

From 2014 to 2017 the seagrass is stable for most sites in Quang Ninh. There are 2 new seagrass sites (Mong Cai and Quang Yen) that are newly discovered in 2017 survey.

Table 8. Seagrass area in Quang Ninh

#	Site	Area (ha)			Changes 2002 to 2017
		2002	2014	2017	
1	Móng Cái	-	-	50	Incerase due to incompless survvey in 2000
2	Vụng Hà Cối	150	100	100	Reduced by 30%
3	Vụng Đầm Hà	80	700	700	Incerase due to incompless survvey in 2000
4	Bãi Quan Lạn	100	50	50	Reduced by 50%

5	Hoàng Tân	–	400	400	Incerase due to incompless survvey in 2000
6	Đầm Nhà Mạc	500	200	200	Reduced by 60%
7	Quảng Yên	–	–	300	Incerase due to incompless survvey in 2000
8	Vịnh Hạ Long	100	20	25	Reduced by 75%
	Total	930	1470	1825	

3.2.1.1 The degradation of coral ecosystem

A collection of results of periodic monitoring at fixed cross-sections, research results of WWF (1993, 1994), investigation reports (Yet H.N., 1996, 1998), Nguyen Dang Ngai (2004, 2009, 2010, 2015) showed the change of corals in areas in Quang Ninh over time as follows:

Ha Long Bay is an area subject to the strongest impacts from humans such as water transport, tourism, fishing, mining, waste, industrial and domestic wastewater... all affect the water quality of the bay. Meanwhile, coral ecosystems are very sensitive to water quality. Therefore, the gradual loss of coral reefs is an inevitable thing if there are no measures to minimize the sources of pollution and harm to the coral reefs.

Survey results show that historically, Ha Long Bay is one of the most diversed coral reef area in Northen Vietnam, with 157 species identified with a the number of coral species on reefs in Ha Long area has decreased through time. In 1998, the average number of species per coral reef in the region was 63.5 species, in 2002-2003 the number of species decreased to 34.2 species and by 2010 the number of species remained only 22.4 species.Thus, after 12 years (from 1998 to 2010) the number of coral species here has decreased to 64.8% (i.e., nearly 2/3). Currently, the reef with the highest number of species in Ha Long Bay has only 37 species compared to 78 species in previous years (JICA, 1999).

Table 9. Number of coral species identified through various surveys in Ha Long Bay

TT	Reef	No. of Species		
		1998 survey	2002-2003 survey	Decrease (%)
1	Cống Lá	73	39	46,6
2	Hang Trai	78	22	71,8
3	Cống Híp	46	40	13,0
4	Cống Đỏ	51	27	47,0

5	Tùng Ngón	75	29	61,3
6	Cọc Chèo	58	48	17,2
	Average	63,5	34,2	42,8

Regarding the coral reef community structure, it was found that the species composition structure was less diverse than before. Due to the strong change in environment, especially the increase in turbidity, the non–adapted species are gradually reduced such as Acroporidae species in 1998 in an area with 36 species, in 2003 only 18 species were found. and by 2015 there were only 10 species left. Some species that can adapt to turbid environments such as Galaxea, Goniopora, Pavona have unchanged number of species (due to the ability to "self–clean" thanks to long tentacles or create a mucous membrane that does not allow sediment to settle on) thrives and dominates the whole reef (typically reefs in Hang Trai and Dau Be areas).

3.3 Wastewater

3.3.1.1 Households and Tourism wastewater

The estimation results of wastewater flow from domestic and tourism activities for 2015 and 2019 are presented in the following table.

Table 10. Estimated wastewater discharge from households and tourism activities

#	Types	Total discharge (million m3/year)			Max discharge after treatment (from permits) – million m3/year		
		DB1	DB2	DB3	DB1	DB2	DB3
2015							
1.1	Households	33.44	14.95	4.09	1.02 – 5.88*	0	0
1.2	Tourism	3.32	0.035	0.14	0	0	0.70
2019							
2.1	Households	41.68	11.36	8.26	1.2 – 5.88*	0.054	–
2.2	Tourism	5.99	0.063	0.25	0.61	–	0.70

By 2020, domestic wastewater discharge in Quang Ninh had increased from 52.5 to 61.3 million m3/year (+16.7% compared to 2015) while centralized treatment capacity remains unchanged. This indicated an increasing portion of untreated[3] domestic wastewater are flowings into the environment during the accounting period, especially in the common senses that most of the households' septic systems are poorly managed (Worldbank, 2013).

---

[3] Or more correctly premilinary treated via septic tanks and hygiene toilet system – as almost all households in Quang Ninh already have. The rate of population in Quang Ninh that have hygiene toilet system in accordance with the 2019 General Population Census (table 20) is 99.5%.

3.3.1.2 Healthcare wastewater

By 2015, in the province there were 32 health care facilities and hospitals, in which 24 already have wastewater treatment facilities; the remaining 11 facilities either did not have or have but the wastewater treatment system did not meet the requirements.

The average discharge of wastewater from these health care facilities and hospitals in Quang Ninh during this period was about 1,441.7 m3/day (~526,220 m3/year) (Quang Ninh DONRE, 2015). As there were no detailed data for each drainage basin, the estimated total discharge in 2015 are calculated in propotioned with 2020's total discharge from each basin, where data are available for compilation.

In 2020, the data was compiled in (Quang Ninh DONRE, 2021) included wastewater discharge data from the survey of 13 hospitals and 21 healthcare centres across the province. The following table presents the estimated healthcare wastewater in Quang Ninh in 2015 and 2020, the data was extracted from (Quang Ninh DONRE, 2015, 2021 and from discharge permits data).

Table 4. Healcare wastewater in in Quang Ninh

#	Total discharge (m3/year)			Max discharge after treatment (from permits) – m3/year		
	DB1	DB2	DB3	DB1	DB2	DB3
2015	395,831	88,045.3	42,343.8	764,775	298,570	58,400
2020	774,530	172,280	82,855	826,725	244,550	67,525

3.3.1.3 Industrial wastewater

For max allowed discharge after treatment: Calculated from the 2009–2020 discharge permits issued by Quang Ninh PPC and MONRE.

Table 12. Estimation result for the industrial wastewater extent account.

#	Types	Maximum allowed discharge after treatment, from permits – million m3/year)			Total discharge (estimated) million m3/year		
		DB1	DB2	DB3	DB1	DB2	DB3
	2015						
1.1	Coal mining and processing	98.55	75.57	0.00	57.20	52.80	0.00
1.2	Industrial zones/clusters	0.84		0.37	9.25		1.03
1.3	Other Industries*	20.93	7.35	6.40	24.55	8.62	7.51
1.4	Thermal Power Generation						
1.4.1	– Cooling water	2,337.05	3,666.19	0.00	N/A	N/A	N/A

1.4.2	– Other wastewater (e.g., run off, bottom ash storage area etc.)	0.66	3.78	0.00	N/A	N/A	N/A
2020							
2.1	Coal mining and processing	168.71	154.58	0.00	64.79	65.68	0.00
2.2	Industrial zones/clusters	1.24	0.00	8.37	5.70	0.00	4.68
2.3	Other Industries*	27.34	8.27	9.11	48.74	7.18	7.00
2.4	Thermal Power Generation						
2.4.1	– Cooling water	3,208.13	3,666.19	0.00	4,995.38	3,666.69	0.00
2.4.2	– Other wastewater (e.g., run off, bottom ash storage area etc.)	25.59	3.78	0.00	0.79	4.11	0.00

*: Estimated for industry facilities located outside of the industrial zones/clusters (excluding coal minings).

As seen on the Table , wastewater from coal mining and processing operations contribute from 62 – 68% of total industrial wastewater discharge (not counted cooling water from thermal power plants) in Quang Ninh. Untreated coal mining wastewater in some areas in Quang Ninh are acidic (pH=3.3–3.8) and including heavy metals and suspended solids (Quang Ninh DONRE, 2015). Both treated and untreated water from mines flows into the rivers systems and finally ended up in the coastal water in Ha Long Bay and Bai Tu Long Bay.

(Quang Ninh DONRE, 2015) indicated that the total volume of mining wastewater from the whole coal mining zones in Quang Ninh Province in 2015 was estimated at around 110 million m3 /year, in which about 86% are treated in someway or others. The estimation actual wastewater discharge from coal industries in 2020 is 130 million cubic metres, in which approximately 50% was treated (Quang Ninh, DONRE, 2020).

Permit data shows that there was significant investment into wastewater treatment of the coal industry in Quang Ninh from 2013 – 2020, with an increased in design treatment capacity (or maximum allowed discharge) from 5.4 million m3/year (by 2012) to 171 million m3/year (by 2015) and 323 million m3 year (by 2020). Most of the permits are issued by MONRE (approx. 304 million m3/year by 2020).

The permit data shows that already by 2015, supposedly, the Vietnam coal industry should already have more than enough treatment capacity for its wastewater. However, as stated in both (Quang Ninh DONRE, 2015 and 2020) water pollution from coal mining activities persisted by 2020 (see section 2. Condition Account for more information on water quality). This may indicate an underestimation of actual discharge from the coal industry.

3.3.1.4   Terrestrial surface water condition

Despite efforts by the coal industry to invest in water treatment since 2013, most of the terrestial water bodies in Quang Ninh province were showing signs of degrading water quality overtime from 2011–2020, excepted for upstream water bodies in the mountainous areas where there were no significant land use changes.

The period of 2011–2020 in Quang Ninh were also marked with rapid infrastructre and urban development activities especially in the coastal area, this may explain why some of the parameters such as TSS, COD and BOD_5 show signs of increased in 2016–2020 when compared to 2011–2015 period in almost all terrestial surface water bodies in Quang Ninh.

3.3.1.5   Marine water condition

From 2011–2020, the coastal areas of Quang Ninh (marine unit A1.1, A1.2, and A2.1) near drainage basins 1 and 2 are showing consistent signs of pressures from land use changes, industrial, urban development, aquaculture, and tourism activities, which was shown through a distinct higher value of parameters such as TSS, COD, BOD5 and NH_4^+ compared to other marine units further from shorelines. Coastal water in drainage basin 3 (marine unit A4) were also showing signs of impact, but to a lesser extent.

For the marine unit C1 – the core zone of Ha Long Bay World Heritage Site and C4 - the marine water around Cô Tô and Trần Island, water quality remained quite stable from 2011–2020. However, the northern rim of the Ha Long Bay WHS, near marine unit A1.2 and A2.1 was already show signs of consistent elevated level of TSS and COD, which indicated impacts from inland and tourism activities are, in a way, reaching to the protection zone already.

The decrease in oil and grease concentration in water in 2016–2020 compared to 2011–2015 shows that the strict enforcements of bilge water treatment (installation of oil–water separator) since 2015 of Quang Ninh province, applied to all tourist boats operated in the area, were effective.

4   CONCLUSION AND RECOMMENDATION

4.1   Conclusion

Ocean Economy

Calculation results of the added value contribution of ocean economy activities shows that on average in the period 2018–2020, **the total scale of added value at current prices of ocean economy sectors reached 16,178.7 billion VND/year (704.1 million USD),** equivalent to **8.4%** of the GRDP in Quang Ninh province. In the period 2018–2020, Year 2019 the added value of ocean economy activities made the largest contribution with 8.6%, equivalent to 16.7 trillion VND. In 2020, due to the impact of the Covid–19 epidemic, the value–added ratio of marine economic sectors accounted for only 8.08% of the GRDP of Quang Ninh province and reached a value of 17.7 trillion VND (774.4 million USD).

Within the ocean economy estimation for 2020, the highest contribution was from fishery 38%, the industry and transportation had similar contribution (18.4 and 18.6% respectively), other service (19.3%) and the sector with lowest contribution is accommodation and tourism (5.3%).

The economic sectors have significant contributed to GRDP of the provinces, but it is also a source of pollution. In the last 10 years (2011–2020), **the main contribution** of wastewater flows from registered sources in Quang Ninh are (i) **industrial activities** (of which coal mining and thermal power generations are contributing the major share) and (ii) **domestic wastewater**.

Ecology

Mangrove forest is stable and slightly increased (1.9%) in term of area. However, there is a **clear trend of reclassification of function zoning toward production forest**. From 2015 to 2020 there are 10.4% of mangrove protection and 46% of mangrove special use forest was reclassified as

mangrove production forest. This is a clear indication of Quang Ninh to use mangrove forest more extensively for economic development. Area estimation from remote sensing image from the same period showed similar trend with mangrove being stable and slightly increased both in term of area and quality. However due to lack of field investigation for accuracy assessment, the remote sensing-based result for this study should be considered as indicative. Nevertheless, remote sensing monitoring showed cleared advantages as a low-cost and effective method for operational mangrove forest monitoring.

Seagrass beds are seriously degraded both in term of area and quality. As shown by the data on species composition, the area and density of distribution is very sparse in most of the study areas. Half of the survey sites have seagrass cover reduced by 50%. Seagrass ecosystems are degraded especially seriously in Ha Coi and Hoang Tan due to recent activities of water surface reclamation for aquaculture and massive land reclamation to build economic zones and urban areas. Of the 7 seagrass species in Quang Ninh, 1 species was no longer observed in the last survey in 2018.

From 2010, corals in the coastal area of Quang Ninh have declined sharply. The largest decrease is in the Co To archipelago, which has decreased by 90% in area and coverage, followed by the Ha Long Bay area, which has decreased by about 30% compared to 1995. The main reasons for the decline are increased turbidity in the water. high in coastal areas and destructive fishing (cyanide) in Co To. Currently, there are no coral reefs of very good condition (coverage of living corals over 75%), only 1 reef of good type (coverage between 51-75%) in Bai Tu Long, and the poor and the average. Tran and Co To islands have only poor reefs.

The result of initial seagrass mapping using Landsat 8 showed that using a water profile algorithm from other location (Phu Quy Island) lead to over estimation of seagrass area. Therefore, it was not possible to conduct a temporal remote sensing-based seagrass mapping comparison. Additional investment is needed to conduct marine survey (water profile measurements, seagrass measurements) to improve the seagrass mapping method that are more suitable to characteristic of Quang Ninh marine areas.

The initial assessment of using international dataset for coral and seagrass mapping showed positive result. While UNEP/WCMC global dataset only give indicative location of seagrass and coral, newer dataset such as Alen Coral Atlas (using 3 m resolution Planet image) provide more accurate and higher resolution map that can be used directly as input for provincial level assessment.

Environment

The improvement/stabilization in oil and grease concentration in the ocean of Quang Ninh since 2015 is a good showcase of sound, cost-effective and feasible policy (i.e., the regulation which required all tourist boats to install an oil-water separation system) where it is not only relatively simple to enforce, but also required reasonable investment from the tourism industry.

Some examples of unquantified run-off flows resulting from environment incidents causing by heavy rainfalls such as the (i) 2015 partially broken of waste-rock dam in Cẩm Phả Coal mining area, and (ii) the 2016 and 2018 mudslides from the construction area of FLC Ha Long Bay Luxury Resort & Golf Club, caused hundreds of billions VND of damage, are showing that the impacts of urban development and industrial activities in the coastal area in Quang Ninh (especially the rapid urbanize coastal areas of Ha Long Bay and Bai Tu Long Bay) to the coastal marine units which are not yet fully estimated and reported. Future policy and research should also consider the extent and condition of wastewater discharge from non-point sources to create better, and more informed, management/planning solutions.

Environmental monitoring of water quality in Quang Ninh have been further ramped up since 2019 with the issuance of Decision 5354/2019 where the number of monitoring sites and frequency are increasing by several folds for both water, air, soil, and for the first time, consisted of a list of monitoring points for sediment. This shows that the authorities in Quang Ninh are aware of the issues and are trying their best to establish proper environmental data collection and monitoring, which would eventually contribute to more effective management and enforcement of environmental regulation in the province. However, for effective implementation, adequate resources should be allocated for this monitoring task.

4.2 Recommendation

Quang Ninh province should look further into the result of each sector in ocean economy to optimize the ocean economy planning. Despite the clear advantages of having strategic location for ocean transportation, access to ocean natural resources and tourism attraction the direct contribution of ocean economy to provincial GRDP is relatively low (8.08% in 2020). The contribution of accommodation and tourism sector only accounted for 5.3% ocean economy is also rather low given that Quang Ninh tourism strategy aiming at growing tourism sector to contribute 10% of GRDP in 2020. For fishery (both capture and aquaculture) the sector with highest contribution to ocean economy (38%), Quang Ninh could have further investment to improve the fishery processing toward higher quality product in the value chain.

To conduct an accurate assessment of the contribution of ocean economy to economic growth, it is necessary to develop enhanced information collection program and compiling more detail *supply and use table* to calculate the direct and indirect contributions of the marine economy to the economy. Only with that data collection system in place we will be able to have a comprehensive assessment for all aspect of ocean economy.

For mangrove forest, although Quang Ninh managed to keep the mangrove area stable during 2015-2020, the economic development in some areas will be overlap with mangrove forest. The construction of Dam Nha Mac and Tien Phong industry zone in Quang Yen district will replaced a significant area of mangrove forest (500-800 ha). While this change was part of the economic development plan and there is land-use-change decision in place, it is very important that the clearance of mangrove forest is conducted carefully according to required Law and regulation. The remaining mangrove forest adjunction to new industry zones should be protected with high priority and whereas possible investment should be put in place to create favorable condition for remaining mangrove to grow, e.g., construction of water channel so that new construction did not block sea water to go in and out of the mangrove forest. It is also important that the lost mangrove will be replanted in other suitable area according to the requirement in forestry law.

Coral reef and seagrass play key role in maintaining the fish and other aquatic population. As the largest sector in ocean economy (38%), the fishery industry is largely dependent on seagrass and coral reef as a healthy natural habitat for hatching and providing food. As the area and condition of both seagrass and coral is decreased sharply in the last 10 years, Quang Ninh should consider having both near term and midterm policy to: i) having systematic assessment of seagrass and mangrove to quantify the area and condition of seagrass and coral; ii) invest in protection of remaining seagrass and coral habit by appropriate action plan such as re-enforce the marine protection zone at important seagrass and coral sites, reduced the aquaculture farming in key sites. The coal mining, sea leveling, and infrastructure construction need to pay attention to environmental protection, especially in rainy days as the sediment follow into the sea will kill near coast seagrass and coral.

The 2021 Revised Law on Statistics currently listed 11 environment indicators to be reported in the national accounts system, in which there are only two wastewater's related indicators: 1. percentage of industrial, manufacturing, and high-tech zones have centralized water treatment systems which meet the environment standards and 2: percentage of industrial clusters have centralized water treatment systems which meet the environment standards. On the other hand, the Circular No.20/2018 – BTNMT issued by MONRE regulating the statistical data reporting mechanisms of the natural resources and environment sector included (i) 8 water-resource indicators, and (ii) 18 environmental pollution related indicators. These included (i) total volumes of water extraction, usage, and of wastewater discharges which have been permitted by the provincial authority (extend account); and concerned substances levels in surface-water, groundwater and marine areas (condition account). For effective ocean accounting in Vietnam, there should be consideration to integrate more environment data into the national account system.

The results of the Ocean Account could be used as input for the development of provincial Socio-economic Development Plan 2026 – 2030, including optimizing spatial planning and natural capital resource allocation.

5 References

1. Cao Văn Lương, Đàm Đức Tiến, Đỗ Công Thung, 2014. Hiện trạng cỏ biển khu vực ven bờ tây vịnh Bắc bộ. Tạp chí Khoa học và Công nghệ Biển, 14(3A): 223–229. doi:10.15625/1859-3097/14/3A/5196.
2. Cao Văn Lương, Đỗ Công Thung, 2019. Thành phần, phân bố các loài cỏ biển tại Quảng Ninh và Hải Phòng – hiện trạng và biến động. Tạp chí Khoa học và Công nghệ biển, 19(3A):333-342.
3. Cao Văn Lương, Nguyễn Mạnh Linh, Đỗ Công Thung, Phạm Thị Kha, Nguyễn Văn Minh, Định Hải Ngọc, Masakazu Hori, 2021. Phân tích định lượng mức độ tường đồng và đa dạng loài của một số thảm cỏ biển tại Việt Nam. Tạp chí Khoa học và Công nghệ biển, 20(4B):225-234.
4. Cao Van Luong, Nguyen Van Thao, Teruhisa Komatsu, Nguyen Dac Ve and Dam Duc Tien, 2012. Status and threats on seagrass beds using GIS in Vietnam. Remote Sensing of the Marine Environment II, edited by Robert J. Frouin, Naoto Ebuchi, Delu Pan, Toshiro Saino, Proc. of SPIE Vol. 8525, 852512.
5. Chỉnh, T.N, 2020, The Status of Coal Demand, Supply, and Imports – Challenges and Development Strategy, Part 1, Vietnam Energy Association.
6. Coral map IUCN
7. Đỗ Công Thung và nnk, 2009. Nghiên cứu các giá trị đa dạng sinh học vịnh Hạ Long phục vụ cho việc quản lý, phát huy giá trị đa dạng sinh học của di sản. Báo cáo tổng kết đề tài. Lưu trữ tại thư viện Viện TN&MTB.
8. Geography Institute - Vietnam National Academy of Science, 2013, Status of Coastal Water Pollution in Quang Ninh.
9. Hemminga M.A. and Duarte C.M., 2000. Seagrass ecology. In press, Cambridge University Press.
10. http://www.iucnredlist.org/details/173342/0 (ngày 31/6/2017).
11. IPSPONRE (2019), Vietnam Ocean Accounting Report, Case Study of Quang Ninh.
12. Lăng Văn Kẻn, 1991b. San hô đá và các rạn san hô ở quần đảo Cát Bà. Tuyển tập Tài nguyên và Môi trường biển, tập I. NXB KHKT, tr. 146 – 151.
13. Miguel D. Fortes., 1988. Mangroves and seagrass beds of East Asia: Habitats under stress. Ambio Vol. 17, No. 3, East Asian Seas, pp. 207–213.
14. Nguyễn Đăng Ngải, 2004. Sự biến động của quần xã rạn san hô khu vực Hạ Long, Cát Bà. Kỷ yếu hội thảo Việt Nam – Italia, NXB Đại Học quốc gia Hà Nội.
15. Nguyễn Đăng Ngải, 2006. Phát hiện mới về địch hại ăn san hô ở Cát Bà. Tạp chí biển Việt Nam, ISSN12/2006, tr14-15.
16. Nguyễn Hữu Đại và cộng sự., 1999. Các thảm cỏ biển ở vùng biển phía nam Việt Nam. Tuyển tập Báo cáo Khoa học Biển toàn quốc lần thứ IV, tập II: 967-974.
17. Nguyễn Huy Yết và Lăng Văn Kẻn, 1995. Thành phần loài và sự phân bố san hô của vịnh Hạ Long. Báo cáo của Hội nghị KH Sinh vật biển lần thứ I. Nha Trang 10/1995.
18. Nguyễn Huy Yết và nnk, 1999. Điều tra, nghiên cứu sự suy thoái san hô ở vùng biển ven bờ phía Bắc, đề xuất các giải pháp bảo vệ và phục hồi. Báo cáo đề tài cấp Trung tâm. Lưu trữ tại Viện TN &MT biển.
19. Nguyễn Huy Yết, 1990. San hô cứng ven bờ tây vịnh Bắc Bộ, hiện trạng và vấn đề bảo vệ tài nguyên RSH. Báo cáo của Hội nghị KHKT ngành Thuỷ sản 1986 – 1990. Hà Nội.

20. Nguyễn Huy Yết, 1993. Dẫn liệu về thành phần loài và phân bố của san hô cứng vịnh Hạ Long. Tạp chí Sinh học tháng 3-1996 số 18(1):7-13

21. Nguyễn Văn Tiến và cộng sự, 2004. Tiến tới quản lý hệ sinh thái cỏ biển Việt Nam (Approaches to management of seagrass ecosystem in Vietnam). Nhà xuất bản Khoa học và Kỹ thuật, 132tr.

22. Nguyễn Văn Tiến và cộng sự, 2006. Đánh giá nguồn lợi cỏ biển vùng ven biển miền Trung, Tây Nam Bộ và đề xuất các giải pháp sử dụng bền vững nguồn lợi. Báo cáo tổng kết đề tài Khoa học Công nghệ độc lập cấp Viện Khoa học và Công nghệ Việt Nam, 182 tr.

23. Nguyễn Văn Tiến, 2013. Nguồn lợi thảm cỏ biển Việt Nam. Nhà xuất bản Khoa học Tự nhiên và Công nghệ, 336tr.

24. Nguyễn Văn Tiến, Từ Thị Lan Hương, 2008. Phương pháp nghiên cứu Cỏ biển (Seagrass research methods). Nhà xuất bản Khoa học Kỹ thuật Hà Nội.

25. Nguyễn. T. T. N. (2014). Study on zoning of water quality for Ha Long Bay and propose measures for management and usage, Dissertation for Doctor of Philosophy in Environmental Science, Hanoi National University.

26. Phạm Đình Trọng và nnk, 1999. Kết quả điều tra nhanh tài nguyên biển và tiềm năng bảo tồn, đề xuất cơ sở khoa học xây dựng khu bảo tồn biển đảo Trần. Báo cáo tổng kết đề tài "Điều tra nhanh tài nguyên biển đảo Trần và Ba Mùn". Lưu trữ tại thư viện Viện TN&MTB.

27. Phạm Đình Trọng, 1999. Kết quả điều tra nhanh tài nguyên biển và tiềm năng bảo tồn, đề xuất cơ sở khoa học xây dựng khu bảo tồn biển đảo Ba Mùn. Báo cáo khoa học lưu trữ tại Viện Tài nguyên và Môi trường biển, 97tr.

28. Phân viện Hải Dương học tại Hải Phòng, 1998. Nghiên cứu lập kế hoạch quản lý môi trường vịnh Hạ Long, Việt Nam. Báo cáo kết quả khảo sát. Phần V, Các chỉ thị sinh học. Lưu trữ tại thư viện Viện TN&MTB.

29. Quang Ninh MARD, (2021) Draft Synthesis Report – Quang Ninh Water Security Program.

30. Quang Ninh DONRE, 2014 Environmental Master Planning of Quang Ninh Province (and Ha Long Bay) up to 2020, vision 2030.

31. Quang Ninh DONRE, 2015, Report on the status of the environment in Quang Ninh province for the period 2011–2015.

32. Quang Ninh DONRE 2016, Narrative Report – Water Resources Master Planning of Quang Ninh Province to 2020, vision 2030.

33. Quang Ninh DONRE 2018, Environmental Monitoring Report.

34. Quang Ninh DONRE (2020) Report on the status of the environment in Quang Ninh province for the period 2016–2020.

35. Quang Ninh DONRE (2021), Draft Narrative Report – Assessment of Carrying Capacity of Terrestrial Water Bodies (Rivers and Lakes)

36. Status and degradation of coral ecosystem of Vietnam. Report of the KC.09.27/06–10 program 2009)

37. UNEP, 2008. National Reports on Seagrass in the South China Sea – Vietnam. UNEP/GEF/SCS Technical Publication, No.12, 32 p.

38. The World Bank, 2013, Performance of the Wastewater Sector in Urban Areas: A Review and Recommendations for Improvement – Vietnam Urban Wastewater Review.

39. WWF Vietnam Marine Conservation Northern Survey Team, 1994. Survey report on the Biodiversity, Resource Utilization and Conservation Potention of Co to Island, Quanh Ninh, North Viet Nam. P. 1 – 74.

40. Wastewater discharge permits data in Quang Ninh province (2009–2020), issued by Quang Ninh PPCs and the Ministry of Natural Resource and Environment (MONRE).