The Evaluation of Ecological Service Value of Liaohe River Estuary Wetland

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Abstract. Taking the wetland of the Liaohe River Estuary as the research object and combined with the emergy theory, aquatic product supply service, plant resource supply service, atmospheric oxygen content regulation service, atmospheric carbon dioxide content regulation service, water regulation service, biological habitat regulation service, scientific research culture service value, leisure and entertainment service value are chosen to evaluate the ecological service value of the Liaohe Estuary wetland in 2019. The results of the study show that the total emergy value of the wetland at the mouth of the Liaohe River is 59.931 billion yuan. Among them, the value of supply services is 2.057 billion yuan. The value of regulation services is 53.508 billion yuan, and the value of cultural services is 4.366 billion yuan. In the entire value of Liaohe estuary wetland, regulation service value > cultural entertainment value > supply service value. Among them, the ecological service value of Liaohe estuary wetland mainly comes from water resource regulation service value and biological habitat regulation service value. Therefore, the ecological service value Research is of great significance to the development and utilization of water resources.

Keywords: Liaohe estuary wetland; ecological service value; ecological service value evaluation

1. Introduction
The administrative area of the Liaohe River Estuary Wetland belongs to Panjin City, Liaoning Province. It is located at the mouth of the Liaohe River. It has a subhumid monsoon climate of the northern temperate zone. In the research area, the area of swamps, beaches and mud flats account for a large proportion. The Liaohe River Estuary Wetland not only has abundant plant and animal resources, it also has various value of ecological service such as climate regulation, flood regulation, water conservation and so on. Based on the ecological and environmental water requirement to stay the wetland ecosystem healthy, would give the best play to the ecological service value of Liaohe river estuary wetland. In order to clearly demonstrate the ecological service value of Liaohe estuary wetland ecosystem, the paper evaluate the value of ecosystem services by 2019 in Liaohe estuary wetland, provide the basis for scientific and reasonable to use and management Liaohe estuary wetland resources.
2. Construction and Method of Wetland Ecosystem Service Value Assessment

2.1. Construction of the Ecosystem Service Value Evaluation System

There are many methods for evaluating the value of wetland ecosystem services, and its value can be evaluated from different angles. This research starts from the perspective of dividing the ecosystem service types into four categories proposed by MA [1], and builds the Liaohe River Estuary wetland ecosystem service value evaluation system based on this classification [2-3]. The four types of ecosystem services are: supply services, regulation services, support services and cultural services [4]. Some scholars believe that support services and regulation services can be collectively known as regulating services. Therefore, this study divides the ecosystem services of the Liaohe Estuary wetland into three categories: supply services, cultural services, and regulation services [5-6]. The specific ecological service classification of Liaohe estuary wetland in table 1.

| Type of service | Types of ecosystem services                                      |
|-----------------|-----------------------------------------------------------------|
| Supply services | Aquatic product supply service                                   |
|                 | Plant resource supply service                                    |
| Regulation services | Atmospheric oxygen content regulation service                  |
|                 | Atmospheric carbon dioxide content regulation service           |
|                 | Water regulation service                                         |
|                 | Biological habitat regulation service                            |
| Cultural services | Scientific research culture service value                        |
|                 | Leisure and entertainment service value                          |

2.2. Ecosystem Service Value Assessment Methods and Processes

To evaluate the value of various ecosystem services, first of all, to construct a reasonable evaluation index system, use the energy conversion ratio to obtain the macroeconomic data of the corresponding service, such as output, dry matter weight, research results, etc., and then use the emergy conversion rate to convert it's converted into emergy, and finally, the monetary value of the corresponding service is obtained through the monetary value conversion rate. The technical route of assessing the value of various ecosystem services is shown in figure 1.

Figure 1. Technical route of assessing the value of various ecosystem services.
3. Basic Data

3.1. Ground Cover Information
The wetland cover information is extracted from the 2019 Landsat 8 remote sensing image of the study area. The resolution of the image is 30m and the time is September of that year. The operating software uses Erdas and ArcGis. In addition, it is necessary to collect relevant maps of the study area and use GPS to conduct field surveys. According to the field survey, the wetland cover types of wetlands are divided into lakes, tidal flats, reeds, rivers, paddy fields, dry fields and residential areas, totaling 7 categories. These 7 types of cover information are extracted to obtain various types of land use information in 2019. As shown in table 2.

Table 2. 2019 Land Coverage Information of Liaohe Estuary Wetland. (Unit: km²)

| Type                  | Phragmites | River | Lake | Mud flat | Settlement place | Paddy field | Upland field | Summation |
|-----------------------|------------|-------|------|---------|-----------------|-------------|--------------|-----------|
| Area                  | 447.67     | 309.23| 110.89| 214.5   | 76.79           | 122.71      | 6.17         | 1287.96   |

3.2. Other Data
The emergy conversion rate of this study refers to Li Kai’s study [7], see table 3. Other data such as annual output of aquatic products and annual output of plant resources are derived from field surveys, as well as from the statistical data of Liaoning Province Statistical Yearbook [8] and Panjin City Statistical yearbook and so on [9]. According to the survey, there are about 1096 species in the wetland, with various plant species and precious wild animals. There are 407 animal species, including 253 species of birds and 124 species of fish. According to statistics, there are 5 species of national Class I protected animals. There are 30 species of Grade II protected animals. The main aquatic product of the wetland in the Liaohe River Estuary is river crab.

Table 3. Emergy conversion rate table.

| Service            | Type                          | Emergy conversion rate   |
|--------------------|-------------------------------|--------------------------|
| Supply services    | Aquatic product               | 3.49×10⁴ sej/J           |
|                    | Plant resource                | 3.49×10⁴ sej/J           |
|                    | Atmospheric carbon dioxide    | 3.87×10⁷ sej/J           |
|                    | content                       |                          |
| Regulation services| Atmospheric oxygen content    | 5.11×10⁷ sej/J           |
|                    | Water resource regulation     | 4×10⁵ sej/J              |
|                    | Biological habitat            | 408.02×10¹⁶ sej/种        |
| Cultural services  | Scientific research culture   | 3.39×10¹⁶ sej/种          |
|                    | Leisure and entertainment     | -                        |

Note: "-" represents the emergy conversion rate of leisure and entertainment. Since leisure and entertainment value is monetary value without conversion, there is no emergy conversion rate for leisure and entertainment value.

4. Evaluation and Analysis of the Service Value of Wetland Ecosystem

4.1 Supply Services
The supply service value of the wetland in the Liaohe River Estuary is divided into two categories,
divided into the supply service value of plant resources and the supply service value of aquatic products. Due to the special geographical location and climatic conditions of the Liaohe River Estuary Wetland, based on the extraction of ground cover information and field investigations, Panjin City, where the Liaohe River Estuary Wetland belongs, is famous for river crabs and has a large area of river crab farming fields. The main plants in this area are phragmites. Therefore, the calculation index of aquatic product supply service value is river crab, and the calculation index of plant resource supply service value is phragmites. The annual output of crabs in the wetland of the Liaohe River Estuary is obtained by consulting the statistical data of the Liaoning Provincial Statistical Yearbook, which is 1.84×10^10 g. The annual output is converted according to the energy conversion ratio of material production materials of 1.67 to obtain the energy supply of the aquatic products in the wetland of the Liaohe River Estuary, which is calculated as 3.07×10^14 J, converting the energy of aquatic products through the currency value conversion rate to obtain a service value of 2.91×10^8 yuan; according to the extraction results of land cover information, the area of phragmites in the wetland of the Liaohe River Estuary in 2019 is 447.67×10^6 m^2, according to investigations and studies, the annual output of phragmites per unit area is 249.17g/m^2, and the annual output of phragmites in the study area is 11.15×10^10 g. Similarly, the annual output of phragmites is converted according to the energy conversion ratio of the material production raw materials, and the energy supply of the plant resources in the wetland of the Liaohe River Estuary is 18.62×10^14 J, and then the energy of the plant resources is converted through the currency value conversion rate to obtain the plant resource supply service value of 17.66×10^8 yuan; Summing the two parts of the value of the supply service, it can be obtained that the value of the supply service is 20.57×10^8 yuan.

4.2 Regulation Service

Regulation services include three categories, namely atmospheric composition regulation, water resource regulation and biological habitat regulation. The following is a value assessment of these three types of adjustment services.

(1) Service value of atmospheric composition adjustment

A variety of plants in wetlands have a regulatory effect on atmospheric components. Wetlands are not only the "kidney of the earth" but also the "lungs of the earth". Plants regulate the content of O2 and CO2 in the atmosphere through photosynthesis and respiration. Therefore, the equation of photosynthesis and respiration can be used to obtain the amount of CO2 absorbed and the amount of O2 released by plants to produce per gram of dry matter. Namely: Plants use 6722J solar energy for photosynthesis, and need to absorb 264g of CO2 to produce 108g of glucose and 193g of O2. It can be converted into: 1.63g of CO2 is consumed for per gram of dry matter produced, and 1.20g of O2 is produced. According to the information on the surface cover of the Liaohe River Estuary, actual surveys, and plant quality and yield, the CO2 absorption and O2 emissions that can be obtained for atmospheric composition adjustment services are 1.82×10^11g and 1.33×10^11g, respectively. After emergy conversion, the service value of atmospheric composition adjustment is 3.76×10^8 yuan.

(2) Water resources regulation service

As an estuary wetland, its geographic location is unique, and it is the center of water resources regulation in the Liaohe River. Water resource regulation is one of the most important regulation services. By consulting the Panjin Statistical Yearbook and the collection of relevant network data, the total water storage of the Liaohe River Estuary wetland ecosystem in 2019 is 25.31×10^8 m3; the total water storage needs to be converted into energy as the basic data for water resources regulation services The emergy conversion rate of the resource is converted to obtain the water resource regulation emergy service value of the Liaohe River Estuary wetland, which can be calculated by formula (1), which is as follows:

\[ N = W \times \rho \times J \]  

Where: N is the total annual water conservation energy of the wetland; W is the total amount of wetland water storage; ρ is the density of rainwater 1.03×10^6 g/m^3; J is the Gibbs free energy of
rainwater 4.94J/g.

Substituting the basic data into the formula (1), the total water resource regulation capacity of the study area is 128.78×10^{14}J, and the water resource regulation service value is 140.02×10^8 yuan.

(3) Regulation service value of biological habitat

In the traditional sense, the value of biological habitat regulation service is to convert the habitat of a species into the biological habitat regulation service value of the species through the average emergy conversion rate of the species. According to survey statistics, there are about 407 species rich in species in the wetland of the Liaohe River Estuary, of which about 377 species of birds and fish are the most important species in the region, accounting for 92.63% of the total species. Therefore, the species with the largest proportion of the evaluated species in the wetland of the Liaohe River Estuary is selected for evaluation, but not all species. Therefore, it is necessary to convert the emergy conversion rate of the species to the emergy conversion rate of the evaluated species, and then evaluate the service value. The formula of emergy conversion rate is shown in formula (2).

\[ T_r = T_{r0} \times \frac{S_0}{S} \]  

Where: \( T_r \) is the species emergy conversion rate of the Liaohe estuary wetland; \( T_{r0} \) is the average emergy conversion rate of the species, \( S_0 \) is the Liaohe river estuary wetland area, and \( S \) is the global area.

Substituting the area of reed fields and the average emergy conversion rate in the habitat of birds and fish into formula (2), the emergy conversion rate of the wetland species in the Liaohe River Estuary is calculated to be 380.87×10^{16}sej/species. After the conversion of the emergy conversion rate of the biological habitat regulation service value, the service emergy value of the biological habitat of the Liaohe river estuary wetland can be obtained as 391.30×10^8 yuan.

4.3. Cultural Services

Cultural service value includes scientific research cultural value and leisure and entertainment value. The evaluation of the scientific research and cultural value of the wetland in the Liaohe River Estuary is based on the method proposed by scholars such as Meillaud [10], such as formula (3)

\[ EM = T \times 6 \times 33.9 \times 10^{16} \]  

In the formula, \( EM \) is the cultural value of scientific research, Yuan; \( T \) is the number of academic papers published during the research period.

According to the search results of major Chinese literature search databases, there are 24 articles in 2019 with the key words of Liaohe River Estuary Wetland, substituted into the formula, and the cultural service value is 13.26×10^8 yuan.

The value of leisure and entertainment is calculated based on the tourism benefit per unit area of Liaoning Province in 2019 of 2.36×10^6 yuan/km\(^2\) as the parameter of the leisure and entertainment value of the wetland in the Liaohe River Estuary. After calculation, the leisure and entertainment value of the wetland in the estuary of the Liaohe River is 30.40×10^8 yuan.

5. Conclusion and Analysis of the Service Value of the Wetland Ecosystem in the Liaohe River Estuary

The value of various ecosystem services calculated above is summarized, and the results are shown in table 4.

| Service Type | Raw data | Emergy conversion rate (sej/a) | Emergy value (10^8 yuan) | Monetary value (10^8 yuan) | Proportion/ |
|--------------|----------|-------------------------------|--------------------------|--------------------------|------------|

Table 4. Liaohe Estuary Wetland Ecosystem Service Value Summary.
1) The supply service consists of two parts: aquatic product supply service and plant resource supply service. Since the main plant resource of the Liaohe Estuary Wetland is reed and its area in study area accounts for about 34.76% of the total area of study area, to study the largest coverage type, the annual output of plant resources is much greater than the annual output of aquatic products. Under the same emergy conversion rate, the emergy value of converted plant resources is $1.76 \times 10^8$ yuan, which is much greater than that of aquatic products whose emergy value is $2.91 \times 10^8$ yuan, and plant resource supply service is the main service type of supply service.

2) In the regulation service, according to the equations of photosynthesis and respiration, 1.63g of CO$_2$ is consumed for per gram of dry matter produced, and 1.20g of O$_2$ is produced. The amount of CO$_2$ and O$_2$ in the adjustment of atmospheric composition are close, so the energy conversion is obtained. The ratio of CO$_2$ regulation service value to O$_2$ regulation service value is approximately 1:1. The calculation shows that water resource regulation service value is $140.02 \times 10^8$ yuan, accounting for 23.36% of the regulation service value, and the biological habitat regulation service value is $391.30 \times 10^8$ Yuan, accounting for 65.29% of the adjustment service value. It can be concluded that in the adjustment service value: biological habitat regulation service value> water resources regulation service value> CO$_2$ atmospheric composition regulation service value> O$_2$ atmospheric composition regulation service value.

3) Through research, it is found that the total service value of the Liaohe Estuary Wetland in 2019 is $599.31 \times 10^8$ yuan, of which the regulation service value is the main service value, accounting for 89.28% of the total service value, and the emergy value of the regulation service is $535.08 \times 10^8$ yuan; Supply services and cultural services account for a relatively small proportion, accounting for 3.44% and 7.28% of the total service value, respectively, and their emergy is $20.57 \times 10^8$ yuan and $43.66 \times 10^8$ yuan, respectively. The emergy of biological habitats accounts for the largest proportion of regulation services, accounting for 73.13% of regulation services.
The above results indicate that biological habitat is the most important component of wetland ecological service value. The rational use of wetland ecosystem can increase the service value of its ecosystem, but the increase of human activities will lead to the decrease of ecosystem service value.

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