

ОЦЕНКА ЭКОСИСТЕМНЫХ УСЛУГ ВОДНО-БОЛОТНЫХ УГОДИЙ В ПРОВИНЦИИ КУАНГНИНЬ, ВЬЕТНАМ

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Аннотация

Водно-болотные угодья содержат различные прямые и косвенные выгоды для благополучия людей во всем мире. Однако урбанизация и изменения климата отрицательно сказываются на биоразнообразии и пользе, получаемой от водно-болотных угодий, особенно во Вьетнаме. Экономическая оценка стала потенциальной информацией, позволяющей сбалансировать экономическое развитие и прибыль с целями охраны природы. Целью данного исследования является оценка значений 11 видов прибыли, получаемой на девяти водно-болотных угодьях в провинции Куангнинь, Вьетнам, на основе как высокотехнологичных, так и традиционных методов. Показано, что водно-болотные угодья в Куангнине приносят более 339 миллионов долларов США дохода в год, а на острове Ван Дон – более 83 миллионов долларов США в год. Отдых и туризм принесли более 128 миллионов долларов США от водно-болотных угодий. Следующим является аквакультура с 70 миллионами долларов США. Охрана этих ценностей должна совершенствоваться, чтобы исследованные субрегионы и в будущем оставались природным наследием или заповедными территориями.

Ключевые слова: экономическая оценка, доход, прибыль, экосистема, прибрежные водно-болотные угодья.

EVALUATING WETLAND ECOSYSTEM SERVICES IN QUANG NINH PROVINCE OF VIETNAM

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Abstract. Wetland ecosystems provide various direct and indirect benefits for human well-being on the global scale. However, urbanization and climate changes have affected the biodiversity and benefits obtained from wetland ecosystems negatively, particularly in Vietnam. The economic evaluation provides valuable information to balance the benefits obtained from economic development and natural conservation. The aim of this study is to evaluate the economic values of 11 benefit types obtained from eight wetland ecosystems in Quang Ninh province, Vietnam based on remote-sensing, GIS and interview methods. As a result, the wetland in Quang Ninh provides more than 339 million USD annually, especially in Van Don Island with more than 83 million USD per year. The recreation and tourism have used more than 128 million USD from the wetland ecosystems. Next one is the aquaculture with 70 million USD. The values for conservation need to be improved if sub-regions in the research area become a natural heritage or global natural reserve in the future.

Keywords: *economic evaluation, benefit, ecosystem, coastal wetland.*

INTRODUCTION

Wetland Ecosystems Services (WES) are estimated to be worth \$47.4 trillion per year, representing 43.5% of the total monetary value of all-natural biomes in the world [38,42]. This ecosystem has high biological productivity, both bringing great economic benefits, preventing natural disasters for coastal communities, and especially valuable for cleaning the environment and balancing the ecology [59],[2],[7],[25],[41],[65]. But according to the Convention Secretariat of the Convention on Wetlands (Ramsar), sea level rise, severe storms, and human activities decreased the area of the world's wetlands by approximately 35% between 1970 and 2015, including 34% of mangroves, 30% of seagrass beds, and 31% of coral reefs [46]. The WES value has been reduced about 9.9 trillion dollars per year between 1997 and 2011, equal to approximately 1.4 times China's 2011 GDP [32], [43]. As a consequence, it is highlighted that destroying wetlands would lead to significant financial harm [4], [29], [34], [51],[54]. Human effects on coastal WES values are poorly understood, particularly in developing areas where wetland changes are accelerating as a result of rapid urbanization and industrialization of the local communities[21], [27]. Therefore, the evaluation of WES value has become an important task in assessing the effects of new land-use planning to natural conservation and economic development [14], [18], [47], [50], [52], [53].

Many coastal wetland assessment projects have been implemented around the world [4], [10], [60], [64]. In Australia, there is an overview of wetland monitoring and evaluation programs which includes some comparisons with similar programs in other parts of the world [11], [48]. And in United States, a guidebook describing 40 wetland assessment methods had been developed [24], [28], [57], [62]. All methods have been developed for various purposes, including qualitative and quantitative assessment of habitats, performing impact assessments, determining wetland function, assessing wetland function [20], [22], [33], [37], [47], [63] to community planning, education and inventory, and choosing the integrity of watersheds and wetland ecosystems [12], [16], [17], [35], [49], [54]. Besides the legal instruments, economic tools are also used effectively to manage natural resources and the environment [19], [23], [26], [44]. However, these studies do not provide a suitable method to accurately estimate the cost and benefits of ecosystems to local people. Furthermore, due to rapid population growth, strong economic development during the opening period, along with poor management or inadequate protection of some localities, wetland ecosystems have been degraded strongly [39], [58], [61].

In Vietnam, Quang Ninh coast is one of the largest wetland areas of the Northeast coastal region with a diverse and rich mangrove ecosystem, especially with the World Natural Heritage of Ha Long Bay [8], [31], [40], [55]. This area is also a favorable environment for aquatic species to live and develop [30]. Moreover, there are many wetlands being proposed for conservation by Ramsar. Nonetheless, there was a period when their mangroves was reduced in both area and quality because of the expansion of aquaculture and other development activities [9], [30]. Until now, the management and conservation has not really been completed [13], [56]. In addition, in the future Dong Rui Wetland in the Wetland of Quang Ninh coastal area can become a Ramsar site of the world [3], [15], [45]. Therefore, the aim of this study is to evaluate the wetland ecosystem services in Quang Ninh in order to protect, exploit and use sustainably the natural resources. Once the benefits obtained from the wetland ecosystems are evaluated, different scenarios are generated to orientate the economic and sustainable development.

STUDY AREA

The selected study area is the wetland of Quang Ninh province, which has an important geographical position in socio-economic development. Quang Ninh is topographically characterized by forests, long coastlines, high mountains and islands, which could be divided into 11 types, including eight types of wetlands, one none flooded type with an altitude over 2.5m and one type below the 6 m depth. The eight wetland types could be subdivided into two groups: coastal wetlands (five types) and artificial wetlands (three types) (Figure 1).

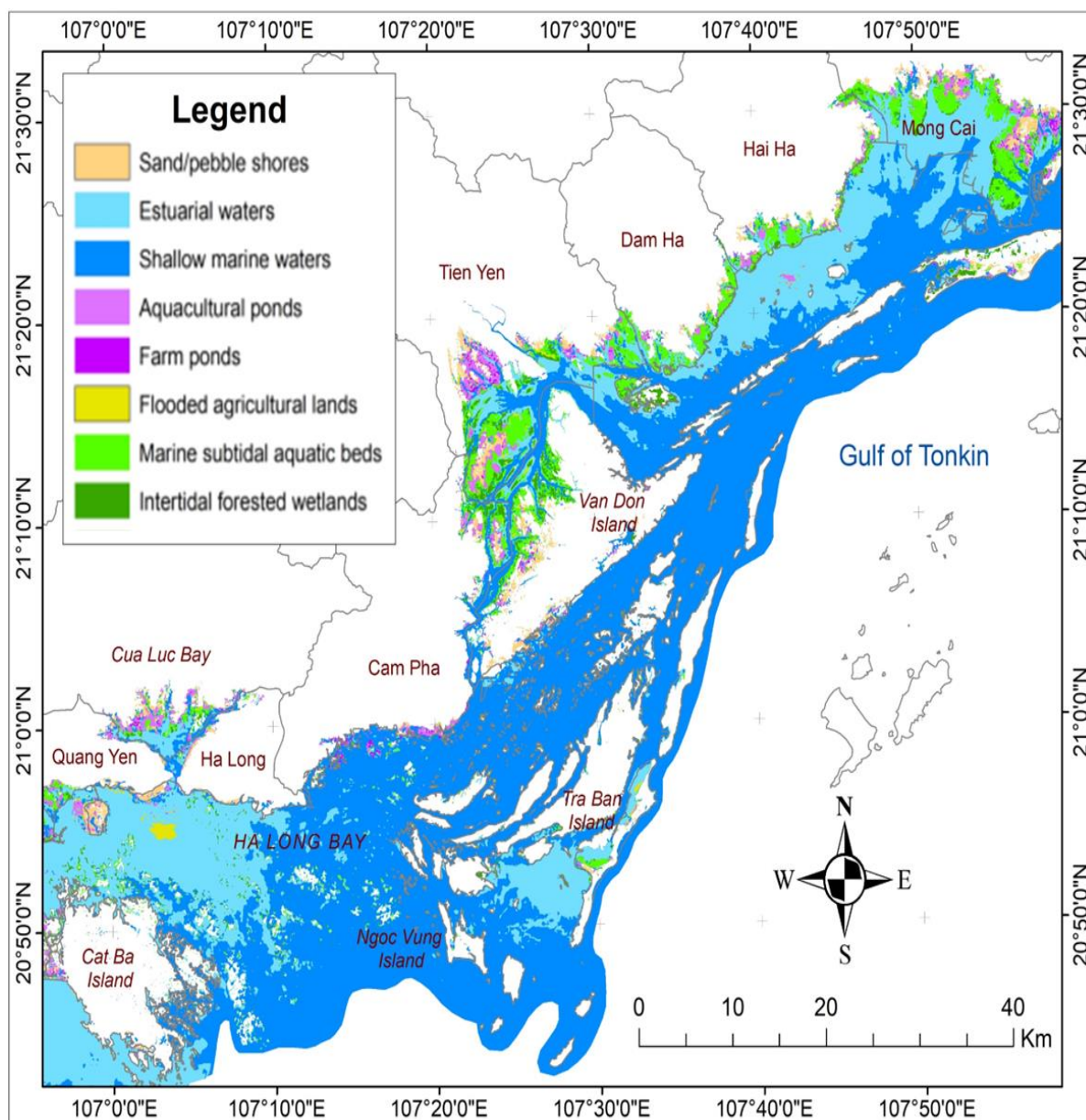


Figure 1. Distribution of wetland ecosystems in Quang Ninh province [12]

The Decision No. 34/2009/QD-TTg dated March 2, 2009 on the development planning of the coastal economic belt in the Gulf of Tonkin emphasized the important of developing this belts into regional dynamic economy entire Northern region and in improvement of cooperation in China and ASEAN countries. This shows that the wetland ecosystem in the Quang Ninh area

plays an important role not only for local people, but also for many related regional and international issues.

METHODS

By expert methods, secondary document researches and field interviews with 320 households conducted in September 2020, prominent, specific and important groups of ecosystem services values in the study area were identified and estimated. The interviewees are ecologists, geographers and environmental economists, managers in District and Commune People's Committee and local habitants whose livelihoods directly depend on wetland resources.

In this study, the important eco-service values of wetland ecosystems are identified and quantitatively estimated, such as: value of aquatic products (X_1), aquaculture (X_2), waterfowl (X_3), wet rice cultivation (X_4), beekeeping (X_5), tourism (X_6), natural disaster protection (Y_2), carbon storage (Y_3), option values (Y_4), existence value (Z_1), and bequest value (Z_2).

Method estimating the use values

Estimating the direct use values

The overall direct valuation process is carried out through the following 4 steps:

Conduct a survey to obtain data on the output of products that provide direct resources such as seafood, rice fields, bees, firewood and waterfowl of one household/area on average in one year, average cost of equipment investment in one year and total number of people or total exploited area. The output and investment costs of each species are calculated according to the median value of the collected data;

Determine the average revenue for that product by collecting data and local market prices;

Estimate the total revenue in one year and the total cost in one year;

Valuate the ecotourism of the product type.

The product type is valued by the different formulas

a. For the wild fishing, based on the cost-benefit of Boardman et al. (2018) [5] and the characteristics of study area, the value of ecosystem services of wild-caught fishery products in the entire estuary, tidal flats and mangroves in the coastal wetlands of Quang Ninh in one year (USD) is calculated as follows:

$$X_1 = \{H \times n_i \times ((q_i \times m_i + p_i \times k_i) - C_i)\} / 1000$$

Where i is the ordinal number of caught aquatic species;

H is the total number of people fishing in the wild of a district;

n_i is the percentage of exploiters of species i (%);

q_i is the catch volume of species i per person in the season (kg/person/year);

p_i is the catch volume of species i per person in off-season (kg/person/year);

m_i is the price of 1 kg of species i in the season (USD);

k_i is the price of 1 kg of non-seasonal species i (USD);

C_i is the investment cost for catching species i in one year (USD)

b. The value of ecosystem services of aquaculture (X_2) in the entire bay and tidal flat area of Quang Ninh coastal wetland in one year (USD/district) is calculated by following formula:

$$X_2 = (S \times n_i \times (NS_i \times P_i - C_i))/1000$$

Where i is the ordinal number of waterfowl species;

S is the aquaculture area of the whole area (ha);

n_i is the percentage area of species i (%);

NS_i is the yield of species i in 1 ha/year (kg/ha);

P_i is the market price of 1kg of species i (USD);

C_i is the cost of aquaculture investment of species i in 1 year (USD);

c. The Value of ecosystem services of Waterfowl (X_3) raising in 1 year in Quang Ninh coastal wetlands (million VND) is calculated as follows:

$$X_3 = (T \times n_i \times (W_i \times P_i - C_i))/1000$$

Where: i is the ordinal number of waterfowl species raised;

T is the total number of waterfowl of the whole area/district (bird);

n_i is the percentage of species i (%);

W_i is the meat weight of one individual in species i (kg);

P_i is the market price of 1kg of meat of species i (USD);

C_i is the investment cost of raising waterfowl of species i in 1 year (USD).

d. Value of ecosystem services for wet-rice farming in one year in Quang Ninh coastal wetlands (USD) is calculated as follows:

$$X_4 = S \times (NS \times P - C)$$

Where S is the total area of wet rice cultivation of the whole region/district in 1 year (ha);

NS is the yield of rice obtained on 1ha in 1 year (quintal);

P is the market price of 1 quintal of rice (USD);

C is the investment cost of 1 hectare in 1 year (USD).

e. Value of Beekeeping (X_5) for honey in one year in Quang Ninh coastal wetland (USD) is calculated as follows:

$$X_5 = T \times (SL \times P - C)$$

Where T is the total number of bee colonies of the whole area/district in one year (swarm);

SL is the honey production of one bee colony in one year (liter);

P is the market price of 1 liter of honey (USD);

C is the investment cost of beekeeping of 1 colony in one year (USD).

f. The tourism value is calculated by the integration of statistical values and GIS evaluation results on the InVEST tool. To quantify the value of tourism and recreation in specific sub-regions, the models of “recreation and tourism” and “Ecosystem quality” in the InVEST tool were integrated [7], [25]. The “Recreation and Tourism” model provides the level of recreation

and tourism for indigenous peoples and tourists based on how often photographs taken in the study area are uploaded to the internet and their accessibility to tourist attractions. It is assumed that a higher number of uploaded photos may represent higher visitor attention. In addition, the “scenic quality” model provides locations that can be observed by tourists [46]. This could be an upland or coastal area, however, only wetland data are collected. The output of the “leisure and tourism” model is the input of the “landscape quality” model. The maximum radius from the place where the photo was taken is 8km. The value of tourism (X_6) and entertainment is calculated as follows:

$$X_6 = \frac{GTDV}{\sum_{i=1}^n (L_i \cdot A_i)} X_6 = \frac{GTDV}{\sum_{i=1}^n (L_i \cdot A_i)}$$

In which, GTDV is the total value of tourism and resort collected from interviews and statistics, L_i and A_i are attractive values, and the area of wetland ecosystems is attractive at "i".

Estimating the indirect use values

a. Investments in marine transportation, environmental protection, disaster prevention

There are investment projects on water transport to prevent flooding and planting mangroves along the coastal strips to prevent storms from causing coastal erosion. Coastal protection and disaster prevention in Quang Ninh are very concerning. In addition, coastal protection and disaster prevention projects in the coastal districts of Quang Ninh are covered. Investment capital sources are from district, provincial and government budgets. All investment values of these projects are aggregated and divided equally by the number of years of construction and use, in order to give the average value of these works in 1 year.

b. Carbon Accumulation Value

Carbon sequestration values in wetland ecosystems are referenced from previous studies. In particular, Murray and Pendleton (2011) and Li et al. (2010) provided a useful assessment of the carbon sequestration of different wetland ecosystems in different countries, such as seabed aquatic beds and aquaculture ponds [6], [32]. The value of carbon accumulation (Y_3) is calculated according to the following formula:

$$Y_3 = (S_{CO_2} \times k) \times SHST.$$

In which, S_{CO_2} is the amount of CO₂ absorbed;

k is the cost to generate 1 ton CO₂ ($k = 11$ USD/ton CO₂),

SHST is the area of each ecosystem unit (ha).

Estimating the option value

Information in surveys is about the value of choice, or the value that people contribute to conserve, restore and develop the resources of the wetland ecosystem in order to maintain them to serve the needs of people living in the coastal strip of Quang Ninh. The Present Value of the District/region (Y_4) is calculated using the following formula:

$$Y_4 = M_i \times H/1000.$$

In which: i is the payment level for the option values (USD);

M_i is the average value of a current fund-payer at payment level i (USD);

H is the total population of a district (person).

Estimating the non-use values

Bequest value

The bequest value contributed by the people/government is used to conserve, restore and develop the resources of the wetland ecosystem in order to maintain them to serve the needs of future generations living there. In consequence, from the investigated questionnaire form, the Bequest Value of the District/region (BDV) could be estimated as follows:

$$Z_1 = M_i \times H / 1000.$$

In which: i is the payment level for the bequest values (USD);

M_i is the average value that a person contribute to future fund at payment level i (USD);

H is the total population of a district (person).

The Y_4 and Z_1 are difficult to estimate. This level of payment is aimed at maintaining and developing the ecosystem, serving the needs of current use (for Y_4) and future use (for Z_1).

Existence value (Z_2)

Existence value is estimated from the data on investment projects with the purpose of conserving natural resources of districts in recent years. The measure is often determined based on the aids of national and international conservation organizations. Environmental protection work in Quang Ninh is also very concerned by agencies and departments. Investment capital is aggregated from the district, provincial and central budgets, domestic and foreign units and organizations. It is also taken into account of ODA funds from the Support Program to Respond to Climate Change (SP-RCC), the city budget, the Program on Forest Protection and Development in the period 2011 - 2020, climate change program, capital of World Bank and enterprises. All of these investment capitals are converted to cash flows of the projects to the time of calculation. The average annual total investment capital for the coastal districts of Quang Ninh is determined from these calculations.

Estimating the total value

The total value of the wetland ecosystem is a sum of the direct and indirect use values, the option value and the unused values. The direct use value is totalized from $X_1, X_2, X_3, X_4, X_5, X_6$. The indirect use value is the sum of the value of carbon accumulation, and the value of coastal protection and disaster prevention. Use value is the sum of direct use value, indirect use value and option value. The unused value is a sum of the bequest and the existence values. The above values will be calculated for each district and aggregated for the entire province, thereby calculating the total use value for the entire province of Quang Ninh.

Total Ecosystem Service Valuation (ESV)

The assessment of the entire wetland ecosystem includes direct use value, indirect value, optional value and non-use value. Accordingly, the total value of ecosystem services was calculated by the following formula:

$$ESV = \sum_{n=1}^6 X_n + \sum_{m=1}^3 Y_m + \sum_{i=1}^2 Z_i$$

ESV values are calculated for seven economic regions in the Northeast Vietnam region, as well as for the entire region. Based on the total value and area of each ecosystem in the whole region, the ESV value of each ecosystem was calculated per hectare. After combining with the map of ecosystem distribution of the years 2000, 2005, 2010, 2015 and 2020 and the statistics of the province, the change of the total value of WES over the past 20 years in the Northeast Vietnam region was assessed by multiplying the ESV value of each ecosystem by their area each year (Table 1).

Table 1. Scenarios of land use change in wetlands area in Quang Ninh province, Vietnam until 2030

Land use/cover	Economic scenario	Sustainable scenario	Planning scenario
Agricultural lands	Increased 1.5 times	Decreased half times	Decreased to 29,000ha
Mangrove	Decreased half times	Increased two times	Increased to 34,000ha
Aquacultural lands	Increased two times	Decreased half times	Increased to 33,700ha

In addition, 3 land- use- change scenarios were proposed to predict the trends of WES value change over the next 10 years in the study area (Table 1). The “Economic scenario” focuses on expanding the area of land for aquaculture and agriculture, while the area of mangroves decreases significantly. Meanwhile, “Sustainable scenario” focuses on expanding mangrove area and reducing area for aquaculture. Finally, the “Planning scenario”, proposed by decision 1588/QĐ-UBND [1] of the province, is expected to change the coverage area by 2030 to meet economic needs and protect the environment.

RESULTS

Component values of ecosystem services

Direct use value

Currently, in the coastal districts of Quang Ninh, the fishery species caught by people are mainly in the estuaries, tidal flats and mangroves (Table 2, Table 3). Mangroves in Quang Ninh have many species of trees, reflecting the diversity of salinity and benthic material in each place and also the distribution of aquatic species. The aquatic species in the mangrove forest in Quang Ninh are quite abundant. Ecological service value of wild-caught aquatic products in the entire estuary, tidal flats and mangroves in the coastal wetlands of Quang Ninh: 61.38 million USD. In which, Van Don and Quang Yen districts provide highest value in wild fishing with about 20 million USD. Due to special industrial economic in Cam Pha district, this region does not focus on wild fishing. Although the coastline from Mong Cai to Dam Ha district is about 70km, the value of wild fishing only reaches more than 12 million USD.

Table 2. Value of wild fishing in 1 year in Quang Ninh coastal wetlands (Unit: million USD)

District	Number of exploiters (person)	Average production of one species (ton)	Revenue	Investment Cost	Value
Mong Cai, Hai Ha,	4,749	3,752	14.37	2.06	12.31

Dam Ha					
Cam Pha city	200	161	0.16	0.09	0.07
Van Don	5,180	5,260	22.8	2.25	20.55
Tien Yen	3,445	2,722	10.43	1.49	8.93
Quang Yen town	6,840	23,772	78.2	58.68	19.52
Entire Region	20,414	35,669	125.95	64,57	61.38

Table 3. Value of aquaculture in Quang Ninh coastal wetlands (Unit: million USD)

District	Area (Ha)	Yield in 1 year (ton)	Aquaculture Revenue in 1 year	Aquaculture cost in 1 year	Aquaculture Value
Mong Cai, Hai Ha, Dam Ha	5,455	11,896	54.01	30.35	23.66
Cam Pha City	221	771	3.32	1.68	1.64
Cua Luc	890	3,102	13.36	6.75	6.61
Van Don	3,300	17,252	71.9	44.83	27.07
Tien Yen	1,432	416	3.62	0.84	2.78
Quang Yen town	7,532	6,176	15.77	6.94	8.84
Entire Region		39,616	161.99	91.39	70.6

In Quang Ninh, aquaculture is mainly in ponds, on tidal flats, in estuaries and in mangroves. Currently, there are two popular farming occupations: improved extensive farming and industrial farming, in which shrimp, crab, fish and mollusks are raised. Ecosystem services value of aquaculture in 1 year in Quang Ninh coastal wetland is 70.6 million USD. The production of clam farming in Quang Ninh province is over 31,500 tons per year, the average yield is over 7.5 tons/ha, accounting for nearly 23% of the province's total aquatic production in 2019. In addition, sea crabs released by farmers along with shrimp ponds have also brought high economic benefits to the locality. In six researched areas, the districts from Mong Cai to Dam Ha provide more than 23 million USD. Although this value is lower than its in Van Don district (with more than 27 million USD), it shows that the main livelihoods of local household in Mong Cai to Dam Ha is aquacultural production.

For waterfowl farming, people in the coastal areas of Quang Ninh have taken advantage of the resources of mollusks, plankton, shrimp and fish in mangroves, tidal flats and estuaries to raise

waterfowl and have achieved high production. Value of ecosystem services of waterfowl is estimated of 1,761.1 thousand USD/ year. Over the last 4 years, eggs and meat of the Quang Ninh sea duck started to come into markets of northern Vietnam. This duck breed is raised in saltwater or brackish water and often eats shrimps.

For agricultural cultivation, the value of ecosystem services in 1 year in the coastal wetland area of Quang Ninh: 41,565.5 thousand USD. Agricultural cultivation also brings great value to the wetlands in the northeastern coastal area, including the coastal districts of Quang Ninh. In the study area, people mainly cultivate wet rice, so this study focuses on measuring the value of wet rice cultivation in 1 year.

In line with the development and protection of the mangrove system, people in the coastal districts of Quang Ninh have taken advantage of the flower season to exploit honey by developing beekeeping in mangroves. In summer time, when the forest *Sonneratia*, *Aegiceras corniculatum* *Bruguiera* bloom, people often bring out the beehives for ideal growth. Annually, a colony of bees can provide households 15-20 liters of natural honey on average. With an average price of 4,3 USD /liter according to direct interview data, the income from selling honey is about 4.313,1 – 6.469,7 USD /year. In addition, beekeepers also have income from selling bee seeds for 43,1 USD per colony. Value of ecosystem services from beekeeping in 1 year in Quang Ninh coastal wetlands: 262 thousand USD (Table 4).

Table 4. Value of beekeeping for honey in 1 year of Quang Ninh coastal districts

(Unit: thousand USD)

District	Number of swarms	Yield (litre)	Revenue	Cost	Bee production
Cua Luc	1.000	7.333,3	96	30	66
Van Don	210	420,0	5	2	3
Tien Yen	1.000	2.000,0	22	9	13
Quang Yen	4.500	6.750,0	220	39	181
Entire region	6.710,0	16.503,3	342	80	262

For the tourism industry, this activity in the coastal districts of Quang Ninh province has brought a huge annual revenue to the local budget and increased income for the people. In the study area, the calculation of cultural services and natural recreational value is based on the entrance fee and revenue of the local ecotourism industry. The potential costs of tourists, residents and other stakeholders in this sector include: entrance fees to tourist attractions, environmental protection fees, marine litter collection fees, and fees for other services. Accordingly, the tourism value from the ecosystem of Quang Ninh coastal wetland is 28,769.6 thousand USD.

Indirect use value

The two analyzed indirect use values include the value of protection/prevention and reduction of natural hazards and the value of carbon accumulation. After integrating with Carbon value data and ecosystem distribution map of Quang Ninh area, the total value of carbon accumulation in the study area is 15,651.8 thousand USD. The value of coastal protection and disaster prevention in the study area is 4,382 thousand USD. According to the survey results from the

District and Commune People's Committee, because the sea dyke here is located entirely inside the mangrove area, it is protected by this system. The dyke is the boundary between multiple types of ecosystems: agricultural ecosystems, rural populations, mangroves and shallow water areas. Therefore, the protection value for the sea dyke is the value of the mangrove ecosystems located outside the dyke. The sea dyke is less vulnerable to wind or storm surges, all resources inside the dyke are protected, and people's lives are guaranteed. Therefore, it can be said that mangroves have great protection value.

Option and bequest value

At the time of interview, the option value of wetland ecosystems in Quang Ninh was 3.7million USD (Table 5). Meanwhile, the calculated bequest value for wetland ecosystems in Quang Ninh is 3.6 million USD. Accordingly, the highest investment of managers and local households for both optional and bequest values was found in Quang Yen district (1.1 million USD/year), while the lowest one was found in Van Don district (0.15 million USD/year). More than 30% of local households would like to send about 10 USD for both values, although more than 60% of them would not like to spend money for these budgets.

Table 5. *Option and bequest value of people's contributions to the fund for conservation, restoration and development of wetland resources in order to maintain them for current and future use needs*

District	Population (person)	Option value (Million USD)	Bequest value (Million USD)
Mong Cai, Hai Ha, Dam Ha	212.500	0.6	0.68
Cam Pha city	191.400	0.74	0.63
Cua Luc	272.700	1.05	0.89
Van Don	46.600	0.13	0.15
Tien Yen	50.600	0.14	0.16
Quang Yen	146.000	1.11	1.1
Entire region		3.78	3.6

Existence value

The embankment, dams, dikes, culverts, canals, ditches, and harbors are type-2 works with a used time of 20 years with a wear rate of 5% /1 year. Other structures such as irrigation ponds have a used time of 10 years with a wear rate of 10%. Quang Ninh has a large mangrove forest area (over 23,000 hectares), distributed mainly in localities such as Mong Cai, Tien Yen, Quang Yen, and Van Don. The natural mangrove forest of Quang Ninh coast has a high density of 5,000-9,000 trees/ha, with an average canopy diameter from 1-2m and average height from 1-

2m. Many environmental protection investment projects in coastal districts are invested from investment capital sources: district, provincial and central budgets, and private and international organizations such as ODA capital of the program to respond to climate change, World Bank capital. With investment projects in mangrove development, dyke protection and environmental improvement, the existence value of the study area is 7.6 million USD.

Total Value of ecosystem services in Quang Ninh coastal wetlands

After summing up all the above calculations, the total value of ecosystem services in Quang Ninh Wetlands is calculated at about 339,398 thousand USD (Table 6). Based on the data, the value of ecosystem services in Van Don district is the largest with a total value of 83,399 thousand USD /year. However, its value per hectare of area ranks fourth after Quang Yen, Cua Luc Bay, Cam Pha. Although Quang Yen town is only ranked 4th in terms of total value of ecosystem services with 57,833 thousand USD /year, the value per hectare of this area is highest, 1.9 thousand USD /year. This is partly because the large area of ecosystems in Van Don district is mainly water surface for aquaculture and fishing.

Table 6. Total value of ecosystem services of wetland ecosystem in districts and regions of the Quang Ninh coastal areas in 1 year (Unit: thousand VND/year)

Value	Total value	District					
		<i>Mong Cai – Dam ha</i>	<i>Cam Pha</i>	<i>Cua Luc</i>	<i>Van Don</i>	<i>Tien Yen</i>	<i>Quang Yen</i>
I – Use Value	328,153.3	70,347.2	36,212.3	69,380.8	76,224.3	19,297.9	56,690.8
A - Direct Use Value	304,336.7	63,312.7	33,995.2	65,665.9	70,841.3	17,740.6	52,781
Fishing value	61,382.2	12,313	69.1	-	20,549.4	8,932	19,518.7
Aquaculture value	70,596.4	23,658.7	1,644	6,608.5	27,073	2,776.6	8,835.6
Waterfowl farming value	1,761.1	835	115.4	434.3	85.2	74.5	216.7
Wet rice farming value	41,565.5	18,345.2	3,471.1	2,297	2,261.3	5,944.5	9,246.3
Beekeeping value	262	-	-	65.2	2.7	13	181

Recreation and Tourism value	128,769.6	8,160.9	28,695.7	56,260.9	20,869.6	-	14,782.6
B - Indirect Use Value	20,033.8	6,429.7	1,479.1	2,663.4	5,250.3	1,413.2	2,798
Value of natural risk reduction	4,382	1,925.4	326.1	131	580.2	95.1	1,324.2
Value of carbon accumulation	15,651.8	4,504.3	1,153	2,532.4	4,670.1	1,318.2	1,473.8
C - Option Value	3,782.8	604.9	738	1,051.5	132.6	144	1,111.8
Option Value	3,782.8	604.9	738	1,051.5	132.6	144	1,111.8
II - Non-use Value	11,245.6	1,029.6	626.3	1,022.8	7,175.6	248.3	1,143.1
Bequest value	3,603.3	677.4	626.3	892.4	148.5	161.3	1,097.3
Existence value	7,642.3	352.2	-	130.4	7,027	87	45.8
Total Value of Ecosystem Services	339,398.9	71,376.8	36,838.7	70,403.6	83,399.8	19,546.1	57,833.9
Area of Ecosystems (ha)	320.203,3	99.172,9	25.636,6	48.672,9	92.653,9	23.318,4	30.748,5
Total Value of Ecosystem Services per Ha by administrative unit	1.1	0.7	1.4	1.4	0.9	0.8	1.9

Scenarios in ecosystem re-allocation options

Based on the land use/cover maps from the years 2000 to 2020 and the average use value from each wetland ecosystem, the fluctuation of use value over 20 years is represented and predicted (Figure 2). The degradation of the use value is a result of the conversion from traditional agricultural and aquacultural production to intensive and sustainable ones. In general, the total use value in the Quang Ninh province, Vietnam have decreased since 2005 till now, although the economic values of some manufacturing industries were significantly increased. Accordingly, the area of agricultural ecosystems significantly reduced, leading to the decrease

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of their economic benefits from 73 to 59 million USD. The area of intertidal forested wetlands reduced slightly from the year 2000 to 2010, but recovered till 2020, therefore their values have been remained at more than 19 million USD. In contrast to the reduction of use values in marine subtidal aquatic beds, sand/pebble shores, and estuarine waters, the use value from aquaculture ecosystems increased more than twice from the year 2000 to 2020.

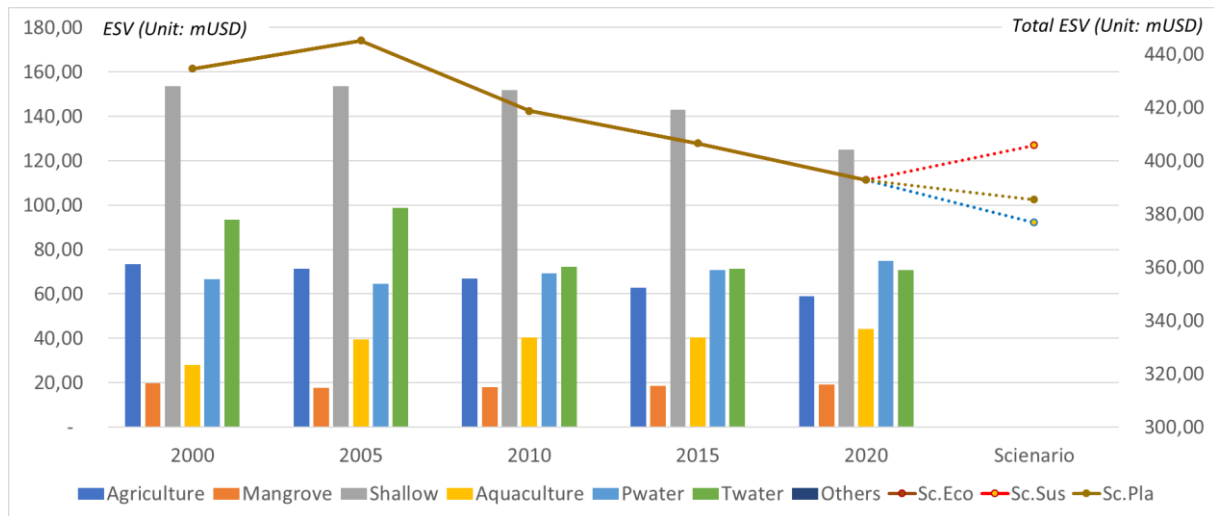


Figure 2. Changes of use values obtained from wetland ecosystems over 20 years and prediction in three scenarios till 2030 in Quang Ninh province, Vietnam.

DISCUSSION

The value of resources in the coastal wetland ecosystem of Quang Ninh has continuously changed over the past 20 years. In this study, the assessment of direct values such as aquaculture, marine resources, medicinal herbs, and tourism is added and updated more than in previous studies. For example, the wetland area in Tien Yen district brings in 0.8 thousand USD/ha/year (Table 6); this value is higher than the previous study by Mai et al. (2003) [36] with the value 0.75 thousand USD/ha/year. However, the last evaluation results have been inconsistent, especially without considering optional, existential, and transmission values. This makes information integration difficult. The results of this study suggest that the benefits from wetlands to local people could be even greater. For accurate calculations, previous studies need to inherit studies to get better products. In addition, the valuation method helps to assess the potential of the ecosystem more not only comprehensively but also accurately reflects the values of ecosystem services that the Quang Ninh people have from the wetlands. Therefore, this study has taken the lead in synthesizing 11 types of wetland biodiversity values for the coastal strip of Quang Ninh. On that basis, this method can be applied entirely to wetlands in all coastal areas of Vietnam in the future.

Research results show that 100% of interviewees are aware of the benefits and value of wetlands for their livelihoods. In Quang Ninh province, agriculture is not the main economic sector (accounting for only 5% of the province's economic structure), but this industry plays a decisive role in the lives and socio-economic conditions of the local people. 70% of interviewed households need to use rice land for daily living. However, agricultural activities in wet rice tend to decrease gradually due to low economic efficiency. This is reasonable when the product quality is not high; the livelihood transformation will help people stabilize their lives in the

future. Instead, people are gradually transforming the crop structure from wet rice land to a model of growing fruit trees and growing organic vegetables. In addition, the raising of waterfowl in some districts has also received more attention, especially commercial sea duck farming because it provides a great source of income for the people and also provides meat for the Northern provinces of Vietnam.

Situated in the North of Vietnam, Quang Ninh Wetland is one of the four major fishing grounds, with great value in terms of reserves and species diversity. Fisheries caught in coastal wetlands include shrimp, fish, crab, and mollusks such as mussels, clams, and oysters. In particular, the Van Don district is invested by managers and creates favorable conditions for mollusks and is currently planned to become the largest mollusk farming area in Quang Ninh province. Nonetheless, the current aquaculture and near / far fishing activities have caused severe pollution of the water source. A reasonable solution to fishing in the current area is to limit the time and place of fishing. Therefore, resources from the sea will be guaranteed and maintained for a long time. People need to be aware of limited coastal resources. As a result, the government's allowable catch is now aiming for a lower target of 18,000 tons/year instead of 30,000 tons/year to ensure long-term benefits for the people and protect the area's biodiversity. Beekeeping and extensive fishing in the mangrove ecosystem is a new livelihood that helps local habitants have a high economic income. This economy forms large beekeeping cooperatives in coastal communes/districts. People in the coastal provinces of Quang Ninh not only plant and protect the mangrove system but also take advantage of the canola flower season to exploit honey, creating favorable conditions for developing mangrove beekeeping. Importantly, beekeepers are very conscious of protecting mangroves for long-term economic efficiency and a stable and sustainable living environment. This makes beekeepers both economic exploiters and forest rangers. Each year, a colony of bees can bring each household 15-20 liters of natural honey. With an average price of 5 USD/liter, income from selling honey is about 5,000 - 7,000 USD/year, not including income from selling bees for 50 USD/swarm. Currently, beekeeping requires strict implementation methods and procedures planned according to cooperatives. If this principle is ensured, people can completely focus on beekeeping. With the size of mangroves not increasing much, beekeeping will be limited, such as the number of households participating in this field. This requires more detailed studies to clarify the area's future bee industry development load.

CONCLUSION

The benefits derived from the eight wetland ecosystems were clearly assessed based on the integration of various valuation methods. Local people in the study area received the greatest value from the undersea and sandy shore ecosystems. Aquaculture ecosystems yield the highest value per hectare, while shallow water areas have the lowest value. Wetland ecosystems in Quang Ninh are worth more than 340 million USD a year from 11 WES types. This value has dropped by about 15 percentage points since the year 2000, and it has the potential to drop by an additional three percentage points by the year 2030 if the planning of the local management is carried out. In order to avoid this degradation of ESV in the future, it is necessary for the economic growth in the area of research to require the gains of the indirect use values, particularly in the marine subtidal aquatic bed, estuarine, and intertidal forested wetland ecosystems, in the direction of achieving a balance between environmental conservation and the development of the economy. Both the methodologies and the findings of this study have

the potential to be used in the future for research pertaining to additional wetland regions in Vietnam as well as in other nations.

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