Study of Water Resources Accounting in China

——A Case Study Based on Anhui Bozhou

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Abstract: Due to the increasing concern on the trade-off between economic development and environmental protection, this paper focuses on the accounting of the ecological environment net assets. The objective of this paper is water resources accounting based on a case study of Bozhou in Anhui province. By adopting the market value method and the alternative engineering method, all the value amounts are summarized to form the ecological balance sheet of water resources. Then the assets, liabilities and net assets are developed based on the data of Bozhou.

1. Introduction

Since the reform and opening up, China's economic growth has grown rapidly. However, the ecosystem management model needs further explored. The actual value of the ecosystem to human society is often underestimated due to the lack of effective reflection mechanism in the current economic market.[1]For example, China's total water resources is 2,876.12 billion cubic meters in 2017, and the per capita water resources accounted for 2074.5 m^3.The pressure on regional water resources was lower than the Asian average, ranking below the global level, and the regional distribution was extremely uneven. Facing the substantial increase in resource demand, developing the ecological asset assessment system is vital for improving resource management and maintain ecological coordination and development.

In last decades, the capitalization of ecosystems has drawn highly attention of policy makers, such as the Costanza's assessment of global ecosystem services in 1997, the Millennium Ecosystem Assessment Project (MA2005), and the "Ecosystem Gross Production Value (GEP) Assessment" developed by the Chinese Academy of Sciences [2] [3]. Researchers in China have also pointed out that the current assessment of ecological services "is mainly reflected in the changes in ecosystem services in different assessment periods", while the lateral changes in the same evaluation period have fewer research results.[4]

Moreover, Chinese government has expressed highly attention on the environment resources asset management. In April 2015, the "Opinions of the CPC Central Committee and the State Council on Accelerating the Construction of Ecological Civilization" marked the central concern and attention

of natural resources. On April 10, 2018, the Ministry of Natural Resources of the People's Republic of China was officially established, which means that the development of China's natural resources asset management has become more systematic.[5] The preparation of natural resources balance sheet is beneficial to clarify the economic value of the ecosystem, fully consider its cost, and thus participate more effectively in the market economy. It is conducive to macro-level supervision and comprehensive cadre examination and supervision system. And the system of accountability to improve the evaluation system of local governments in China.

Based on the current society's emphasis on natural capital accounting and the progress of research at home and abroad, this paper will combine the current domestic research theory with reference to the progress of the Guizhou Provincial Bureau of Statistics's accounting office to explore the preparation of natural resources balance sheet, and using the example of Bozhou to carry out an framework analysis.

2. Theory Framework of Water Resources Accounting

Based on the ecosystem-based service assessment system, the treatment of the water resources ecological balance sheet can be divided into value accounting and functional volume accounting. The functional quantity focuses on the statistical description from the physical level, which is characterized by intuitive and accurate, like the total amount of pollutants, the amount of pollutants to be cleaned, the number of tourists. However, since the main body is different, measure unit is different, it is difficult to compare horizontal data and statistics data. This determines the functional change accounting only suit for the direct change analysis of single object.

Therefore, the value analysis used in this paper is based on the functional quantity, by converting the amount of functional quantity of a product or service into the value accounting[6],which measured by price. The value is determined from the two aspects, the main cost and the related cost. As shown infigure1, the common value methods of water resources ecosystem services are divided into market value and alternative market.

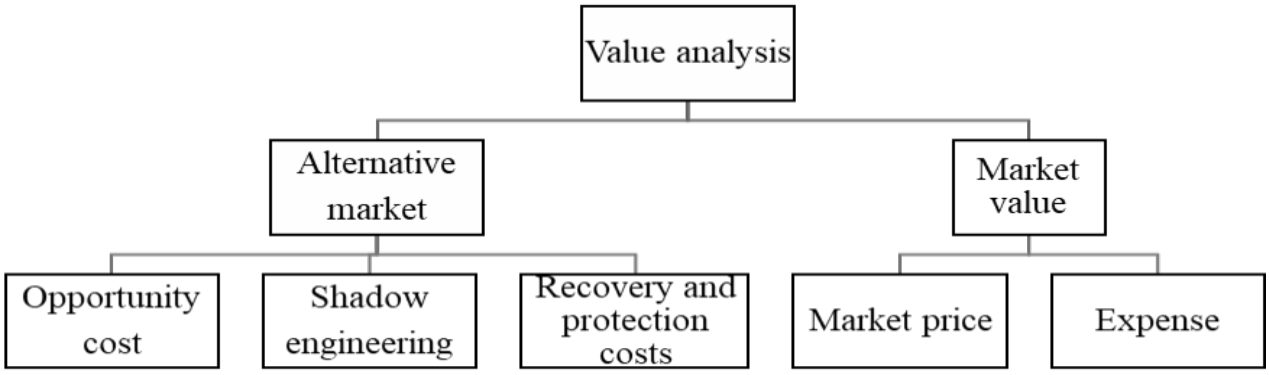

Figure 1: Framework of water resources accounting.

Based on the situation in Bozhou, the market price method and the shadow engineering method are mainly used. According to the disclosure of water resources information, the water supply value and freshwater products are mainly analyzed.

1)Market price method

For ecological assets or ecological services with actual market prices, they can be expressed directly by the product of price and quantity. The essence is to use ecological assets as part of the assets to

participate in the production process. As a result, ecological changes will affect prices and output levels by affecting production efficiency and production costs. [7] Based on this, the analysis of the value of ecological assets can be expressed by changes in market prices and productivity.

2)Shadow Engineering method

The shadow engineering method, also known as the alternative engineering method, is to estimate a loss item that is not directly obtainable, assuming a project with similar actual effects but not actually carried out is used. The method of engineering construction cost to replace the economic loss of the project to be evaluated. For example, natural water has the function of purifying water quality, it is difficult to obtain direct value quantification. Therefore, an alternative project can be found, such as building a sewage treatment plant. The water purification capacity of the sewage treatment plant can be compared to the self-purification capacity of the water body. The input cost of the sewage treatment plant can be regarded as the related function of the natural water body when it is polluted - the alternative cost of purifying the water quality.

However, there are two limitations to using alternative costs. First, the measurement of the shadow engineering method is based on the transformation of functional quantities, while natural assets have multiple functions, resulting in a one-to-one correspondence that cannot be perfected. Second, the alternative project is not unique, which leads to a large cost gap for different replacement costs, which affects the accuracy and representativeness of the results.

2.1. Asset Accounting Framework

At present, China's mainstream water resources accounting system includes three categories: supply contribution, regulation contribution, and culture contribution.[8]

2.1.1. Calculation of Water Supply Value

Water supply value is based on the necessary output, take market value method to calculate. Including urban domestic water, rural domestic water, industrial water, agricultural water. By using these index, we can get water supply value if we combined with current water prices.
the formula is:

$$V_{\text{Water supply}}=\sum(w_{\text{Water supply}})*P_{i.} \quad (1)$$

Where: $V_{\text{Water supply}}$ is the amount of water supply to the economy; $W_{\text{Water supply}}$ is the functional quantity of water supply for the i-type water users; P_i is the unit price of water for the i-th user.
The environmental cost conversion by alternative cost method is:

$$V_{\text{Environmental water supply}}=W_{\text{Environmental water supply}}*V_{\text{Economic water supply}}/W_{\text{Economic water supply}} \quad (2)$$

Where: $V_{\text{Environmental water supply}}$ is the amount of water supply to the environment;$W_{\text{environment water supply}}$ is the amount of water supply function corresponding to the environmental main body. $W_{\text{economic water supply}}$ is the water supply function of the water user in the economy.

2.1.2. Calculation of Freshwater Value

Freshwater value means the water environment provides for freshwater products, and is accounted for using the market value method. Its accounting entities include economic freshwater products and wild products. Due to the local environmental transformation activities started in Bozhoy in 2017. The freshwater wild fishing has been temporarily banned, and the river channel has been cleaned up on a large scale, only economic farming has been carried out. Therefore, only the economic freshwater product accounting is carried out in this paper.
The formula is:

$$V_{\text{Economic freshwater products}}=\sum(q_{\text{Artificial i}}*p_{\text{Artificial i}}+q_{\text{Wild i}}*p_{\text{Wild i}}) . \quad (3)$$

Where: $v_{\text{Economic freshwater products}}$ is the amount of product value corresponding to the economy; $Q_{\text{Artificial i}}$, $Q_{\text{Wild i}}$ is the artificial and wild aquaculture production of the i-type freshwater products; $P_{\text{Artificial i}}$, $P_{\text{Wild i}}$ is the price of artificial and wild breeding market for i-type freshwater products.

2.2. Liability Accounting Framework

Similar to the logic that assets can be directly converted through functional quantities, the value of water liabilities is based on the loss of water resources. This requires the introduction of a new concept, “water environment pressure”. Water liabilities are only generated when the negative impact of human economic activity on the water environment exceeds a critical value, resulting in stress overload.[9]

2.2.1. Excessive Water Withdrawal

According to the source of water, excessive water withdrawal can be divided into surface water overtake and groundwater overtake. For surface water, the current internationally recognized upper limit for the development and utilization of river surface water resources is 40%. Based on this, the threshold can be set at 40%. [10] For groundwater, gradient pricing can be used based on the depth of groundwater exploitation.

2.2.2. Excessive Emissions of Pollutants

Since water resources have the characteristics of self-purification, the critical value can be set as the pollutant discharge when the water pollutants exceed the water body's capacity.

2.2.3. Value Accounting

On the basis of the functional quantity, we can determinate the price of each type of final product and service and deduce the value of the accounting water ecological liabilities. For the calculation of the function quantity to the value quantity, refer to Section 2.1 for the accounting method and thinking of the value of the environmental entity assets, which will not be repeated here.

3. Case study based on Bozhou

3.1. Water Resources Asset Accounting

A complete water resources asset accounting balance sheet should consider the supply services, mediation services and cultural services. They are converted into value by the adaptive cost method,

and finally summarized in value accounting, according to the actual situation of local water resources in Bozhou, some evaluation indicators are not applicable. Considering the data collection difficulty, this asset preparation will only select the supply water supply, and the freshwater products will be compiled.

3.1.1. Data Source

1)Water supply data
Data such as the amount of water entering and leaving the country, the total amount of water resources, and the variables of water storage are involved. These data can be found in the water resources bulletin published by Bozhou government.

Table 1: Summary of water resources in Bozhou in 2018.

Category	2018 (100 million m^3)	2017 (100 million m^3)	Compared with 2017 (%)
Precipitation	83.62	77.05	+8.5
Surface water	18.84	15.83	+19
Shallow groundwater	15.54	NA	NA
Groundwater resources	11.26	NA	NA
Total amount	30.16	NA	NA
Water production coefficient	0.36	NA	NA

2) Water usage data
According to the local public water bulletin, the total water consumption of the city is 1.054 billion m^3. The specific water use ratio is shown in the following Table 2:

Table 2: Specific water use ratio.

Category	Farm irrigation	Forestry, Husbandry and Fishing	Industry	Urban public	Live of residents	Ecology
Ratio	55.0%	3.9%	18.2%	3.1%	16.2%	3.6%

3) Freshwater product production data
Normally, freshwater products are divided into wild aquatic products and cultured aquatic products. Due to the extensive environmental rectification carried out in Bozhou in 2018, wild aquatic products have been thoroughly cleaned up and cannot be effectively aggregated. Freshwater products are mainly divided into fish, crustacea, shellfish and others four categories.

3.1.2. Functional Quantity Accounting

1) Water supply functional quantity

Table 3: Water supply functional quantity.

Type	proportion(%)	Water consumption (10,000 m^3)
Farmland irrigation	55.0	57970.0
Forest fish	3.9	4110.6

industry	18.2	19182.8
Town public	3.1	3267.4
Resident life	16.2	17074.8
ecosystem	3.6	3794.4

2) Freshwater product functional quantity

There are many types of freshwater products in Bozhou. However, due to the implementation of the province-wide river clearing and remediation campaign in 2018, the wild species in freshwater products have been greatly damaged and require a long ecological cycle to be restored. Therefore, this time only the capacity of the artificial breeding is accounted. The production of artificial culture was obtained from the 2018 Bozhou Statistical Yearbook as shown in Table 4.

Table 4: Freshwater product functional quantity

Area/(t)	Total	Breeding	Fishing	Fish	Crustacea	Shellfish	Other
Citywide	53540	47235	6305	4936	855	470	44
Wucheng	13160	12630	530	458	62	NA	10
Guoyang	14230	12570	1660	1610	47	3	NA
Mengcheng	13950	11543	2407	1716	647	10	34
Lixin	12200	10592	1708	1152	99	457	NA

3.1.3. Value Quantity Accounting

1)Water supply value

The value of water supply is based on its functional quantity. The economic function can be directly calculated by the market value method, which is obtained from the water usage of each industry and the performance of the water unit; Among them, the resident population of Bozhou in 2018 was 5.169 million, and the urban population was 2.057 million, accounting for 39.79%. The domestic water will be distributed according to this ratio; the environmental water retention will be treated as a substitute unit by the sewage treatment plant, only considering Sewage treatment price. The calculated values are as follows:

Table 5: Water supply value.

Accounting entity	Water type	Water supply (10,000 m^3)	Unit price (yuan/m^3)	value (ten thousand yuan)
Economic	Rural life	10280.74	1.6	16449.18
	Town life	10061.46	2.2	22135.21
	Agricultural water	62080.6	1.6	99328.96
	Industrial water	19182.8	1.74	33378.07
	Subtotal	101605.6		171291.42
Surround-ings	Retain water	3794.4	0.75	7345.80
	Subtotal	105400		7345.80
Total				178637.22

2) Freshwater product value

The value of freshwater products consists of economic value and environmental value. Economic value includes fishing and breeding. The amount of aquaculture in 2018 has been calculated by the

statistical yearbook, which is 671.1 million yuan. In the fishing industry, fish mainly include crucian, chub and grass carp. According to the current price of the farmer's market, it can be set at 7.5 yuan/500g, which is 15,000 yuan/t. Also, Crustacea, shellfish and others can be basically evaluated by the market price. The statistics are as follows:

Table 6: Freshwater product value.

Accounting entity	product type		Production (t)	Unit price (yuan/t)	Value (ten thousand yuan)
Economic	Fishing	Fish	4936	15000	7404.00
		Class A	855	61050	5219.78
		Shellfish	470	59800	2810.60
		Other	44	107890	474.72
	Breeding		47235	NA	67110.00
Surroundings	Wilding		0	NA	NA
Total					83019.1

The value of water resources assets can be obtained by summarizing the above indicators. The assets value (water supply, freshwater products) in Bozhou in 2018 was 26,656,320 yuan. The economic volume is 2,384,142,200 yuan, accounting for 91.11% of the total value; the environmental amount is 73.45 million yuan, accounting for 8.89% of the total value.

3.2. Water Resources Liability Accounting

As a fast-growing emerging city, Bozhou is China's “medicine capital”, the largest trading market for Chinese herbal medicine raw materials. Its water usage gap is very large, and water demand has increased sharply in recent years. After the surface water cannot meet the needs, the groundwater has to be exploited, resulting in possible geological problems such as subsidence cracks and long-term lack of groundwater. In addition, the brewing industry in Bozhou is developed, there are more than 80 wineries in the city, such as Gujinggong. These large-scale wine enterprises have caused serious industrial pollution, excessive sewage discharge, serious river pollution, and severe water quality problems.

Since 2017, in response to the policy guidance of the central “Clear water and green mountains are like gold and silver mountains.”, the Bozhou Municipal Government has cooperated with Anhui Province to launch many environmental remediation actions against water pollution, and has successively established a number of new small sewage treatment plants, regulated river hygiene and improve the relevant river chief system. In this context, it is important to clarify the main water liability framework of Bozhou, and debt accounting was carried out for excessive water withdrawal and excessive pollutant emission.

3.2.1. Functional Quantity Accounting

1) Excessive water withdrawal

The effects of excessive water withdrawals include economic and environmental impacts. By economic impact, there are surface water, shallow groundwater and middle groundwater. The upper limit of development and utilization of surface water in Bozhou is 40% of the total water resources. In 2018, the surface water resources of Bozhou was 1.884 billion m^3. The calculated threshold value was 754 million m^3. According to the Water Resources Bulletin, the amount of shallow groundwater

recoverable in Chenzhou in 2017 decreased by 112 million m^3 from the beginning of the year, and the shallow groundwater level is lower than the available amount.

The medium and deep groundwater exploitation is 180 million m^3. For many years, the industrial and urban life of Bozhou mainly uses the middle groundwater as the water supply source. According to the data of recent years, the range of the old thermal power plant and the Gujing winery formed by the city of Bozhou is about 540km^2. The environmental aspect mainly considers the impact on freshwater products and water purification. The freshwater products here are net assets in the asset business and are therefore no longer considered. In summary, the liabilities caused by excessive local water withdrawal are as follows:

Table 7: Excessive water withdrawal.

project	Usable amount (100 million m^3)	Actual usage (100 million meters^3)	Debt (100 million m^3)
Surface water	7.54	7.62	-0.08
Shallow groundwater	0	1.12	-1.12
Deep groundwater	0	1.80	-1.80
Total amount	7.54	10.54	3.00

2) Excessive emission of pollutants

The surface water resources in Bozhou are extremely scarce, so the excessive discharge of pollutants has less effect on the water supply. The impact on pollutant emissions here only considers the purification of water quality, which means the replacement cost. The specific pollution situation is as 2018 Water resources report.

3.2.2. Value Quantity Accounting

The value calculation is divided into excessive water withdrawal and excessive pollutant emission. In order to ensure the consistency of accounting policies, the market value method is still used for excessive water withdrawal, the virtual water supply is distributed according to the ratio, and the alternative cost method is adopted for the evaluation of pollutant emission value.

1) Excessive water withdrawal

Table 8: Value quantity accounting of excessive water withdrawal.

Accounting entity	Water type	Water supply ratio (%)	Water supply (10,000 m^3)	unit price (yuan/m^3)	value (ten thousand yuan)
economic	Rural life	9.75	2925	1.6	4680
	Town life	9.55	2865	2.2	6303
	Agricultural water	58.9	17670	1.6	28272
	Industrial water	18.2	5460	1.74	9500.4
surroundings	Retain water	3.6	1080	0.75	810
total			30000		49565.4

2) Excessive emissions of pollutants

The pollution emission value of Bozhou can be calculated according to the alternative cost method.

According to the requirements of the "Notice on Adjusting the Sewage Charge Collection Standards and Other Issues" issued by the State in 2018, the calculation results are as follows:

Table 9: Excessive emissions of pollutants.

kind	Governance cost (yuan/kg)	Function quantity (t)	Value (ten thousand yuan)
Cod	1.40	3944.00	552.16
Ammonia nitrogen	1.40	590.00	82.60
Volatile phenol	0.08	0.51	0.00
Total ammonia	0.50	1546.00	77.3
Total phosphorus	0.25	99.00	2.48
total			714.54

3.3. Bozhou Water Resources Balance Sheet

Based on the last two sections, the Bozhou water resources balance sheet in 2018 is summarized in Table 10.

Table 10 Bozhou water resources balance sheet: Unit: 10,000 yuan.

Project type	Economic side surface	Environmental aspects	Total
I. Assets			
Water supply	171291.42	7345.80	178637.22
Freshwater products	83019.10	——	83019.10
2. Liabilities			
Excessive water withdrawal	48755.40	810.00	49565.40
Excessive emissions of pollutants	714.54	——	714.54
Third, the net asset value			1811376.38

4. Conclusions

This compilation is based on the definition of assets and liabilities in traditional accounting, choose the measurement method and classify the source assets and liabilities of water resources. Combining the water resources data of the city of Zhangzhou in 2018, compiled the balance sheet on the basis of the market value method and the shadow engineering method.

The main innovation of this paper is reflected in the linking of the conditions of assets and liabilities through functional quantity, which ensures the consistency of internal accounting measurement principle. A case study on the preparation of water resources balance sheet in Bozhou was carried out, which reflected the state of the first year of water resources remediation activities in Bozhou. It's conducive to timely and accurate confirming of current malpractices, and providing samples and references for subsequent developments and assessments

In view of the current research on water resources balance sheet, due to the weak nature of its interdisciplinary research and the poor theoretical foundation, there are still many shortcomings in the method. In terms of classification, there are still many limitations. Besides, some measures, such as the related costs caused by cultural influences, which is failed to find a reasonable way to measure

and represent.

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