A STUDY ON ECOLOGICAL PRODUCTS VALUE ACCOUNTING IN THE THREE GORGES REGION OF YANGTZE RIVER IN CHINA IN 2018

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Abstract. To facilitate the assessment of ecological product value and provide a convenient means of measurement, it is imperative to enhance the value accounting system. Thus, this study aims to develop a methodology for assessing ecological products that accounts for both product quality and cost. This approach is used to determine the ecological product value for the three provinces and cities in the Three Gorges region of China, which are located in the middle and upper reaches of the Yangtze River, namely Hubei Province, Hunan Province, and Chongqing Municipality. According to the results, the ecological product value of Yangtze River's Three Gorges regions was USD 32,499,414,905.7 (2,339.417 billion yuan) in 2018. Clean water made up USD 129,845,354,411 (934.657 billion yuan) of this amount, while agricultural products contributed 140.476 billion. With a value of USD16,154,661,055 (11628.50 billion yuan), Hubei province had the greatest ecological product value. In light of these results, this study advocates for strategies to ensure the diversified and balanced development of ecological products. It recommends the establishment of a market platform dedicated to ecological products, as well as the formulation of rules and protocols governing ecological product transactions.
Keywords: *value accounting system, ecological products, clearwater service, fresh air products' value*

Introduction

China is placing a growing emphasis on green and sustainable development. When looking at national policies, it is clear that China is dedicated to realizing General Secretary Xi Jinping's vision of "ecological priority and green development," which has become a fundamental cornerstone of the country's green development strategy. Consequently, establishing a mechanism to actualize the value of pristine natural environments has taken on paramount importance. The ecological product is a concept set for the realization of ecosystem services as commodities in the potential market. Ecological products are the basic elements to realize the coordinated development of an ecological economy (Rembiałkowska, 2007; Xin-gang and Fan, 2019). However, compared with traditional industrial products, ecological products are difficult to be mortgaged, transacted, and realized under the current market mechanism. To realize the value transformation of ecological products and conveniently measure their value, the first thing to be solved is to establish a scientific value accounting mechanism (Farber et al., 2002; Liu et al., 2010). On April 26, 2021, the General Office of the Central Committee and the State Council (CPC) issued a guideline on setting up and improving a mechanism to realize the value of ecological products. The middle and upper reaches of the Yangtze River basin, as a vital position in China's ecological economic construction, are still exploring the establishment of the value realization mechanism of ecological products.

Review of literature

The research on the value of ecological products in Chinese academia mainly includes the connotation and theory of ecological products (Liao et al., 2021; Liu, 2020; Wang, 2019) the realization path (Huang, 2020; Wang et al., 2020; Zhou et al., 2023) and mechanism (Li, 2018; Ma et al., 2020; Zhang, 2020) of ecological products value, and the accounting method (Li et al., 2021; Li et al., 2021; Qin and Cao, 2022). As the air, climate and other ecological products have strong consumption externalities, they should be included in the scope of basic public services and equalization, the governments of beneficiary areas should purchase ecological products produced in areas with important ecological functions, so as to achieve mutually beneficial goals of environmental protection and economic development (Qiu and Jin, 2019). Determination of ecological products, index system, evaluation framework and specific measurement methods is a problem faced in ecological product value evaluation (Ma et al., 2020; Zhang, 2020). Therefore, some scholars sorted out ecological value accounting at home and abroad and put forward countermeasures and suggestions (Yu et al., 2020).

Foreign researchers mainly focus on the mechanism of Payment of Ecosystem Service (PES), the influencing factors and the accounting of natural capital, and there are few studies on ecological products. Buonocore et al. (2020) assessed the value of natural capital in a Mediterranean Marine Protected Area, applying energy and eco-exergy accounting methods. Some scholars have studied PES cases. Pfaff et al. (2019) studied the coordination degree of contributions of upstream water service providers and downstream beneficiaries to PES from the collective level in several basins in Mexico and concluded that coordination among PES participants would increase social capital within the mechanism over time. Bauchet et al. (2020) investigated the actual implementation of PES in the Tropical Andes and suggested that academics and PES practitioners should cooperate to resolve the differences between academics and practice. Some scholars also had research on the factors affecting the PES mechanism. Wang and Wolf (2019) proposed that when there are sharp disparities in the economic and ecological status of ecosystem service providers and beneficiaries, the PES mechanism is more likely to succeed. Ola et al. (2019) reviewed the published literature on PES programs and found that the payment incentives that cover costs and the location-specific constraints of PES projects are of profound importance in cost-effectiveness. Some scholars have studied the accounting methods of natural capital. Ochuodho and Alavalapati (2016) proposed a method to include natural capital accounting into the input-output table and into the national accounting system based on the United Nations Environmental and Economic Accounting System.

Chinese researches on value realization of ecological products are mainly about the value accounting and evaluation of ecosystem services, the interpretation and classification of ecological products, and the value realization of ecological products, etc. Some scholars have constructed different methods of value accounting of ecosystem services. Pfaff et al. (2019) used the market value method, alternative market method and virtual market method to calculate the value of ecosystem services. Based on the energy method, Liu et al. (2021) proposed an agricultural ecosystem service qualification method and calculated the ecosystem services and dis-services of typical agricultural products per unit area in China. Some other researchers have explained the formation mechanism and connotation of ecological products from different angles.

Based on Marx's capital cycle theory, Zhang et al. (2020) clarified the boundary and scope of ecological products and ecological capital, according to the viewpoints of academic circles on ecological products, natural capital, and ecological capital. Yang et al. (2023) explored the connotation and classification of water eco-products, pointed out that the value of water eco-products included functional quantity and value quantity, and proposed that the functional quantity of water eco-products should be calculated in the classification of supply, regulation, and cultural category.

In summary, there are few analytical studies on the construction and application of ecological product accounting systems all over the world. Western researchers focus on the field of payment for ecosystem services (PES), natural capital accounting, the accounting method of natural capital, and the influence mechanism of PES. Whereas, Chinese scholars concentrated on the construction of ecosystem service value accounting indicators. Therefore, this paper will construct the measurement method of the ecological product evaluation index from the perspective of material quality and price, and calculate the value of ecological products in Hubei Province, Hunan Province, and Chongqing City in Three Gorges of Yangtze River.

Policies regarding ecological products

In China, the term "ecological products" appeared relatively late and was first mentioned in the National Planning for Main Functional Areas issued by The State Council in 2010 (Zhang, 2020). According to the planning, ecological products include agricultural products, industrial products, and service products, as well as fresh air, clear water, and pleasant climate (Li and Wu, 2012; Wu, 2015). In recent years, provinces along the Three Gorges of Yangtze River have made great achievements in exploring green development, owing to the improvement of relevant policies and systems. In September 2019, the Department of Natural Resources of Hubei Province began to carry out ecological product value realization path as well as ecological compensation pilot work in nine counties and districts. In April 2020, the value realization mechanism of Ecological products in Ezhou City was selected for the Typical Cases of Value Realization of Ecological Products (the first batch) released by the Ministry of Natural Resources. In January 2021, at the Hubei Province Natural Resources Work Conference, the relevant officers introduced that ecological protection and restoration policies are planned to be issued. Meanwhile, they prepared to explore the value realization mechanism of ecological products and modify the value accounting method of natural resources' ecological products.

On April 8, 2020, the Hunan Department of Industry and Information Technology issued the Hunan Green Design Product Evaluation Management Measures, planning to build a green manufacturing system that is efficient, clean, low carbon cycle, and sustainable. In November 2020, the ecological governance and comprehensive development case of Chuangzi River in Changde City was selected for the Typical Cases of Value Realization of Ecological Products (the second batch) released by the Ministry of Natural Resources. Hunan provincial government focused on the pilot projects of ecological protection and restoration in Xiangjiang River Basin and Dongting Lake in recent years. To sum up, the work of promoting the realization and accounting of the value of ecological products in Hunan province is insufficient, and their construction of ecological civilization mainly focuses on ecological restoration and protection and the development of the green manufacturing industry.

As for Chongqing, in April 2020, two cases from Chongqing were selected into Typical Cases of Value Realization of Ecological Products (the first batch). In the exploration of value realization of ecological products, Chongqing expanded the ecological function of land quota, implemented the forest coverage index transaction, brought ecological products into the market under the leadership of the government, and included it in the assessment index of subordinate units. In December 2020, the signing ceremony of realizing the value of Chongqing's "carbon sink+" ecological products was held in Wanzhou. Under the 14th Five-year Plan, Chongqing plans to start a specialized ecological products program. Chongqing has made great progress in promoting the value realization of ecological products but there is still room for improvement of its ecological product value accounting mechanism.

Materials and methods

Accounting methods and data sources

Zhang et al. (2016) pointed out that the value of ecological products is composed of high-quality environmental factors such as clear water, air, and soil. The value of an ecological product is determined by its quality and price. The quantity of ecological products, agricultural products, clear water, and fresh air provided by the ecosystem. The price is determined by the market. Since the market of ecological products is incomplete, alternative market methods and equivalent factor method are adopted if there is no market price. The total value of ecological products in each province is as follows:

$$TV = \sum_{l=1}^{3} EPV_l \qquad (Eq.1)$$

$$EPV_l = APV_l + CPV_l + FPV_l \qquad (Eq.2)$$

where TV (Total value) is the total value of ecological products in Hubei, Hunan, and Chongqing, EPV_l (Ecological products' value) is the total value of ecological products in region l, APV_l (Agricultural products' value) is the value of agricultural products in this region, CPV_l (Clearwater products' value) is the value of clear water products, and FPV_l (Fresh air products' value) is the value of fresh air products.

The value of ecological products mentioned above is as follows:

$$APV_l = \sum_{i=1}^{m} AP_i \times P_i \qquad (Eq.3)$$

$$CPV_l = \sum_{j=1}^{n} CP_j \times P_j \qquad (Eq.4)$$

$$FPV_l = \sum_{k=1}^{q} HT_k \times P_k \qquad (Eq.5)$$

As agricultural products have a well-developed market, the market pricing method is applied to determine the price. AP_i (Agricultural products) is the output of category i agricultural products, and is the price of category agricultural products. As there is no well-developed market for clear water products, the value equivalent factor method (Xie et al., 2015) is adopted for pricing. CP_j (Clearwater service) is the number of services provided by the water area, and is the price of services provided by water area per unit area. As there is no well-developed market for fresh air products, the alternative market method is adopted from the perspective of loss. HT_k (Health terminal) is the change of the health terminal caused by the change of air pollutant concentration, and P_k is the economic loss of the health terminal k.

Accounting indicators and data sources

Agricultural products

Agricultural products belong to the ecological products that provide services, and their value is determined by their output and market price. The agricultural products in this study are divided into agricultural, animal husbandry, forestry, and fishery products. The output statistical information comes from the statistical yearbook of 2019 published by the investigated governments, and the price information comes from the China Yearbook of 2019 of Agricultural Price Survey, market information published by the government, and market reports of major agricultural product information websites, etc.

Clearwater products

Water supplies not only food but also raw material production and water resources. Besides, it provides regulatory services, including gas and climate regulation, environmental purification, and hydrology regulation; Moreover, it provides support services, including soil conservation and the maintenance of nutrient cycling and biodiversity in their ecosystems, which is of value to people, directly or indirectly. Waters can also serve as landscapes to enrich human cultural life. The highest value is hydrological regulation (102.24), and the lowest value is Nutrient cycle maintenance (0.07). The equivalents of various services in water areas are shown in the following *Table 1*.

Table 1. The equivalents of various services in water areas in 2018

Type	Equivalent
Production of material	0.23
Water supply	8.29
Gas regulation	0.77
Climate regulation	2.99
Environment purification	5.55
Hydrological regulation	102.24
Soil conservation	0.93
Nutrient cycle maintenance	0.07
Biological diversity	2.55
Landscape function	1.89

In terms of the total amount of services provided by water areas CP_j, the service value provided by 1 ha of farmland ecosystem is taken as a standard equivalent value, that is, the price of services provided by a unit water area P_i.

$$CP_j = S \times SE_j \qquad \text{(Eq.6)}$$

S is the water area of the research object, the statistical data comes from the China Meteorological Science Data Sharing Service platform (http://www.cma.gov.cn/2011qxfw/2011qsjgx/), 2019 remote sensing data and GIS-related literature, and SE_j (Service equivalent) is the service equivalent of the service j of the water area.

Fresh air products

Inhalable particulate matter (PM2.5), the main pollutant in the atmosphere of China, has the most significant relationship with adverse health effects on the human body. The alternative market method is adopted for air value accounting. According to the secondary standard of PM2.5 in China's current Ambient Air Quality Standard, from the perspective of health economic benefits, the environmental value assessment method was used to estimate the economic loss of human health damage that could be reduced under the current concentration in Hubei province, Hunan Province and Chongqing city. The Poisson regression model was adopted to get the changes in health effects of residents exposed to PM2.5, and then the health benefits of air effects were obtained by the modified human capital method and disease cost method. The accounting methods are as follows:

Step 1, account for the change of health terminals.

$$\Delta HT_k = EP \times M_k \times \left(1 - \frac{1}{\exp\left[\beta \times \left(PC_0 - PC \right) \right]} \right) \qquad \text{(Eq.7)}$$

ΔHT_k is the change of the health terminal k, $k = 1$ refers to all-cause death, $k = 2$ refers to respiratory disease, $k = 3$ refers to circulatory disease, $k = 4$ refers to chronic obstructive pulmonary disease of the whole population or chronic respiratory disease of people under 70 years old, $k = 5$ refers to lung (trachea and bronchus) tumor disease. EP (Exposed population) is the exposed population[1], M_k is the actual mortality or morbidity of the health effect terminals, β is the expose-response relationship coefficient (Wang and Wolf, 2019; Zhang et al., 2020), PC is the actual concentration of PM2.5, and is the baseline concentration of PM2.5. The statistics come from the Chinese center for Disease Control and prevention(https://www.chinacdc.cn/kjxm/), Huajing Industrial Research Institute (https://www.huaon.com/).

Step 2, calculate the health-economic benefits of each health terminal.

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[1]The permanent population of Hunan Province in 2018-2021 is 6635, 6640, 6645.39, and 66.22 million respectively. The permanent population of Hubei Province in 2018-2021 was 59.17, 59.27, 57.75, and 58.23 million, respectively. The total population of Chongqing Municipality in 2018-2021 is 3,403.64, 3,416.29, 3,412.71, and 3,416.66 million, respectively.

Economic losses from all-cause premature death (HB_1):

$$HB_1 = \Delta HT_1 \times HCL \qquad (Eq.8)$$

$$HCL = \sum_{y=1}^{t} GDP_y = GDP_0 \times \sum_{y=1}^{t} \frac{(1+a)^y}{(1+r)^y} \qquad (Eq.9)$$

The economic loss of all-cause premature death is calculated using the revised human capital method (Jin and Zhang, 2018). ΔHT_1 is the number of all-cause premature deaths and HCL (human capital loss) is the revised per capita human capital loss. t is the average lost life years to premature death, GDP_y is the discounted value of per capita in the future year, and GDP_0 is the base year per capita GDP. a is per capita GDP growth rate, and r is the social discount rate (Xin-gang and Fan, 2019). These data are from China Statistical Yearbook 2019, Hubei Statistical Yearbook 2019, Hunan Statistical Yearbook 2019, and Chongqing Statistical Yearbook 2019.

Economic losses from other health terminal incapacitation (HB_{2-4}):

$$HB_k = \Delta HT_k \times \left(CH_k + WD_k \times CH_{wdk} \right) \qquad (Eq.10)$$

The economic loss of hospitalization disability of other health terminal is calculated by disease cost method, where ΔHT_k is the number of hospitalized respiratory diseases, CH_k is the hospitalization cost of the disease k, WD_k is the number of days off work due to illness, and CH_{wdk} is the cost of days off work due to illness. Data were collected from China Statistical Yearbook 2019, Hubei Statistical Yearbook 2019, Hunan Statistical Yearbook 2019, and Chongqing Statistical Yearbook 2019.

Results and analysis

The value of agricultural products

The total value of agricultural products in the Three Gorges of Yangtze River in 2018 was USD19,515,347,348 (1,404.76 billion yuan), among which the economic value of agricultural products in Chongqing was USD31,412,296,299 (226.113 billion yuan), USD77,849,948,586 (560.382 billion yuan) in Hunan, and 618.265 billion yuan in Hubei. Crops contribute to the main part of the economic value of agricultural products in the Three Gorges of Yangtze River, accounting for 66.12% of the total value. Livestock products, forestry products, and fishery products account for 21.14%, 6.19%, and 6.55%, respectively in *Table 2*.

The value of clear water products

The total value of clear water products in Three Gorges of Yangtze River is USD129,845,354,411 (934.657 billion yuan). The clean water products provide the region with services such as raw material production, climate regulation, soil nutrient maintenance, and aesthetic landscape, which is of high value. The value of clear water

in Chongqing, Hunan, and Hubei are USD117,334,365,800 (84.46 billion yuan), USD42,456,674,799 (305.613 billion yuan), USD75,655,312,493.5 (544.5845 billion yuan) respectively.

Table 2. Output value of agricultural products in 2018

Type	Product	Output[1]		
		Chongqing	Hunan	Hubei
Crops	Food crops	28.974	94.083	92.658
	Oil	4.349	15.846	21.591
	Cotton	0	0.608	1.06
	Bast fiber	0.17	0.117	0.139
	Sugar plant	0.238	0.884	0.726
	Tobacco	0.746	2.277	0.789
	Herbs	0	19.529	0
	Vegetable and melon	74.174	156.826	147.657
	Tea	40.281	39.266	45.935
	Fruit	11.47	91.055	37.361
	Subtotal	160.402	420.491	347.916
Livestock products	Poultry meat	39.883	92.762	139.814
	Honey	1.982	0	0
	Eggs	3.881	0	17.599
	Cocoon	0.786	0	0.232
	Subtotal	46.532	92.762	157.645
Forestry products	The volume of timber felled	0	0.28	2.876
	The Volume of bamboo fell	0	0	3.559
	Other agricultural products	0	36.602	28.199
	Production of seedling	15.453	0	0
	Subtotal	15.453	36.882	34.634
Fishery products	Aquatic product	3.726	10.245	78.071
	Total	226.113	560.382	618.265

[1]In billion yuan

The value of fresh air products

The result shows that fresh air in the Three Gorges of Yangtze River has no effective value in 2018. The annual average PM2.5 concentrations in Chongqing, Hunan, and Hubei are 40, 41, 71 $\mu g/m^3$ respectively, which all fail to meet the second-level national standard. The health benefits loss due to PM2.5 pollution of premature death, respiratory diseases, lung neoplasms, and so on is as high as USD 41,582,807,452.1 (29932.27 billion yuan). Hubei province has the highest loss, and premature death is the highest in that of health terminals. The specific accounting results are shown in *Tables 3* and *4*.

The value of ecological products in Three Gorges of Yangtze River

As shown in *Figure 1,* in 2018, the total effective value of ecological products in the Three Gorges of Yangtze River was USD32,499,882,789.1 (2,339.417 billion yuan),

where the value of agricultural products was USD14,514,119,348 (1,044.760 billion yuan), and the total value of clean water was USD 129,846,563,041.1 (9,346.657 billion yuan). Hubei province accounts for a relatively high proportion of the effective value of ecological products in the Three Gorges of Yangtze River, but its economic value loss caused by air pollution is also at a high level. It is urgent to ensure the balanced development of ecological products in Hubei Province. Air pollution is generally present in both Hunan and Chongqing. Air pollution control is a common task of the Three Gorges of the Yangtze River.

Table 3. Health terminal effect in 2018

Health terminal	Health effect[1]		
	Chongqing	Hunan	Hubei
All-cause death	73049	188236	2775008
Respiratory disease	16450	29796	0
Circulatory disease	23608	72555	642497
Chronic respiratory disease[2]	87238	6175	187338
Lung neoplasm	12867	29617	0
Total	213212	326379	3604843

[1]In person
[2]Chronic obstructive pulmonary diseases of the whole population or chronic respiratory disease of people under 70 years old

Table 4. The loss of health terminal benefit in 2018

Health terminal	Health benefit[1]		
	Chongqing	Hunan	Hubei
All-cause death	-71.668	-139.891	-2769.61
Respiratory disease	-0.174	-0.293	0
Circulatory disease	-0.25	-0.713	-7.138
Chronic respiratory disease[2]	-0.922	-0.061	-2.081
Lung neoplasm	-0.136	-0.291	0
Total	-73.15	-141.247	-2778.83

[1]In billion yuan

The value of ecological products of Three Gorges of Yangtze River is USD 43,145,732,879 (310.573 billion yuan) in Chongqing, USD 120,306,484,462 (865.994 billion yuan) in Hunan and USD 22,623,610,550 (162.85 billion yuan) in Hubei. *Figure 2* illustrates the Three Gorges of the Yangtze River the contribution of agricultural ecological product value is generally higher than that of clear water. Chongqing has the highest value of agricultural products, accounting for 73%, while Hubei has the highest value of clear water products, accounting for 47%. As agricultural products are relatively basic ecological products, there is room for further development of ecological products in regulating services, maintenance services, and cultural services. Governments of TEEGC still have much to do in developing the value of ecological products.
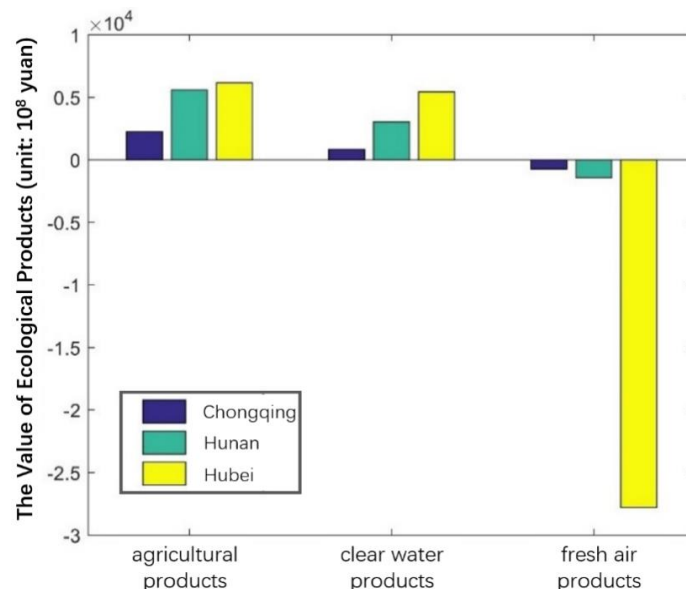
Figure 1. *The value of ecological products in Three Gorges of Yangtze River in 2018*
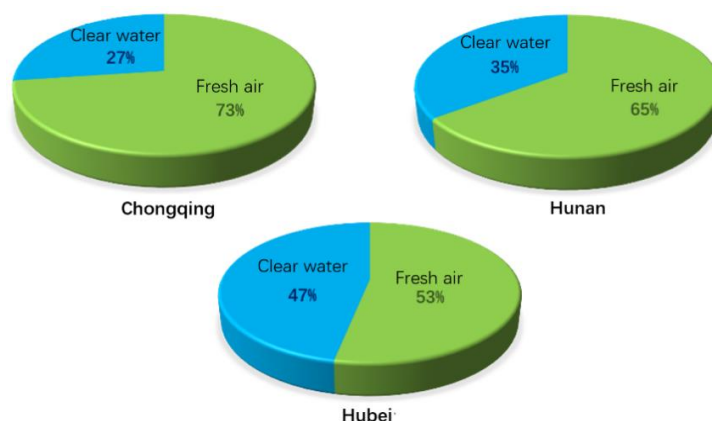

Figure 2. *Ecological product value distribution in 2018*

Discussion

Eco-products are an important element in realizing the transformation of "green mountains are golden mountains" and a medium for "green mountains" to enter the market, provide services for human beings, and contribute to human welfare. Based on the principle of harmony between human beings and nature, eco-products can externalize the potential value of "green mountains" and provide a "pressure pump" for China's ecological and economic development to realize "ecological priority and green development" as soon as possible. development". In this study, the value of eco-products in three provinces and cities in the Three Gorges region, Hubei, Hunan, and Chongqing, located in the middle and upper reaches of the Yangtze River, was calculated, and the results showed that eco-products have considerable value. If the ecological products market is developed in the studied provinces and cities, the realization of ecological products will greatly help to alleviate and improve the current contradiction between ecological protection and economic development.

Ensure the balanced and diversified development of ecological products

According to the calculation results of this study, the values of agricultural products and clear water in Hubei Province, Hunan Province, and Chongqing City remain at the normal level and still have room for further growth. However, the air quality is not optimistic. As an ecological product, the air of the Three Gorges of the Yangtze River has no effective value. The lack of air value greatly restricts the diversified development of ecological product value in the middle and upper reaches of the Yangtze River. Therefore, governments are obliged to address the root causes of air quality problems and expand the value of clean air.

The main air pollution in Hubei province is excessive concentrations of fine particulate matter. First of all, to improve air quality, in urban land management, special ecological function zones should be planned to create urban green space. Open spaces covered by vegetation or water, which can provide natural and recreational functions, can reduce PM2.5 concentration, improve the overall air quality, and bring huge population health benefits (Han et al., 2023). Secondly, when the air value is low, it is suggested that improving air quality goes hand in hand with realizing the value of other ecological products. In the transformation process of "green mountains are golden mountains", implementation of the circulation of ecological environmental governance rights is advised, which conduces to the realization of both the improvement of the ecological environment and the value-added of ecological products. Finally, vigorously develop green science and technology, encourage scientific and technological innovation, promote the coordinated development of green industry and ecological industry, and fundamentally reduce the generation of inhalable particulate matter.

Build a trading platform for ecological products

"Green mountains are golden mountains" put forward other attributes of ecological products except public ones. Enabling ecological products to circulate as commodities requires trading platforms. Due to the long-standing public nature of ecological products, the government must lead and guide the transformation of some of them into commodities and promote the emergence of trade. However, the sustainability of the trade of ecological products cannot rely solely on the government but requires a platform with high openness and multi-participation. The original intention of ecological products is to realize the harmonious coexistence between man and nature.

Therefore, it is not desirable to apply a completely free market platform to ecological products. On the premise of maintaining openness, the government needs to examine the credit status and business qualification of the trading subjects according to the category of ecological products. For example, during the period when the participants hold the ecological products for business, the environmental protection departments are obliged to supervise the use of the ecological products, to ensure that the ecological assets are transferred in the form of value-added and their inherent value is not damaged.

As for the implementation of the trading of ecological products, provincial and municipal governments can select the pilot areas, such as Ezhou in Hubei Province, to build a comprehensive trading platform for emission rights, water rights, carbon sinks, natural assets, etc. In the value realization pioneer zone, considerable progress has been made in the preliminary work, such as the division of natural asset ownership and the increase of ecological product value, which is suitable for operating the platform. With

the rapid development of informatization, the platform construction is recommended to adopt the online and offline dual-track system and critically learn the successful cases of developed countries. It is a wise choice for financial institutions to participate in the construction under stable conditions, which helps to inject vitality into the construction of the ecological product market.

Establish trading rules and ownership of ecological products

At present, the forms of ecological product trading mainly include ecological compensation, resource quota trading, ecological equities trading, resource property right circulation, etc. Mazar and Zhong (2010). The main principle of ecological compensation is that whoever damaged should compensate. The subject of ecological protection has the right to obtain ecological compensation from the subject of ecological damage, and the subject of ecological damage has the obligation to pay the cost of ecological damage. Based on clear ownership of natural resources, ecological product trading is dominated by government participation. In China, the ownership of natural resources is mainly owned by the state and the collective, and there is no complete sense of individual ownership of natural resources, only a certain part of individual rights to natural resources. This obstructs the extensive application of ecological compensation and greatly reduces the participation of individuals and enterprises in ecological compensation.

The content of the ecological compensation agreement signed between provincial governments lacks a unified standard. In river basin ecological compensation between provinces, Hunan province, and Chongqing city signed an ecological compensation agreement, which is based on whether the upstream city reaches the standard of ecological governance in a certain period as the basis to decide whether the final compensation party is the upstream city or the downstream city. This is similar to the betting agreement in financial options, and relevant agreements have also been signed by various cities and governments in Hunan Province. However, in the field of watershed ecological compensation, there are no clear rules and regulations on how to judge, monitor the governance results, and calculate the compensation amount. Therefore, establishing a scientific compensation standard in light of the characteristics of ecological governance is still a problem that need to be addressed. Depending on the calculation methods in this paper, the evaluation criteria should be more detailed complying with the ecological and environmental standards issued by China. Besides, the government is supposed to guide relevant departments to establish a statistical index system and do the basic work of statistical accounting of indicators pertinently.

Resource property rights transfer mode is a value realization mode in which the property owners of ecological resources benefit through the sale and purchase of resource property rights and shareholding. In this model, the ownership of ecological products is contained in the resource property rights in the market circulation, but in the process of circulation, if the attributes and uses of ecological resources are not clearly defined, the enterprises change the use of assets privately out of interest, and it is just an empty talk to ensure the initial attributes of ecological assets. From the process of realizing the value of ecological products, most of the rights for ecological products are reflected through ownership and management rights, and in some value realization practices, the two are directly mixed without clear rights belonging to ecological products, and the transaction of ecological products can never jump the circle of ownership, which is a major drawback for the future development of ecological

products. Therefore, the ownership of ecological products should be clearly defined in laws and regulations, and the spirit of innovation should be maintained in the practice of ecological products by applying other carriers that can realize the value of ecological products.

Conclusion

In conclusion, this study has underscored the critical importance of establishing a comprehensive mechanism for assessing and realizing the value of ecological products. Through a methodology developed for assessing ecological products based on both quality and cost considerations, the study provided valuable insights into the ecological product value in the Three Gorges region of the Yangtze River. The results highlighted the substantial value of ecological products, particularly clean water and agricultural products, with Hubei Province leading in ecological product value. Furthermore, in alignment with China's emphasis on green and sustainable development, the study emphasizes the need for strategies to ensure the balanced and diversified development of ecological products. Recommendations include the establishment of a dedicated market platform for ecological products and the formulation of rules and protocols governing ecological product transactions. These measures are crucial for realizing the potential of ecological products in contributing to both environmental protection and economic development.

Moreover, the study calls for concerted efforts to address challenges such as air pollution and the lack of effective valuation mechanisms for certain ecological products. It suggests integrating ecological protection into urban land management, promoting green technology innovation, and developing trading platforms with government oversight to ensure the sustainable circulation of ecological products as commodities. Additionally, the study underscores the importance of establishing clear ownership and trading rules for ecological products. This includes standardizing ecological compensation agreements and defining property rights to facilitate the transfer and circulation of ecological resources. By addressing these issues, policymakers and stakeholders can unlock the full potential of ecological products in driving green and sustainable development in China's Three Gorges region and beyond.

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