Estimation of Ecological Compensation Standard Based on Ecological Service Value Calculation

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Abstract: The static calculation of ecological service value is the main basis for determining the value of water ecological service function in a river basin. The reasonable ecological service value calculation is the premise to determine the limit value of ecological compensation standard. Based on the types and calculation methods of watershed water ecological service value, on the basis of comprehensive comparison of the applicable scope and reliability of calculation results of various calculation methods, combined with the landscape characteristics of the study area, the ecological value assessment method of watershed forest system was given. Taking the Shanxi reservoir area in the Feiyun River basin as an example, the ecological value of the four service functions of supply, regulation, culture and support services was calculated, and the total ecological service value of the reservoir area was determined to be 7.062 billion yuan/a. The ecological services value of the forest in Shanxi reservoir area in terms of water retention, environmental purification, and reduction of soil waste requires cost inputs from the people upstream of the reservoir area. In order to achieve the overall equitable, coordinated and sustainable development of the basin, the beneficiaries of the downstream ecological service value of the basin should compensate the upstream 1.498 billion yuan/a, which is about 21% of the ecological service value.

1. Introduction
As a service function beneficial to human development, the supply of ecosystem service value affects stakeholders at all institutional levels. The main problem in the estimation of watershed ecological service value (ES) is that the value is not identified and the data cannot support the local environmental decision-making. ES is not uniformly distributed spatially and flow at different rates, resulting in a mismatch between the ecological services and their beneficiaries on a spatiotemporal level [1-2]. According to the concept of integrated management of water resources and the classification of ecological services, the authors evaluated the ecosystem services at the basin level [3-5]. Indirect and direct drivers of ecosystem change may weaken ecosystem service provision in the upper reaches of the watershed. Drivers include demographic, economic, socio-political, technological, physical or biological factors. The identification and recognition of environmental service providers, beneficiaries and value flows in environmental policies can contribute to the spatial redistribution of resources as the value of services increases or degrades in relation to specific land owners or land management mechanisms, to achieve tangible ecological landscape. It is very important to establish the monetary value evaluation method of ecological service function in the implementation of environmental policy.
Supporting the participation of all ES stakeholders (users and providers) is an important part of maintaining ecosystem services and allocating the costs and benefits of supply and demand budgets equally.

Based on the basin level, forest ecosystems are often the main providers of a range of environmental services, such as water regulation, soil conservation and fixation, climate regulation, habitat supply, food production and recreation services [6-8]. Previous studies have shown that the increase of river discharge is related to the deforestation or forest value conversion of small watershed (<1km²) and large watershed (>700km²). Water users in the lower reaches should compensate for the cost of water conservation and water regulation in the upper reaches of forest protection areas [9-10]. The researchers established a quantitative correspondence relationship between the treatment cost of drinking water and the forest coverage rate, and the change of treatment cost was largely subject to the percentage change of forest coverage rate in the water source area. Watersheds with high forest and wetland coverage are particularly effective in reducing and delaying run-off and purifying water quality. Forest ecosystem service functions are studied from different scales all over the world [11-13].

As the basis for the formation of diversified ecosystem services value, water resources have special characteristics in the accounting of ecosystem services value, which results in the difference of regional water ecological compensation standard. The determination of ecological compensation standard is the key to determine whether the water source can maintain a good ecological status. The existing research mainly adopts the opportunity cost method, the willingness to pay method and the water quantity and quality cost allocation method. The valuation of Forest Ecosystem Services is essentially a measure of the costs and benefits that spill over from traditional markets, and externalities are brought into the decision-making of economic actors through corresponding compensation, so as to realize the ecological friendly behavior of different social subjects. However, as far as the actual situation is concerned, due to the lack of a unified standard for the estimation of indicators and values adopted, and the calculation results of ecological benefits based on the existing calculation theories and methods are often too large to be accepted by the society. Therefore, the reasonable estimation of ecological service value is the premise to determine the limit value of ecological compensation standard. The characteristic scale of ecosystem and its service function determines the spatial scale of ecological compensation problem. Based on the types and calculation methods of the value of basin water ecological services, this paper presents a method for the value assessment of watershed forest ecosystem based on the comprehensive comparison of the applicable scope of various calculation methods and the reliability of calculation results. According to the corresponding relationship between the watershed forest ecosystem service value and the watershed ecological compensation standard, the upper limit of the watershed ecological compensation should be determined in consideration of the payment ability and willingness of the downstream beneficial areas of the study area.

2. Overview of the Research Area
Shanxi Reservoir was formed by cutting off the main stream of Feiyun River and is located in Shanxi Town, Wencheng County. Its catchment area is 1529km², with a total storage capacity of 1.824 billion m³ and a normal storage capacity of 1.291 billion m³, and Shanxi Reservoir area (Zhaoshandu) has 14 main tributaries, including Yuquan stream, Sishi, Xuezhoukou stream, Huangtankeng, Sancha stream, Hongkou stream, and Jujiang stream, etc. Its water system distribution is shown in Fig.1.

The forest coverage rate in the upper reaches of Feiyun River basin is as high as 73.25%. In 2015, the precipitation of Shanxi Reservoir was 2,068.2mm, the annual evaporation was 1,643.1mm (approximately 79% of the annual precipitation), the forest coverage of the reservoir area was 1,66389hm², and the forest area with water conservation function was 139,900 hm². In this area, the resources of grassland and wetland are relatively small, most of which are distributed on the edge of the forest or around the river bank. The water source protection scope and administrative area of the upper reaches of Shanxi Reservoir involve Taishun County, Wencheng County and Ruian city, the economic characteristics of the towns and villages in the region are dominated by agricultural economy, and at the same time, its industrial base is not rich; the downstream of the reservoir is
3. Estimation of forest ecological service value

3.1. measure

The author uses remote sensing technology to classify the types of forest ecosystems, and comprehensively uses digital analysis technology to evaluate the forest ecological service value of the Shanxi Water Control Reservoir. The evaluation content includes climate regulation, nutrient recycling, environmental purification, product provision, water conservation, and conservation. The forest ecosystem of Shanxi Reservoir has four service functions: supply, regulation, culture and support services. The evaluation index system and methods derived therefrom are shown in Table 1.

| Service category | Service project       | Objective function            | Evaluation methods                      | Calculation method                      |
|------------------|-----------------------|-------------------------------|----------------------------------------|----------------------------------------|
| Supply service   | Water conservation    | Adjust the amount of water    | Alternative engineering method          | Water storage × water price             |
|                  |                       | Purifying water quality       | Alternative engineering method          | Water storage × purification cost       |
|                  | Provide product       | Material product production   | Market value method                     | Quantity of material products x market value |
| Regulating services | Conserve the soil    | The solid earth              | Shadow engineering method               | Cost of reservoir per unit volume of water lost |
| Service category | Service project | Objective function                                                                 | Evaluation methods        | Calculation method                                                                 |
|------------------|----------------|-------------------------------------------------------------------------------------|---------------------------|-------------------------------------------------------------------------------------|
| Service project  | Protecting fertilizer | Shadow pricing                                                                      | N, P, K and other nutrient loss × fertilizer price |
| Atmospheric      | Fixed CO₂      | Market/Shadow                                                                        | Fixed amount of CO₂ × price of carbon sequestration or afforestation cost |
| regulation       | O₂ release     | Market/Shadow                                                                        | The amount of O₂ released × the price of industrial oxygen production or the cost of afforestation |
| Purify the       | Absorbing gas   | Cost analysis                                                                        | The amount of absorbed polluting gas × the cost of removing a unit of polluting gas |
| atmosphere       | Dust detention  | Cost analysis                                                                        | Dust holding capacity × reducing cost per unit of dust |
| Support functions| Nutrient       | Shadow pricing                                                                      | The quantity of N, P and K in stand holding × fertilizer price |
| accumulation     | The trees retain nutrients |                                                                                   |                                                                                    |
| Biodiversity     | Species conservation | Cost analysis                                                                        | Shannon Wiener index, endangered index and endemic index were calculated |
| Forest protection| Forest protection | Cost analysis                                                                        | Forest area × forest protection costs per unit area |
| Cultural         | Cultural tourism | Literature evaluation                                                               | The number of literature papers × literature value |
| services         | Scientific research and service |                                                                                   |                                                                                    |
|                   | Forest recreation | The law of travel expenses                                                           | Tourism income |

3.1.1. Water conservation

Forest water conservation refers to the "temporal and spatial" distribution pattern of adjusting forest water volume through forest canopy, ground cover and soil intercepting precipitation, mitigating surface runoff, enhancing infiltration, and reducing flood peaks. The public welfare forest exerts its ecological protection effect through the three processes of canopy interception, litter interception, and forest soil water regulation. This paper uses the difference in water storage capacity between forest land and non-forest land to evaluate the water storage function of public welfare forests in Shanxi Reservoir area, and uses water storage capacity to measure the water purification capacity of public welfare forests [14-15]. The comprehensive water storage capacity method is to comprehensively consider the interception and storage of precipitation by the forest canopy, litter and soil layers. This method can more comprehensively reflect the water conservation function of the forest. The calculation formula is as follows:

\[
w = \sum (C_i + L_i + S_i) \times A_i
\]

Where, \(w\) is the forest regulation water volume (t); \(A_i\) is the area of different forest types (hm²); \(C_i\) is the canopy interception of different forest types (t/hm²); \(L_i\) is the saturated water holding capacity of the forest litter layer (t/hm²); \(S_i\) is the water storage capacity of forest soil (t/hm²).

The benefits of water conservation in public welfare forests are calculated using the shadow engineering method in the "Standards for Evaluation of Forest Ecosystem Service Functions" (LY/T1721-2008) [16]. The functional value of water conservation in public welfare forests is mainly measured from two aspects: water transfer benefits and water quality improvement benefits. The calculation formula is

\[
V_w = w \times (P_1 + P_2)
\]

Where, \(V_w\) is the value of water conservation in the public welfare forest (yuan); \(w\) is the water storage capacity of public welfare forest (m³); \(P_1\) is the shadow price of water regulation and storage (6.11 yuan/m³); \(P_2\) is the shadow price of water purification benefits (2.65 yuan/m³).

3.1.2. Provide product

The direct economic value of forest ecosystem service functions is mainly forest products and forest by-products, including timber, medicinal materials, water (dried) fruits, bamboo shoots and other products. Use the market value method to calculate according to the following formula
Where, $V_p$ is the total value of products provided by the forest ecosystem (yuan); $S_i$ is the distribution area of the $i$-th forest type or fruit (hm²); $V_i$ is the net growth or yield per unit area of the $i$-th forest type (m³/hm²); $P_i$ is the market price of wood or fruit of the $i$-th forest type (yuan/m³); $i$ represents different forest types.

3.1.3. Conserve the soil
The evaluation of the benefits of forest soil retention and fertilizer conservation and soil improvement in the Shanxi Reservoir area is measured from three aspects: the benefits of forest soil retention, forest fertilizer protection and soil improvement. The soil-fixing capacity of forests is expressed by the amount of forest soil in a specific area; the amount of forest soil is measured by the amount of forests that reduce the amount of soil erosion of the same area of non-forested land. The calculation formula is

$$D_i = A_i \times (S_w - S_i)$$

Where, $D_i$ is the soil consolidation amount of forest type $i$ (t/a); $A_i$ is the area of different forest types (hm²); $S_w$ is the soil erosion modulus without forest land (t/(hm².a)); $S_i$ is forest type $i$ Forest soil erosion modulus (t/(hm².a)).

The ecological benefits of forest soil consolidation in the reservoir area are

$$V_s = D_i \times \frac{C_r}{\rho_i} = A_i \times (S_w - S_i) \times \frac{C_r}{\rho_i}$$

Where, $V_s$ is the annual soil fixation value of the forest (yuan/a); $D_i$ is the soil fixation amount of forest type $i$ (t/a); $C_r$ is the reservoir capacity cost (yuan/m³); $\rho_i$ is the average density of sediment (T/m³).

In this paper, the monetization value of ammonium bicarbonate, superphosphate and potassium sulfate equivalent to the amount of pure N, P, K in forest fixed soil is used to measure the benefits of forest fertilizer conservation [17]. The calculation formula is

$$V_s = K_x \times \sum \frac{D_i \times \left( N_i \times \frac{C_1}{R_1} + P_i \times \frac{C_2}{R_2} + K_i \times \frac{C_3}{R_3} + m \times C_i \right)}{\rho_i}$$

Where, $V_s$ is the value of the forest's annual soil conservation (yuan/a); $K_x$ is the cost of sand excavation (12.6 yuan/m³); $\rho_i$ is the soil bulk density of forest type $i$ (t/m³); $N_i$, $P_i$, $K_i$ are the nitrogen, phosphorus and potassium content in forest soil (%); $R_1$ is the nitrogen content of diammonium phosphate (%), $R_2$ is the phosphorus content of diammonium phosphate (%), $R_3$ is the potassium content of potassium chloride (%); $C_1$ is the average price of diammonium hydrogen phosphate in the market (2400 yuan/t), $C_2$ is the average price of potassium chloride (2200 yuan/t), and $C_3$ is the average price of organic matter (320 yuan/t).

3.1.4. Atmospheric regulation
The vegetation around Shanxi Reservoir area can absorb carbon and release oxygen, which can effectively increase the free oxygen ion content in the atmosphere, improve the air environment quality, and make it easier for people to live and work in peace. Based on the market value method [18], this paper estimates the economic value of forest carbon sequestration and oxygen release in the reservoir area

$$V_{cp} = V_c + V_o = \sum Q_i \times P_i + \sum Q_0(i) \times P_0$$

Where, $V_{cp}$ is the total value of forest carbon sequestration and oxygen release (yuan/a); $V_c$ is the total value of forest carbon sequestration (yuan/a); $V_o$ is the total value of forest oxygen release (yuan/a); $Q_i$ is the first The carbon fixation amount of type I forest trees (t/a); $Q_0(i)$ is the oxygen release amount of the i-th type forest tree (t/a); $P_i$ is the unit value of carbon fixation amount (yuan/t); $P_0$ is the oxygen release The unit value of the released amount (yuan/t).

Studies have shown that plants can fix 264g of CO₂ and release 193g of O₂ for every 162g of dry matter produced by plants: that is, for every 1g of dry matter produced by plants, they need to absorb.
1.63 g of CO\textsubscript{2} and release 1.19 g of O\textsubscript{2}. In view of this, the project calculates the amount of carbon fixation and oxygen release based on the material balance method
\[ \begin{align*}
Q_c &= 1.6123 \times B_i \\
Q_o &= 1.1724 \times B_i
\end{align*} \]  
(7)
Where, \( Q_c \) is the forest carbon sequestration (t/a); \( Q_o \) is the forest oxygen release (t/a); \( B_i \) is the forest annual net growth biomass (t/a).

3.1.5. Purify the atmosphere
The ecological benefits of forest purification of the atmospheric environment are mainly calculated from three aspects: absorbing polluted gas, holding dust, and providing negative ions.

1) The formula for calculating the ecological value of absorbing sulfur dioxide
\[ U_{SO_2,i} = K_{SO_2} \times Q_{SO_2,i} \times A_i \]  
(8)
Where, \( U_{SO_2,i} \) is the annual SO\textsubscript{2} absorption value of i-type forest vegetation (yuan/a); \( K_{SO_2} \) is the cost of SO\textsubscript{2} pollution control (yuan/kg); \( Q_{SO_2,i} \) is the annual SO\textsubscript{2} absorption per unit area of forest (kg/(hm\textsuperscript{2}.a)); \( A_i \) is the area of type i forest (hm\textsuperscript{2}).

2) Formula for calculating the ecological value of fluoride absorption:
\[ U_{HF,i} = K_{HF} \times Q_{HF,i} \times A_i \]  
(9)
Where, \( U_{HF,i} \) is the annual fluoride absorption value of i-type forest vegetation (yuan/a); \( K_{HF} \) is the cost of treating fluoride pollution (yuan/kg); \( Q_{HF,i} \) is the annual fluoride absorption per unit area of forest (Kg/(hm\textsuperscript{2}.a)); \( A_i \) is the area of type i forest (hm\textsuperscript{2}).

3) Formula for calculating the ecological value of nitrogen oxide absorption:
\[ U_{NO,i} = K_{NO} \times Q_{NO,i} \times A_i \]  
(10)
Where, \( U_{NO,i} \) is the value of nitrogen oxides absorbed by forest vegetation of type i (yuan/a); \( K_{NO} \) is the cost of nitrogen oxide pollution treatment (yuan/kg); \( Q_{NO,i} \) is the annual absorption of forests per unit area Nitrogen oxide (kg/(hm\textsuperscript{2}.a)); \( A_i \) is the forest area of type i (hm\textsuperscript{2}).

4) Formula for calculating the ecological value of dust fall:
\[ U_{Si} = K_S \times Q_{Si} \times A_i \]  
(11)
Where, \( U_{Si} \) is the value of the annual dust retention of i-type forest vegetation (yuan/a); \( K_S \) is the cleaning cost (yuan/kg); \( Q_{Si} \) is the annual dust retention per unit area of forest (kg/(hm\textsuperscript{2}.a)); \( A_i \) is the area of type i forest (hm\textsuperscript{2}).

5) Provide calculation formula for negative ion ecological value:
\[ U_f = 5.256 \times 10^5 \times \sum [A \times H_i \times K_m \times \frac{(Q_m - 600)}{L_m}] \]  
(12)
Where, \( U_f \) is the value of negative ions provided by the forest each year (yuan/a); \( A_i \) is the area of type i forest (hm\textsuperscript{2}); \( H_i \) is the height of forest type i (m); \( K_m \) is the value of negative ions (yuan/a); \( Q_m \) is Negative ion concentration (pieces/cm\textsuperscript{3}); \( L_m \) is anion lifetime (min).

3.1.6. Nutrient accumulation
The forest vegetation in the Shanxi reservoir area constantly absorbs various nutrients from the environment and stores them in their own organs. This paper selects the index of tree nutrient accumulation (nitrogen, phosphorus, potassium) to reflect this function. The calculation formula is:
\[ V_n = \frac{A_i \times B_i \times (N_i + \frac{P_i}{R_1} + \frac{K_i}{R_2})}{R_3} \]  
(13)
Where, \( V_n \) is the annual accumulated nutrient value of forest vegetation (yuan/a); \( A_i \) is the forest area of type i (hm\textsuperscript{2}); \( B_i \) is the annual net productivity of forest vegetation of type i (t/(hm\textsuperscript{2}.a)); \( N_i \), \( P_i \), \( K_i \) are respectively the nitrogen, phosphorus, and potassium content of forest soil (%); \( R_1 \) is the nitrogen content of diammonium phosphate (%); \( R_2 \) is the phosphorus content of diammonium phosphate (%); and \( R_3 \) is chlorinated Potassium content (%); \( C_1 \) is the average price of diammonium hydrogen phosphate in the market (2400 yuan/t), \( C_2 \) is the average price of potassium chloride (2200 yuan/t), \( C_3 \) is the average price of potassium chloride (2200 yuan/t),
and $C_3$ is the average price of organic matter (320 yuan/t).

3.1.7. Biodiversity
The formula for calculating the annual protected biodiversity value of the forest ecosystem in the Shanxi reservoir area is:

$$U_b = \sum (S_{bi} \times A_i)$$  \hspace{1cm} (14)

Where, $U_b$ is the value of forest annual protected biodiversity (yuan); $S_{bi}$ is the value of annual protected species resource per unit area of forest (yuan/hm2); $A_i$ is the forest area of $i$ vegetation type (hm2).

3.1.8. Forest protection
This article uses the public welfare forest to reduce the occurrence of natural disasters such as floods and droughts and the corresponding losses (direct and indirect losses) to measure the forest protection benefits of the public welfare forest. The formula for evaluating forest protection benefits of ecological public welfare forests is:

$$U_r = K_z \sum A_i$$  \hspace{1cm} (15)

Where, $U_r$ is the annual protection value of the forest (yuan/a); $A_i$ is the forest area of the $i$ vegetation type (hm2); $K_z$ is the disaster reduction value per unit area of the forest (yuan/hm2), directly economic through the reservoirs in Wenzhou over the years Conversion of loss, sediment loss and storage capacity loss caused by rivers, lakes and reservoirs.

3.1.9. Cultural Tourism
With the development of society, forest eco-tourism has become more and more popular, and the function of forests to provide leisure and entertainment has become stronger. In view of the actual situation in the Shanxi Reservoir area, the ecotourism industry is relatively developed. The author evaluates the value of forest recreational functions through the number of tourists and their consumption level. The formula for calculating the value of forest recreation is:

$$U_t = \sum N \times c_i \times \rho_i$$  \hspace{1cm} (16)

Where, $U_t$ is the value of forest recreation in the reservoir area (yuan); $N$ is the annual number of visits to the forest in the reservoir area (person); $c_i$ is the average consumption of tourists (yuan/person); $\rho_i$ is the proportion of tourists in the $i$ category (%).

Shanxi Reservoir is a water source protection area in Wenzhou, and its ecological service value is relatively high, and the value of culture, education and scientific research is relatively small, so it will not be considered in the research.

3.2. The calculation results
In the process of calculating the ecological value of the forest ecosystem of Shanxi Reservoir, the data used are mainly from the annual update data of forest resources of Taishun County, Wencheng County and Ruian City in The reservoir area of Shanxi Reservoir in 2015. Publicly published literature; Statistical yearbook, water resources bulletin and environmental quality bulletin of Taishun County, Wencheng County and Ruian city. The relevant statistical data of the functional departments of the forestry Bureau, meteorological Bureau, Water Resources Bureau and Statistics Bureau in Taishun County, Wencheng County and Ruian city. Historical observation data of The Ecological station of Shanxi Reservoir and public data published by the authority. In the calculation process, the values of relevant parameters are mainly based on the current norms and data published by scientific research: the unit regulated water value refers to the Forest Ecosystem Service Function Assessment Norms (LYT_1721-2008); The calculation of the value quantity of purified water quality refers to the average price of water for residents and industry in Wenzhou (2.65 yuan/t); The anion production expense of public welfare forests shall be $5.8185 \times 10^{-18}$ yuan per unit recommended in the Forest Ecosystem Service Function Assessment Standard. The average scientific research value of ecosystems per unit
area was 197.8 yuan /hm² using the average value of Costanza et al. for the global scientific research and cultural function value of forest ecosystems.

According to the evaluation results of forest ecological service function in The Reservoir area of Shanxi Water Control Project in 2015, based on the comprehensive comparison between the forest ecological service value of the reservoir area of Shanxi Water Control Project and previous research values, this paper determined that the forest ecosystem service function value was 7.062 billion yuan /a (7.062 billion yuan /a). The value of forest ecological service in The Reservoir area of Shanxi Water Control Project is summarized in Table 2. The order of the total benefits of each ecological service function is as follows: water conservation benefits (69.84%) > atmospheric regulation benefits (9.12%) > air purification benefits (8.33%) > cultural tourism benefits (5.94%) > forest protection benefits (3.37%) > providing product benefits (2.12%) > conserving soil benefits (1.16%) > biodiversity protection benefits (0.07%) > nutrient accumulation benefits (0.04%). The research results presented by the author are approximately the same as the assessment results of forest ecological service function of Zhejiang province by relevant researchers [14,15,19], which are in line with the regional ecological service function characteristics and can provide a basis for forest ecological protection, biodiversity maintenance and ecological value play in the reservoir area of Shanxi Reservoir.

### Table 2 The forest ecosystem service value of Shanxi Reservoir (Unit: ten thousand Yuan / a)

| Function category | service items | Functional indicators | Ecological Service Lower Limit (ten thousand Yuan / a) | Total value | Value ratio % |
|-------------------|---------------|-----------------------|-----------------------------------------------------|-------------|--------------|
|                     | Broadleaf forest | Coniferous forest | Mixed forest | total |                     |
| **Provision of services** | | | | | |
| Water conservation | | | | | |
| Provide products | | | | | |
| Conserve the soil | | | | | |
| Atmospheric regulation | | | | | |
| Purify the atmosphere | | | | | |
| Nutrient accumulation | | | | | |
| **Regulation service** | | | | | |
| Water conservation | | | | | |
| Purify the atmosphere | | | | | |
| Nutrient accumulation | | | | | |
| **Support function** | | | | | |
| Biodiversity | | | | | |
| Forest protection | | | | | |
| Cultural Tourism | | | | | |
| **Cultural service** | | | | | |
| Research Service | | | | | |
| Forest recreation | | | | | |
| **Total service value** | | | | | |

### 4. Calculation of watershed ecological compensation standards

Ecological compensation originates from natural ecological compensation, which refers to the sensitivity and restoration ability of natural ecosystem to disturbance, and then gradually evolves into economic means and mechanism to promote ecological environment protection. At present, watershed water ecological compensation is mainly based on ecological and economic theories, and the theory of internalization of environmental external cost and public goods is the theoretical basis.

The main goal of forest ecological compensation for Shanxi Reservoir is to provide more clean water for Wenzhou urban area and ensure the water quantity and quality. Therefore, two ecosystem services, fresh water supply and water quality purification, are selected for accounting in this paper. The added value is regarded as the ecosystem service income increased by the upstream people's economic and material input to the downstream residents in the reservoir area, and is the upper limit of ecological compensation [20]. The functions of water conservation, environment purification and soil waste reduction in the value composition of forest ecological services in Shanxi Reservoir area all require the cost input of the upstream people in the reservoir area, while there is no feedback behavior of the upstream input in the downstream area. According to the corresponding relationship between the connotations of water ecological value and the contents covered by the calculation of ecological
compensation standard, the calculation results of the compensation standard (upper limit) based on ecological value in The Reservoir area of Shanxi are shown in Table 3.

Table 3 Calculation results of compensation standard of forest ecological value in Shanxi reservoir (100 million Yuan / a)

| Function category | service items | Functional indicators | Beneficiaries of water ecosystem services | Whether the compensation range | Compensation standard |
|-------------------|---------------|-----------------------|------------------------------------------|-------------------------------|-----------------------|
| Provision of services | Water conservation | Adjust the amount of water | ✓ ✓ | Downstream Nationwide global | No | Currently implemented 14.92 |
| | | Purified water quality | ✓ | Yes | | |
| | Provide products | Material product production | ✓ | | No | |
| | | Fix soil | ✓ ✓ | | Yes | 0.0556 |
| | Conserve the soil | Keep fat | ✓ | | No | |
| | | Fixed CO₂ | ✓ ✓ ✓ ✓ | | No | |
| Regulation service | Atmospheric regulation | Release O₂ | ✓ ✓ ✓ ✓ | | No | |
| | | Dust absorption | ✓ ✓ ✓ ✓ | | No | |
| | | Purify the atmosphere | Produce negative oxygen | ✓ ✓ ✓ ✓ | | No | |
| | | Nutrient accumulation | Tree retention nutrient | ✓ ✓ ✓ ✓ | | No | |
| Support function | Biodiversity | Species conservation | ✓ ✓ ✓ ✓ | | No | |
| | Forest protection | Forest protection | ✓ ✓ ✓ ✓ | | No | |
| | Research Service | | ✓ ✓ ✓ ✓ | | No | |
| | Forest recreation | | ✓ ✓ ✓ ✓ | | No | |
| Cultural service | Cultural Tourism | | ✓ ✓ ✓ ✓ | | No | |
| | | | | | | |
| Total compensation standard | | | | | 14.9756 |

According to the level of upstream ecological protection investment, downstream economic development capacity, regional resource coordination and distribution capacity, people's willingness to pay, social fair development needs, Wenzhou's positioning of ecological compensation in the reservoir area, the richness of Feiyun River water resources, and the ecology of Shanxi Reservoir The current situation and protection efforts, this paper determines that the forest ecological compensation standard based on the dominant level of ecological protection is 1.498 billion yuan/a.

5. Conclusion

In this paper, the ecological value of the four service functions of forest ecosystem supply, regulation, culture and support services in Shanxi Reservoir is calculated to be 7.062 billion yuan/a. In order to achieve the overall equitable, coordinated and sustainable development of the basin, the beneficiaries of the downstream ecological service value of the basin should compensate the upstream 1.498 billion yuan/a, which is about 21% of the ecological service value. The ecological compensation standard scheme should be implemented on the premise that the upper and lower reaches of the reservoir achieve regional integrated development, sufficient water quantity (water supply guarantee rate is 100%), the ecological water quantity of the river meets the demand, the upstream ecology is good, the non-water area of the reservoir realizes full forest coverage and other economic development and the water ecosystem can play a sustainable role. The calculation method of watershed ecological compensation standard based on forest ecological service value in this paper, which has a certain universality and can be extended to the calculation of ecological service value in the southern high-water area. In view of the complexity and applicability of the calculation process of ecological compensation standard, the author will strengthen the exploration of digital research methods of ecological service value in the follow-up research, improve the accuracy of the results. The theory of economic optimization will be applied to the process of determining compensation standards to expand the research field of watershed ecological compensation standards.

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