Ecosystem Services in the Yellow River Basin Based on Ant Colony Optimization Algorithm

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Abstract: The use of ecosystem services creates natural and social material conditions for people's production and living activities. However, the wanton development and utilization of people also seriously damages ecosystem services. The evaluation of ecosystem service quality is an important cornerstone of cultural ecosystem environmental protection and rational use of land resources, and an important key issue to maintain the health of human natural systems and the sustainable development of regional society. This paper aims to study the ecosystem services of the Yellow River Basin based on ant colony optimization algorithm. On the basis of analyzing the evaluation method of ecosystem service function, ecosystem service evaluation model and the important mechanism of ant colony algorithm, the InVEST model is used to analyze the 2010 and In 2020, the two major ecosystem service functions of water supply and soil conservation will be evaluated, and then the changes in ecological service industry functions in different periods will be compared and analyzed. The results show that the soil erosion in the Yellow River Basin showed an increasing trend from 2010 to 2020.

1. Introduction

Ecosystem is a complex dynamic complex with specific composition, structure and function formed by material cycle and energy exchange [1-2]. At the same time, under certain conditions, as an open system closely connected with the external environment, it has the ability of self-sustaining and self-healing and reconstruction. Ecosystems provide human beings with a variety of products and services according to their structure, functions and processes, and maintain the balance between the earth's biogeochemical cycles and life support systems, which are the basic conditions for human survival [3-4].

People have long realized the importance of ecosystem services to human existence and development, and the significant impact of ecosystem services on human economic and social development. Some researchers have explored the functions of ecosystem services and found that

these functions are irreplaceable [5-6]. In the same year, other researchers also explored the relationship between ecosystem functions and human economic and social development, and the water resources, land, animal and plant resources around us are all part of the ecosystem, which is the key to people's lifestyle and economic and social development. It plays an important role in the development of human national economy and promotes it [7-8]. Since ancient times, people have produced and lived on the basis of ecosystem services, but they have not fully realized that the low ecosystem services are leading to ecosystem crisis. Since 1970, human beings began to seriously reflect on the sustainable development of ecosystems and the main reasons for the decline of ecosystem services, and gradually began to explore and study ecosystem services. Some researchers have also discussed issues related to the decline of ecological diversity and the interaction with environmental systems, but the main conclusion is that there is no way to replace the lost ecosystem services, and therefore a new generation of ecological system term "ecosystem services" [9-10]. Subsequently, some scholars further summarized the related concepts of ecological and environmental services [11-12]. Combining all the above findings, the term "ecosystem services" began to be widely recognized by human society and is increasingly used by people. The evaluation of ecosystem services has increasingly become a research hotspot and frontier in the global environment, and it is also an important aspect that countries around the world pay attention to and give priority to.

In this paper, on the basis of consulting a large number of relevant references, combined with the evaluation method of ecosystem service function, ecosystem service evaluation model and the important mechanism of ant colony algorithm, the InVEST model is used to analyze the two aspects of water supply and soil conservation in the Yellow River Basin in 2010 and 2020. The service function of the large ecosystem is evaluated, and then the changes of the ecological service function in different periods are compared and analyzed.

2. Research on Ecosystem Services in the Yellow River Basin Based on Ant Colony Optimization Algorithm

2.1. Evaluation Methods of Ecosystem Services

1) Substance quality evaluation method. The material quality assessment method aims at the sustainable development of the ecosystem business, starts from the ecosystem business mechanism, and makes an overall quantitative assessment of the business services provided by the ecosystem from the perspective of biological quality. The main advantage of material quality assessment is that it more objectively reflects the ecosystem process and the ability to serve the ecosystem itself, and it is not affected by market value, and it can also conduct comparative studies on various ecosystem businesses. The disadvantage is that the material quality assessment method is different from the index system for assessing the quality of various ecosystem services, and the conclusion is not direct enough, nor can it attract the full attention of managers. Secondly, there are differences in the biological quality level of individuals in the service quality of natural ecosystems. A direct comparison between the quality of various ecosystem services, ignoring the spatial table of the socioeconomic environment associated with the provision of ecosystem services.

2) Value evaluation method. The value-quantity assessment method provides a financial evaluation of the service value created for the ecosystem mainly from a monetary perspective. It mainly uses a variety of direct and indirect economic methods to valorize the resources of ecosystem products or services. The advantage is that since the results of various ecosystem business assessments are monetary values, it is possible to compare the value of the same services in various ecosystems and to analyze the services managed by a particular ecosystem in detail. In this way, it is easier for people to discover the service value provided by the natural ecological

environment system more intuitively, and it is easier for local government departments and managers to pay more attention to the local natural ecosystem services. Moreover, the price of the ecosystem business assessment results can be easily integrated into the national financial accounting system. Policymakers at all levels consider better protection and management of ecosystem services in the development of relevant policy plans. However, most of these methods are based on human-centered methods, and the results are subject to a certain degree of subjectivity.

3) Emergy analysis method. The emergy analysis method is a supplement to the above two types of evaluation methods, and adopts the basic principle of evaluating the value of ecosystem services by integrating the value of resources and various energies that cannot save solar energy at a constant conversion rate. If we adopt emergency analysis, by synthesizing human socio-economic system and ecological system, quantitatively analyze the value of goods and services created by ecosystem for people, coordinate the interconnection between human economic and social system, nature and ecological environment, and create new opportunities for people. A political entity that uses natural resources rationally, coexists in harmony with nature, and has outstanding leadership in formulating economic and social development policies. However, there are certain limitations, too many quantities are required, it is difficult to collect information, there are too many elements to be analyzed, and the calculation process is cumbersome and difficult. There are also things with weaker energy relationships that are difficult to measure in solar joules and cannot reflect the system services and scarcity of natural resources in the local ecosystem.

2.2. Ecosystem Service Assessment Model

1) InVEST model. The InVEST model is a free, open source evaluation model developed with the help of the Nature Investment Project to measure the efficacy of different ecosystem services. The model includes several subsections. Different models and calculations can be followed to simulate the efficacy of various ecosystem services under different land resource uses. Different subsections require different amounts of data. Twenty-one versions of the InVEST model have been launched to date, including nine marine ecosystem services and seven assessment models for freshwater and terrestrial ecosystem services. And water quality and other models will be added further.

2) SoLVES model. Researchers can use this model to filter social values and stakeholders, and then normalize the social value by the maximum value. The social value of service. However, since the SolVES model also requires a lot of data processing, when applied to newer scientific research applications, researchers will need to spend a lot of time on field investigation and research. At the same time, due to some important constraints in stakeholder relations and social value selection, the simulation results may be incorrect or deviated to a large extent.

3) ARIES model. ARIES model is an evaluation model of ecosystem service quality. A source can refer to both the main source of ecosystem services and the potential recipients of ecosystem services. Sinks represent the main biophysical parameters of ecosystem services. Water users are those who benefit from the business functions of the ecosystem. In the ARIES model, intelligent artificial modeling is integrated, and the three parts of spatial location and quantity are used, together with the corresponding mathematical calculation methods, to quantitatively evaluate the water business functions of different ecosystems. Taking the application of the water ecological environment maintenance function in the plant ecosystem as an example, the water source refers to the soil that plants need in their life activities. The main users are people and green plants due to soil erosion caused by soil erosion and changes in land use conditions. The SPIES model of the ARIES model can also be used to simulate the spatial dynamics of ecosystem service flows.

2.3. Important Mechanisms of Ant Colony Algorithm

1) The memory function of artificial ants. Artificial ants can remember the way they have traveled, and will not choose the city they have been to when looking for the next city. This function is implemented in the algorithm through the tabu table.

2) The global communication capability of the ant colony. When the ants establish a pathway, the pheromone stays in the route they travel, and the ant colony tends to choose the route with the highest pheromone concentration, thereby gradually concentrating and converging toward the route with the highest pheromone concentration. Pheromones exist independently of the ant colony and are the only means of communication that allow the ant colony to communicate on a global scale.

3) Characteristics of swarm intelligence algorithms. The characteristics of swarm intelligence algorithm are mainly manifested in two aspects: communication ability and distributed computing. The ability of ants is very low, the food exploration is very random, and the ant colony communicates through pheromones to quickly find the shortest path to explore food. It is this information-based positive feedback mechanism that the ant colony communicates with. The team will demonstrate a very efficient search function. In addition, although the ability of an ant is not high, in real-life scenarios, the distributed computing power shown by multiple ants in an ant colony is huge, it can effectively complete a large number of computing tasks, and can fully meet the needs of computing.

3. Data Processing and Parameter Setting

3.1. Water Supply Service

The data input to the model includes annual average rainfall, annual average potential evaporation, root depth, water availability to vegetation, land use type map, runoff boundary map, etc. The annual average rainfall layer was obtained by Knging interpolation in ArcGIS, and the data came from the self-reported rainfall map presented in the study area. The annual mean value of potential transpiration was calculated using the modified Penman-Monteis equation, and the data were obtained from self-testing meteorological stations in the Yellow River Basin.

$$ET_0 = \frac{1}{\lambda}\left(\frac{\Delta}{\Delta + \gamma(1+0.33U)}\right)(R_n - G) + \frac{\gamma}{\gamma(1+0.33U)}\left(\frac{900}{T+273}\right)UD \tag{1}$$

$$R_n = R_{ns} - \sigma\left(\frac{T_{max,K^4} + T_{min,K^4}}{2}\right)\left(0.34 - 0.14\sqrt{e_a}\right)\left(1.35\frac{R_S}{R_{SO}} - 0.35\right) \tag{2}$$

$$\frac{R_S}{R_{SO}} = \frac{\left(a_s + b_s\frac{n}{N}\right)R_a}{(a_s + b_s)R_a} = \frac{\left(a_s + b_s\frac{n}{N}\right)}{(a_s + b_s)} \quad e_a = \frac{e^o(T_{min})\frac{RH_{max}}{100} + e^o(T_{max})\frac{RH_{min}}{100}}{2} \tag{3}$$

Where λ is the latent heat of vaporization with a value of 2.45, Δ is the slope of the saturated water vapor pressure curve against air temperature, γ is the wet and dry bulb constant, U is the wind speed of 2 meters, and Rn is the net radiation.

3.2. Soil Conservation Services

The data that needs to be input into the model includes DEM data, rainfall erosion layer raster, soil erosion layer raster, land use type map, runoff boundary map, etc. The rainfall erosion capacity

raster layer is calculated from the annual mean rainfall by Equation (Equation 4) on a monthly scale and obtained by Kriging interpolation in ArcGIS.

$$R = \sum_{i=1}^{12}\left[1.735\cdot 10^{\left(1.51\lg\frac{P_i}{p}-0.8188\right)}\right] \qquad (4)$$

Where R is the annual rainfall erosivity, and P is the annual rainfall (mm).

Soil erodibility is calculated by formula (5) through the physical and chemical properties of soil.

$$K_{epic} = \left\{0.2+0.3\exp\left[-0.0256SAN\left(1-\frac{SIL}{100}\right)\right]\right\}\cdot\left(\frac{SIL}{CLA+SIL}\right)^{0.3} \qquad (5)$$

In the formula, exp represents an exponential function based on the natural constant e, and SAN, SIL and CLA represent the percentages of sand, silt and clay in the soil, respectively.

4. Discussion

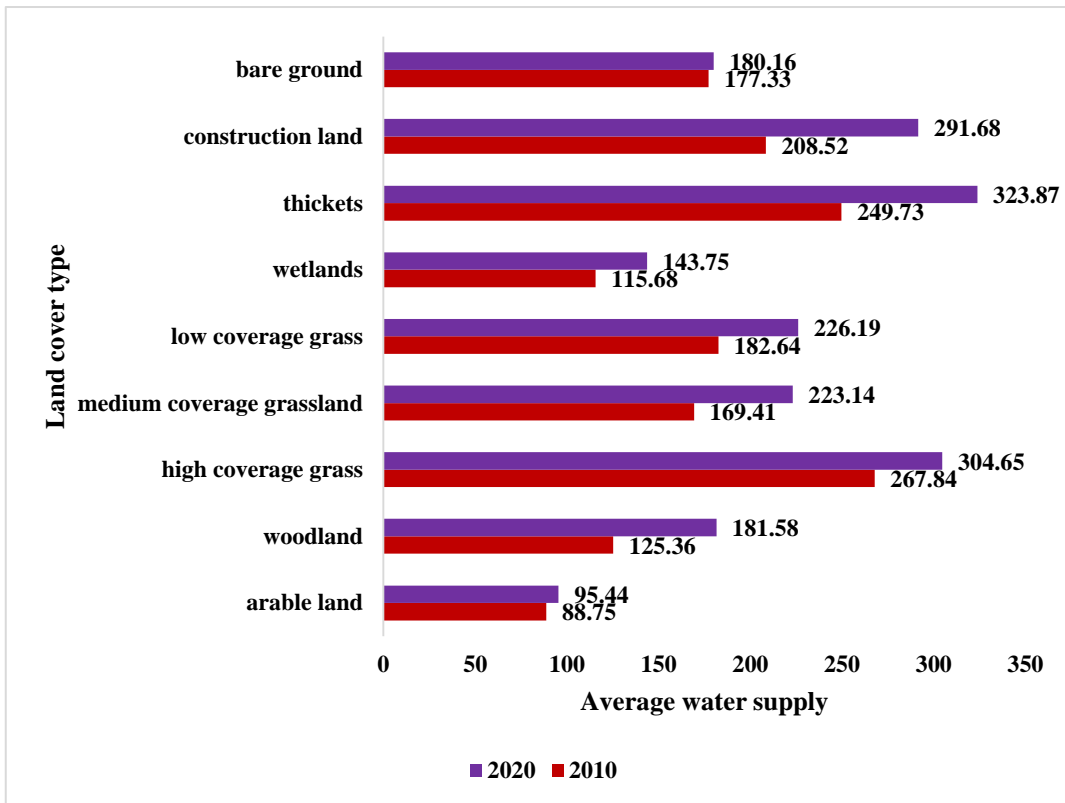### 4.1. Evaluation of Water Supply Service Function

Figure 1. Average water supply of the Yellow River by different types of cover from 2010 to 2020

After calculation, the regional statistics of each land cover type in the Yellow River Basin were carried out to obtain the average water supply of each land use type. From Figure 1, it can be seen that the water supply of different land cover types in different periods has changed. In 2010, the water supply of construction land was 208.52mm, and in 2020, the water supply of construction land increased by 83.16mm; the average water supply of cultivated land the amount of water

increased from 88.75mm in 2010 to 95.44mm in 2020; the average water supply of shrubs was also high, 249.73mm in 2010, an increase of 74.14mm in 2020; the water supply of high-coverage grassland in the basin in 2010 was 267.84mm, the increase in water supply in 2020 was not large, an increase of 36.81mm; the average water supply of medium-coverage grassland increased from 169.41mm in 2010 to 223.14mm in 2020; the average of low-coverage grassland in 2010. The water supply was 182.64mm, and the increase was 43.55mm during 2010-2020; the average water supply of wetlands in 2010 was 115.68mm, which increased by 28.07mm during 2010-2020.

4.2. Evaluation of Soil Conservation Service Function

Table 1. Variation map of soil erosion amount per unit area of different cover types in different periods

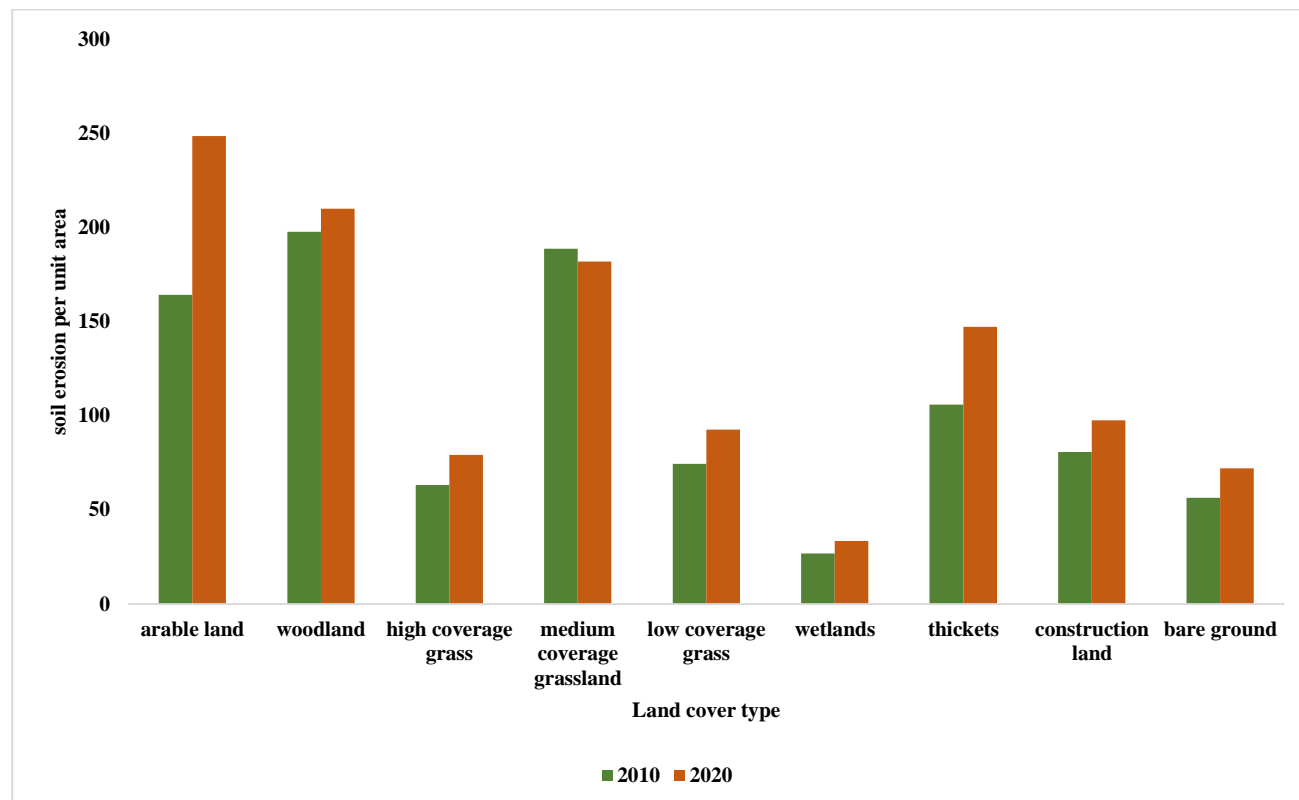| Year	2010	2020
arable land	164.21	248.37
woodland	197.58	209.82
high coverage grass	63.14	79.16
medium coverage grassland	188.66	181.75
low coverage grass	74.39	92.67
wetlands	26.81	33.46
thickets	105.93	147.21
construction land	80.74	97.58
bare ground	56.43	71.95

Figure 2. Variation map of soil erosion amount per unit area of different cover types in different periods

From Table 1 and Figure 2, it can be seen that the amount of soil erosion in both the medium-coverage meadow and the low-coverage meadow is quite large, followed by 0.5 bare land, which is mainly due to the comparison of the distribution and coverage of the medium-coverage meadow. So the amount of soil erosion is larger than other cover types, so the soil erosion amount per unit area is correspondingly smaller. The proportion of construction land area is small, and the soil erosion amount is relatively small, so the proportion of soil erosion amount of construction land is large, and the volume is correspondingly relatively small, so the soil erosion rate per unit area of the building is also high. And the soil erosion rate per unit area of wetland is the least among all soil cover types, indicating that wetland has strong soil protection ability. It can also be seen that between 2010 and 2020, the amount of soil erosion in the source regions of the Yellow River in China has increased.

5. Conclusion

Some studies on the ecosystem services in the Yellow River Basin will help us understand and prepare for the changes in the Yellow River Basin ecosystem in recent years and in the future. The current and future ecosystem protection design in the Yellow River Basin has clear direction, scientific basis and decision-making to provide support for ecosystem protection and sustainable management and ecosystem development in fragile ecological regions.

Funding

Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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