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Monetary Value Evaluation of Linghe River Estuarine Wetland Ecosystem Service Function

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Abstract

In order to achieve sustainable use of Linghe estuarine wetland ecosystems resources, this article calculated and analysed the monetary value of service functions for Linghe river estuarine wetland. The wetland's monetary value of service functions equals to direct use value plus indirect use value and non-use value. Using method of map data visual interpretation and the classification of functional zones, we identified nine main functions of wetland ecosystem services, classified the wetland's functional zones. And the monetary value is calculated based on the functional zones with map data after visual interpretation. Conclusions can be made that the ecosystem service function's monetary value of Linghe river estuarine wetland is a large amount, increasingly awareness on scientific conservation and development of resources should be taken into account.
Keywords: wetland value; ecosystem service function; monetary value evaluation

1. Introduction

Ecosystem service function is the condition and process that the natural ecosystem and its species provided to maintain and meet the needs human life requirements. Besides providing materials for human-beings, it also created and maintained terrestrial life support system, formed the environmental conditions of human existence, supported human's survival and social development. Wetland benefit is reflected by the value of ecosystem service function of wetland ecosystem [1]. From the perspective of ecology and economics, wetland has special ecological functions and economic value, which brings people huge economic, ecological and social benefits. For the reason wetland ecosystem service function is non-material, it is often ignored, which leads to short-term development and utilization of the wetland ecological environment [2-3]. Therefore, in order to protect and develop the Linghe River Estuarine wetland resources reasonably, scientific evaluation of its ecological function's monetary value must be conducted, so that people can understand wetland area's economic value correctly and provide reliable scientific basis in the formulation of management policies.

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2. Data Sources

The geographical coordinates of Linghe River Estuarine wetland nature reserve is longitude 121° 00'~ 121° 30', latitude 40° 45'~ 41° 00'. The wetland is located in southern coast of Linghai city, Liaoning Province, northeast China, it can be classified as river wetland type nature reserve. It has a coastline of 69.3 km and total area of 838.66 hm^2. The average precipitation is 608.9 mm/a, average evaporation is 1972.6 mm/a, average sunshine hours is 2808.2 h/a. The study is based on TM image data of Linghe River Estuarine wetland nature reserve in 1988, 1995, 2000, 2005, 2006, 2007 and 2009. Basic classification information of the nature reserve was extracted with the application of visual interpretation method in ArcView3.3 platform [4-6]. For the reason that the data span is 7 years, the average value of the 7 year data is chosen as basic data to make it more consistent. Variations of wetland types and area information are showed in Table 1.

Table 1. Area of Various Wetland Types in Linghe River Estuarine Wetland

Type	1988	1995	2000	2005	2006	2007	2009	Average Area	proportion
Forest	51.62	49.66	43.66	47.85	48.12	48.22	42	47.3	0.056
Reed	58.12	58.26	64.23	59.87	58.79	65.37	60.34	60.71	0.072
River	12.48	11.08	15.88	14.88	9.08	7.15	13.14	11.96	0.014
Reservoir	1.15	0.71	1.48	0.81	0.64	0.9	0.8	0.927	0.001
Beach	53.94	52.77	57.13	32.93	43.38	46.06	53.03	48.46	0.058
Residential Area	194.72	201.87	219.17	218.21	223.65	220.7	211.19	212.8	0.254
Paddy Field	154.41	152.42	149.81	160.36	153.03	153.39	152.77	153.7	0.183
Dry Land	312.22	311.89	287.3	303.75	301.94	296.87	305.39	302.8	0.361
Total	838.66	838.66	838.66	838.66	838.66	838.66	838.66	838.66	1

3. Classification of ecosystem service function of Linghe River estuarine wetland

Costanza and other researchers divided the global ocean ecosystem into 16 categories and classified ecosystem service function into 16 categories, and evaluated the value of ecosystem service function based on the classification [7-8]. According to Constanza's study on global ecosystem service functions and its classification, we classified the ecosystem service function of the wetland, selected feasible evaluation method to conduct the study on monetization of ecosystem service functions. The ecosystem service function classification of Linghe River estuarine wetland is shown in Table 2.

Table 2.Ecosystem Service Function Classification and Evaluation Method of Linghe River Estuarine Wetland

Types of Value	Ecosystem Services	Ecosystem Functions	Evaluation Method
Direct use Value	Food Production	Conversion of solar energy into edible plants and animals	Market Value Method
	Science and education	Scientific and educational value	Specialist Evaluation Method
	Water supply	Filtering, retention and storage of fresh water	Shadow Project Cost Method

	Water regulation	Regulating runoff and river discharge	Shadow Project Cost Method
	Soil retention	Plants and soil biota in soil retention and formation	Market Value Method
	Disturbance regulation	Influence of ecosystem structure on dampening environmental disturbances	Specialist Evaluation Method
Indirect use Value	Climate regulation	Regulation of global temperature, precipitation and biol. Mediated processes on climate	Carbon Tax & Forestation Cost Method
	Waste treatment	Recovery of mobile nutrients and removal or breakdown of nutrients and compounds	Pollution Control Method
	Biological Control	Population control through trophic-dynamic relations	Ecological Value Method
Non-use Value	Public welfare	Including existence value (EV), heritage value (HV) and option value (OV)	Contingent Value Method

4. Monetary value evaluation of Linghe River Estuarine wetland's ecosystem service function

4.1 Direct use value

4.1.1 Value of food production

Calculated the value of rice using market value method, evaluate its monetary value with the formula [9-10]:

$$V = \sum Y_i P_i \qquad (1)$$

In the formula, V is the value of material goods, Y_i is production of material i, P_i is market price of material i. The area of rice field in this area is 13333 hm^2 in 2009, rice production achieved 9.75×10^3 kg per hm^2, the total output is 13×10^4 t per year, in accordance with current price of 4660 yuan/t per year, rice value is calculated as 6.06×10^8yuan. Take 45532.5 t as annual yield of dry reeds, with market price of 400 yuan/t, the annual reed output value is 0.18×10^8 yuan. The total output of fish and shrimp is 900 million kg each year, with average price of fish is 29 yuan/kg and 32 yuan/kg for the shrimp, calculated the total value of fish and shrimp production is 14.48×10^8 yuan. The total value of plant and animal production includes value of fishes, shrimp and birds, the calculation result is 20.72×10^8 yuan.

4.1.2 Value of science and education

The formula below is used to evaluate science and education value of the wetland

$$V_t = P \times S \qquad (2)$$

In the formula, V_t is science and education value of the wetland, *P* is research fund input into per unit area per year, *S* is total area of the wetland. Considered scientific and education value per unit area of China's wetland ecosystems is 382 yuan/hm^2, while culture function value of global wetland ecosystem is US$ 861/hm^2 according to Costanza's calculation. Considered the average value of the two data, the scientific and education value for per unit area of the wetland is calculated as 3635 yuan/hm^2. The average area of the wetland is 83866 hm^2/a, so calculated scientific and education value of Linghe river estuarine wetland as 3.05×10^8 yuan.

4.1.3 Value of water supply and regulation

Linghe River Estuarine wetland has vast and complex types of area, the article mainly selected marshes and paddy fields to evaluate its value [11-12]. The marsh area is 60.71 km^2 and paddy field area is 153.7 km^2. According to the study of Meng Xianmin, water storage capacity of marsh is 8100 m^3 per hm^2 (also used for paddy field), calculated the total water storage capacity of marsh and paddy field as 174 million m^3. Take project cost of flood storage in same volume as standard to estimate the value of water supply and regulation function. The formula is:

$$Q_t = V_t \times t \qquad (3)$$

Q_i indicates the value of flood storage, V_t indicates wetland water storage, t indicates annual cost of storage capacity for one m^3 per year. Considered annual cost of storage capacity per year is 5.714 yuan/m^3, calculated the value of water supply and regulation function with shadow project cost method as followed.

$$Q_t = V_t \times t = 1.74(\times 10^8 \text{m}^3) \times 5.714(\text{yuan} / \text{m}^3) = 9.94 \times 10^8 \text{ yuan}$$

4.1.4 Value of soil retention

The value of soil retention function is evaluated by calculation of the value of wetland capability on reduction of soil fertility loss [13]. This study selected element of nitrogen, phosphorus, potassium as the standard of calculation. These elements are easily soluble in water or separated from soil in exogenous process and cannot be recycled with the lost part of soil [14-15]. The value of wetland capability on reduction of soil fertility loss equals to loss of soil weight multiply nitrogen, phosphorus and potassium nutrient content in soil of unit weight, then multiply average price of fertilizer composited with nitrogen, phosphorus and potassium. The loss of soil weight equals to the amount of divergence in erosion of grassland multiplies area of the wetland, then multiply soil bulk density. The amount of divergence in erosion of grassland can be replaced by the average value of depth of erosion of grassland, which is 25mm annually. Considered Wetland area is 83866 hm^2, soil bulk density is 1.3g/cm^3, so the loss of soil weight is calculated as followed 27.26×10^6t. According to statistics of the Ministry of Agriculture, the average price of nitrogen, phosphorus and potassium is 366.67 yuan/t, then the annual value of wetland capability on reduction of soil fertility loss equals to 27.26×10^6 t × 0.027% × 366.67 yuan/t, which is 0.03×10^8 yuan.

4.1.5 Value of disturbance regulation

Wetland plants and the vegetation root matrix can prevent soil erosion, slowing water flow into the river, which achieved the result of weakening the flood impact to the embankment [16]. The wetland and its plants can also protect the beach from desertification and storm attack. Thus the environmental disturbances are dampened by the wetland. The value of wetland against storm and floods is US$ 9140 ~30,760/hm^2, the area of tidal flats is 4.85×10^3 hm^2 according to interpretation of available satellite images. Due to low frequency of storms and waves in the region, take the lowest value of 60596 yuan/hm^2 to conduct calculation. With the method of specialist evaluation, the value of disturbance regulation for Linghe estuarine wetland is calculated as 2.94×10^8 yuan.

4.2 Indirect use value

4.2.1 Value of climate regulation

Climate regulation function of wetland is mainly carbon fixation and oxygen emission, completed through photosynthesis and respiration. The equation of photosynthesis and respiration reaction is as followed [17-18].

$$6CO_2\ (264g) + 6\ H_2O \rightarrow C_6H_{12}O_6\ (108g) + 6\ O_2\ (193g) \rightarrow polysaccharide\ (162g) \qquad (4)$$

The major vegetation of Linghe estuarine wetland is reed, which has the area of 60.71km^2.The amount of photosynthesis and respiration reaction can be calculated by analysis of reed as a sample. According to Equation (4), where 1g plant be produced in the ecosystem, 1.63g CO_2 can be fixed, 1.20g O_2 be released. Considered annual reed production of Linghe estuarine Wetland is 45532.5t, calculated the amount of total annual carbon fixation is 7.42×10^{4}t and oxygen emission is 5.46×10^{4}t. Considered the cost of forestation in China is 260.9 yuan/t, the international carbon tax standard is US$ 150/t, calculated the average value is 627 yuan/t, so the value of carbon fixation is 0.47×10^8 yuan. The average cost of using industrial oxygen is 400 yuan/t, so the value of oxygen emission is 0.22×10^{8}yuan. The total value of climate regulation is 0.69 ×10^8 yuan.

4.2.2 Value of waste treatment and biological control

Linghe estuarine wetland is major water source of Linghai city, the water quality directly affects the health situation of residents and industrial and agricultural production [19].The annual industrial sewage of Linghai city is about 1117.25×10^4 t. Considered current cost of treating sewage in Liaoning Province is 0.6 yuan/t, the value of waste treatment 0.07×10^8 yuan.

There is rich habitation of large number of animal species in the wetland. Currently 199 Section, 794 kinds of animals, 82 species of planktons, 60 species of invertebrates, 500 species of vertebrates had been found. There is also 250 species of birds, including 145 species of waterfowls. According to ecological value method, annual maintain cost of nature reserve in China is about 350 yuan/km², considered the total area of wetlands is 83866 hm², the value of biological control for Linghe estuarine wetland is 0.29×10^8.

4.3 Non-use value

The total value of ecosystem service function includes UV (Use Value) and NUV (Non-use Value). Non-use Value is composed of existence value (EV), heritage value (HV) and option value (OV) [20-21]. Currently contingent valuation method (CVM) is the most widely used method to evaluate non-use value of natural resources. Non-use Value of wetlands is based on speculation of future, it depends on people's willingness to pay (WTP). Based on the study of Zhalong wetland non-use values by Cui Lijuan, the willingness to pay (WTP) is 40.00 yuan, the population of urban workers is 0.12 billion, Non-use Value of Linghe estuarine wetland is calculated as 49.34 × 10^8 yuan.

Monetary value of service functions of Linghe estuarine wetland equals to direct use value plus indirect use value and non-use value, which is calculated as 87.07×10^8 yuan.

Conclusions

The ecosystem services function of Linghe estuarine wetland is classified into direct-use value, indirect-use value and non-use value. With reference to Costanza’s method on global ecosystem service function value, the ecosystem service function's monetary value of Linghe estuarine wetland is calculated as 87.07×10^{8}yuan, in which direct-use value is 36.68×10^8 yuan, indirect-use value is 1.05×10^8 yuan and non-use value is 49.34×10^8 yuan. The evaluation results showed the ecosystem service function's monetary value of Linghe estuarine wetland is in a large amount. There should be reasonable development and utilization of the wetland in a healthy and sustainable way.

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