



Recognition, measurement and presentation of water resources liabilities

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ABSTRACT

The construction of the balance sheet of water resources is unable to do without the recognition and measurement of liabilities in water resources. Based on the resent research findings, this paper recognized the existence of liabilities in water resources and advocates verifying the elements of liabilities in water resources. On the basis of comparing the different subjects about the definitions of liabilities, the general characteristics of liabilities were sorted out. The intension and extension of liabilities in water resources were redefined in combination with the unique characteristics of water resources. The liabilities in water resources were grouped to three heads and 10 sub-subjects as watering liabilities, watering environment liabilities and watering disaster liabilities; according to the definition of liabilities in water resources and the current situation about managements and utilizations in water resources in China. The measurement models of liabilities in water resources were constructed by physical quantity measurement and value measurement, respectively. Finally, it was taking Zhengzhou as an example and constructed the liability in water resources balance sheet accounting and analyzed its element structure of water resources liability. This study enriches and improves the theoretical system for the confirmation, accounting and presentation of liabilities in water resources, which realize the practical measurement of liabilities in water resources. It provides the reference for exploring the preparation of balance sheets of water resource and the green development and utilization of water resources.

Keywords: Water resources liabilities; Recognition of water resources liabilities; Water resources liability measurement model; Balance sheet of water resources

1. Introduction

Water resources are not only an ecological wealth, but also as economic and social wealth. In order to promote the construction of ecological civilization and carry out the concept of green development, the Third Plenary Session of the 18th Central Committee of the Communist Party first proposed the idea and requirement of “explore the construction of natural resources balance sheets, and conduct outgoing audits of natural resources assets for leading cadres” [1,2]. Water resources balance sheet has attracted the attention of government agencies and scholars because of it is as one of the first pilot of exploring natural resources balance sheets [3,4]. Under the exploration of related

researchers, scholars have basically reached a consensus on the report elements, table structure and filling logic of the water resources balance sheet and accumulated certain theoretical and practical experience. However, whether to recognize water resources liabilities, how to define water resources liabilities, how to classify water resources liabilities, how to measure and account for water resources liabilities, and how to report water resources liabilities must be faced and resolved in the preparation of the water resources balance sheet. There are still obvious disputes and deficiencies on the important and difficult issues of water resources, which also seriously affects the promotion and application of the water resources balance sheet to a certain extent.

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There has always been a great controversy in the academic and practical circles as to whether there is a water resource liability, as well as the definition and elements of the water resource liability. Geng et al. [5,6] took SNA and SEEA as clues, and through the study of Australia's water resources balance sheet, believed that the current regulations of SNA and SEEA only regarded natural resources as non-financial non-productive assets. These assets in the accounting system did not reflect liabilities, therefore, the balance sheet constructed in China should conform to international practice and the accounting of liabilities of natural resource are uncertain. Based on the necessity and importance of the existence of liabilities of natural resource, Shi and Wang [7] advocated that the liability elements should be recognized as constructing the balance sheet and believed that liabilities of water resources were caused by human economic activities. It was damaged the water resources environment, which exceeded the capacity of the water environment itself. The results of environmental responsibility were the liabilities of water resource. However, some scholars hold different opinions on it. Gao [8] believed that the expenditures in water resources management and the restoration and compensation of water environmental pollution were regarded as liabilities of water resources. There were many conceptual confusions, which did not meet the framework theories of classic balance sheet. Taking the sustainable utilization of water resources as the point of departure, she defined liabilities of water resources based on the increase or decrease between water rights allocation, water rights use and water rights transactions. It was believed that liabilities of water resources should be determined according to the stock and use of water resources assets owned by water rights subjects, and the water resources development and utilization exceeding its allocation and purchase of water rights are defined as liabilities of water resources. Huang et al. [9,10] combined liabilities of water resources with the most stringent water resources protection in China and believed that as long as the annual development and utilization of water resources did not exceed the "three red lines", there would be no liability of water resources in that year. This researcher also considered liabilities as a balance, but the liabilities of water resources cannot be accumulated. In the field of the measurement of liabilities of water resources, there were few research findings at present. Some scholars had carried out researches on the accounting and measurement of liabilities of water resources based on the confirmation of water resources. Xiang and Zheng [11] and Feng et al. [12] believed the recognition and measurement of liabilities of water resources is as a difficult point in the construction of water resources balance sheet. It compared the definition and classification of liabilities between enterprise balance sheet accounting and government departments' financial statistical accounting and discussed liabilities of water resources from the perspective of resource allocation. In case of dividing the accounting subject and the responsible subject, the liabilities accounting was relatively clear. Jia et al. [13] analyzed the formation mechanism of liabilities of water resources and believed that the accounting of liabilities of water resources need to compare the total amount of water resources rights and interests of equity

subjects. When the water consumption of the equity subject was greater than the water resources rights and interests, the liabilities will be incurred and calculated and according to debtor.

In conclusions, the definition and measurement of elements of liabilities of water resources on water assets and liability statements prepared in current practice still belong to the definition in the traditional water resources statistical category, the concept is relatively vague and the content was incomplete. Based on the international reference standard, many scholars believed that the accounting of assets did not include the measurement of liabilities. They believed that my country's balance sheet of water resources should not account for liabilities of water resources or the complexity of liabilities of water resources. It deliberately avoided the concept of liabilities of water resources as designing the balance sheet. At the same time, how to define the concept of liabilities of water resources, how to divide the content of liabilities of water resources, and how to calculate and present the elements of liabilities of water resources were the key issues in compiling water resource balance sheets. Because of lacking of in-depth discussion and research, it directly caused the lack and deficiency of the theory and practice of my country's liabilities of water resources, and seriously affected the construction and application of my country's water resources balance sheet. This study takes the classical meaning of debt as the entry point, on the basis of comparative analysis of the concepts of liabilities and liabilities of water resources and combined with the characteristics of water resources, redefined the connotation and extension of liabilities of water resources. It also confirmed the basic elements of liabilities of water resources and analyzed the basic elements of water resources. In order to provide some theoretical and practical references for the preparation of balance sheet of water resources through this study, the confirmation, measurement and presentation of water resource liabilities were realized by constructing a measurement model of liabilities of water resources.

2. Recognition of water liabilities

2.1. Definition of water liabilities

2.1.1. Liabilities

Liabilities, as an economic term, formed by past transactions or events of the enterprise and expected to result in an outflow of economic benefits from the enterprise. The characteristics of liabilities can be briefly summarized as the following three points: (1) the generation of liabilities must be established on the basis of before or the past and the future transactions, plans and projects cannot form liabilities; (2) the liabilities must be undertaken by the subject with current obligations. The further obligations of the company will not be included in the scope of current obligations, so it could not be included in the category of liabilities; (3) in the process of repayment of liabilities, the economic benefits of the entity will be reduced. In the face of the current obligation, how to judge whether it can be included in the category of liabilities except satisfying the concept of liabilities and it must also meet the following requirements: (1) the economic benefits associated with liabilities, have the

possibility of outflowing the subject. If the possibility can be clearly demonstrated, the current obligation needs to be included in the liability category. However, if the entity complies with the obligation and the probable outflow of benefits associated with it is negligible, the present obligation cannot be included in the liability category; (2) the amount of outflows of economic benefits in the future can be measured reliably. If an obligation will bring outflows of economic benefits, and the amounts of outflows can generally be calculated in combination with relevant regulations or contract documents, but due to the total outflow time is difficult to grasp, and the length of this time will make the calculation of changes in the time value of money and its potential affects.

Environmental liabilities are a special form of liabilities. The "Accounting and Financial Report on Environmental Costs and Liabilities" formulated by ISAR clearly defines environmental liabilities as obligations incurred by enterprises, related to environmental costs, and in compliance with the recognition standards about liability. From the definition of environmental liabilities, environmental liabilities are mainly aimed at enterprises. Quantify the environmental protection obligations of enterprises from the damage to the environment and the cost of restoring the environment from the economic behavior of enterprises. In SNA-2008, liabilities specifically refer to the outflow of financial assets formed by the creditor's rights-debt relationship of financial assets and mutual lending. Similar to the accounting method of financial assets, financial liabilities are also measured by the four-entry accounting methods. Natural resources are defined as non-financial non-productive assets in SNA-2008. In the SNA accounting system, non-financial assets including natural resources have no liabilities. From the definition of liabilities in accounting liabilities, corporate environmental liabilities and national financial liabilities, it can be seen that no matter the definition of liabilities, it involves both creditors and debtors, and will lead to the outflow of future economic benefits. In view of this, this study introduced the environmental subject as a virtual subject, and defined a liability as a current obligation formed by the relationship between the creditor and the debtor, which expected to lead to the outflow of the debtor's economic benefits and the obligation could be reliably measured.

2.1.2. *Water resources liabilities*

At present, the academia about liabilities of water resources mainly focused on the followings: (1) Some scholars advocated that water resources were a type of assets under the sub-accounts of the national balance sheet assets, and this type of assets did not exist in the form of liabilities. It was not necessary to consider the existence of liabilities of water resources; (2) Most scholars insisted on the objective existence of liabilities of water resources, and advocated that it should be discriminated, classified and confirmed, but the academic community has not given an accurate concept of liabilities of water resources.

This study agreed with the existence of liabilities of water resources and advocated the recognition and measurement of elements of liabilities of water resources in the construction of water resource balance sheets. First of all,

one of the main purposes of the state's construction of the balance sheet of water resource is to use the relevant information in the report to examine the use of water resources by government officials so as to effectively avoid the situation of ecological environment damage and excessive resource consumption that cannot be objectively reflected. In addition, if the depletion of water resources is simply regarded as the reduction of assets, it will also violate the principles of reliability and materiality in the principles of accounting information quality. The reduction of water assets and the generation of water liabilities are both related and quite different. The normal reduction of water resources in the process of proper use is not considered to be the generation of liabilities, because these consumptions have been converted into incremental assets of economic society. No compensation is required. However, when the use of water resources is not conducive to the water ecological environment or exceeds the limit of its carrying capacity, liabilities of water resources will be formed. For example, if the water resource usage of the accounting entity does not exceed the "three red lines" promulgated by the state, it can be classified as water resources assets. When the water resource usage of the accounting entity exceeds the red line value, it indicates that the utilization of water resources has caused damage to human beings and the environment, resulting in a compensation obligation for water resources, and water resources liabilities should be recognized. In my country, the national government is the main body of the ownership of water resources, which is also the main body of accounting for water resources assets and liabilities of water resources.

From the perspective of the essence of economics and the main body of accounting of liabilities of water resources, liabilities of water resources refer to the current obligations related to water resources undertaken by the government in a certain accounting period. It has the following characteristics: (1) Liabilities of water resources must be a current obligation formed in the process of using water resources in the past, and the obligations brought about by future use activities cannot be included in the scope of current obligations; (2) The quantity and value of liabilities of water resources assets can be measured reliably, while it is impossible to the category of water resources liabilities; (3) The loss of economic benefits caused by water resources liabilities will occur in the future, and the related obligations that have been paid are no longer included in the category of liabilities of water resources assets.

SEEA-2012 pointed out that for renewable resources, their natural regeneration ability means that under certain management and mining conditions, the interaction and balance between mining and regeneration will be achieved. The total amount of the resource will not show a decrease. This kind of checks and balances can help natural resources enter a state of supply balance. Humans can also use the resources sustainably under the same level of exploitation. However, if the amount of mining far exceeds the amount of regeneration, a balance cannot be formed and this sustainable state will be broken. In the long run, the resource will gradually change from more to less, and eventually lead to the depletion of natural resources. Therefore, for renewable resources, the difference between the amount of resource exploitation and regeneration can be regarded as the

“excessive” consumption in the process of its development and utilization, that is, natural resource assets and liabilities.

In conclusions, combined with the unique characteristics of water resources, liabilities of water resources can be defined as: those arising from the misconduct of water rights entities in the process of water resources development and utilization in the past, which are expected to lead to the pollution and pollution of the water ecological environment of the accounting entity. Damage and outflow of economic benefits, present obligations to cover the loss and compensation, and the cost and loss of which can be measured. The recognition of liabilities of water resources shall meet the following conditions: (1) The development and utilization of water resources exceeds the renewable capacity of water resources; (2) Losses and compensations related to current obligations are likely to happen; (3) Liabilities of water resources can be measured in currency.

2.2. Classification of liabilities of water resources

Domestic scholars have not yet formed a consensus on the division of liabilities of water resources. Some scholars believe that liabilities of water resources should be defined based on the “excessive” consumption of water resources. The resulting excessive consumption of water resources and the destruction of water ecological environment and other losses. Some scholars have also selected the excessive consumption of regional water resources, the excess discharge of water pollutants, and the loss of water ecosystem service supply capacity as indicators of liabilities of water resources from three aspects: water volume, water environment, and water ecology.

Referring to the relevant scholars’ findings on liabilities of water resources, combined with the definition of liabilities of water resources and the current situation of water resources management and utilization in my country, this study believed that liabilities of water resources can be understood as the main body of water accounting in the process of water resources development and utilization with excessive water resources. The current obligations of the accounting subject formed by consumption and ecological environment pollution damage, namely liabilities of water resources, mainly include two parts: “water volume liabilities” and “water ecological environment liabilities”. The water volume liability refers to the overload compensation cost paid by the accounting entity to make up for the loss of excessive water consumption. Generally, the “water consumption red line” promulgated by the state is used as the standard to define the excessive consumption of water resources. The liabilities of water ecological environment refer to the water environment pollution damage caused by the development and utilization of water resources that exceeds the self-purification, recovery capacity of the water ecosystem and water ecological maintenance cost.

Due to the existence of natural disasters, this study advocated the introduction of “water disaster liabilities” as a sub-category of liabilities of water resources, which reflecting the loss of human production and life caused by natural causes, the amount of water resources exceeding the environmental capacity, and the payment for repairing the loss. The cost of my country is a country with frequent floods.

Every year, flood disasters occur in some areas, which resulting in a lot of economic losses and environmental damage. In view of this, this paper takes the subject of “liabilities of water resources” as one of the elements of water resources liabilities, similar to estimated liabilities and contingent liabilities in accounting subjects are determined by the occurrence or non-occurrence of future events. In the “expected liabilities” chapter of my country’s newly revised government accounting standards, it is clear that natural disasters and public event assistance are included in the subject of estimated liabilities as common contingent events of the government, which is the confirmation of “water disaster liabilities” in the water resources balance sheet. As a sub-item of water resources liability, it provides theoretical basis and practical needs. The subjects of “water disaster liabilities” mainly include river floods, mountain torrents, dam-breaking floods and mudslides. Based on this, this paper recognized water resources liabilities as water volume liabilities, water ecological environment liabilities, and water disaster liabilities, with 10 sub-accounting subjects in three categories. The specific subject division and sub-accounting subject description were shown in Table 1.

3. Measurement of liabilities of water resources

Through the above definition of liabilities of water resources, it can be seen that the formation of liabilities of water resources is mainly divided into human factors and natural factors. The shortage of water resources and the destruction of the water ecological environment form water amount and water ecological environment liabilities. For quantitative liabilities of water resources, a threshold value of liabilities of water resources needs to be determined and the consumption of water resources exceeding the threshold value is regarded as water resources. Excessive consumption of resources can then be recognized as liabilities of water resources; for quality in liabilities of water resources, it is necessary to calculate the maximum discharge quantity of pollutants that water resources can bear according to the pollution-bearing capacity of water resources. On the other hand, water natural disasters have caused great damage to human life safety and production and life, resulting in heavy social and economic losses. In many cases, the liabilities generated by them cannot be directly counted in physical quantities, but can be replaced by direct economic loss accounting. It also caused the inconsistency between the physical quantity and the value of liabilities of water resources, and the phenomenon that the value quantity is greater than the valuation result of the physical quantity. On the basis of clarifying the definition of liabilities of water resources and water resource balance sheet preparation, the scientific and operability of liabilities of water resources accounting, the measurement models of water resources liabilities were constructed separately by physical quantity measurement and value measurement.

3.1. Water liability

3.1.1. Outsourced water rights

The liabilities of outsourcing water rights refer to the purchasing of water rights assets by the accounting subject

Table 1
Water resources liability accounting subject

Account code	Level	Accounting subjects	Accounting description
1001	1	Water liability	
100101	2	Outsourced water rights	Water rights purchased by accounting entities through external markets such as water rights exchanges
100102	2	Excessive water consumption	Excessive use of water resources by accounting entities, resulting in a decline in its renewable capacity
1002	1	Water ecological environment liability	
100201	2	Water pollution control	Cost of the accounting subject's investment in the treatment of water polluted areas
100202	2	Water ecological restoration	Calculate the cost of the main body to restore the damaged water ecological environment
100203	2	Water ecology maintenance	Necessary expenditures for the accounting subject to maintain the balance of the water ecological environment
1003	1	Water disaster liability	
100301	2	River flood	Water body of the river rises above a certain level, threatening the area concerned, and causing the water flow of the disaster
100302	2	Torrent	Sudden floods in mountain creeks
100303	2	Dam break flood	Immediate collapse of dams or other water retaining structures, resulting in floods caused by sudden water leakage
100304	2	Debris flow	Special torrents that carry a lot of sand and rocks due to landslides caused by heavy rain, blizzards or other natural disasters
100305	2	Urban waterlogging	Phenomenon of water accumulation in the city caused by heavy or continuous precipitation exceeding the drainage capacity of the city

through market transactions to meet the water resources demand of the accounting subject. The physical quantity measurement of the liabilities of outsourcing water rights is equal to the quantity of water resources purchased by the accounting subject through the water rights trading market. Value quantity measurement is equal to the fees paid for the externally purchased water rights.

3.1.2. Excessive water consumption

Excessive consumption of water resources means that the amount of water resources in the accounting area exceeds the total amount of water allowed to be allocated to it by the state's strictest water resources management. Exceeding this index value will result in excessive consumption of water resources and form water resources liabilities. Therefore, the physical quantity measurement of the water resource excess consumption account takes the total water withdrawal index configured in the accounting area as the reference value, and its value is equal to the water withdrawal exceeding this index; the value calculation is equal to the expenditure of excess water withdrawal, and the calculation formula is as follows:

$$W_{\text{Physical quantity of water resource consumption}} = Q_{\text{Excessive water intake}} \quad (1)$$

$$V_{\text{Value of excess water consumption}} = Q_{\text{Excessive water intake}} \times P_{\text{Water}} \quad (2)$$

$W_{\text{physical quantity of water resource consumption}}$ is the total amount of water resources consumed by water resources that are consumed in the accounting area (hundred million·m³); $Q_{\text{Excessive water intake}}$ is the amount of water extraction of the total water extraction index that exceeds the national configuration of the country (hundred million·m³); $V_{\text{Value of excess water consumption}}$ is the total amount of water resources consumed by water resources in the accounting area (hundred million·yuan); P_{Water} is the unit cost of water resources in the accounting area, and the unit cost can be calculated using the water resource value accounting method (yuan/m³).

3.2. Water ecological environment liability

3.2.1. Water pollution control

Water pollution control refers to the treatment cost of the discharge of water pollutants in the accounting area exceeding the pollutant-holding capacity of the water body, which resulting in a reduction in the quality of regional water resources or loss of their use value, and serious damage to the water environment. The threshold value of water pollution control liability is limited by the water body's ability to absorb pollutants in the accounting area. The discharge of water pollutants exceeding the threshold value will cause damage to the water environment and generate liabilities of water resources. The physical quantity measurement of water pollution control liabilities is equal to the discharge

of water pollutants that exceeds the red line of the water body’s pollution capacity; the value calculation can use the alternative cost method. In the actual calculation, there are virtual treatment costs and actual treatment expenditures for pollutants. This paper advocates that the virtual governance cost was used for value measurement, because the virtual governance cost can comprehensively reflect the cost of the accounting subject in terms of water pollution compared with the actual expenditure. It is more in line with the needs of the construction of water ecological civilization. The calculation formula is as follows:

$$V_{\text{Value of water pollution control}} = \begin{cases} \sum_{i=1}^n (Q_{Pi} - Q_{Ci}) \times TC_{Pi} & , Q_{Pi} > Q_{Ci} \\ 0 & , Q_{Pi} \leq Q_{Ci} \end{cases} \quad (3)$$

$V_{\text{Value of water pollution control}}$ is the total value of water resources liabilities for water pollution control in the accounting area (hundred million-yuan); Q_{Pi} is the emission of pollutants of category i in the accounting area (t/d); Q_{Ci} is the pollutant-holding capacity category i in the accounting area (t/d); TC_{Pi} is the fictitious unit treatment cost of the i pollutant in the economy (t/yuan).

3.2.2. Water ecological restoration

Water ecological restoration refers to the use of comprehensive means to restore the self-healing function of water resources, strengthen the self-purification ability of water resources, and restore the damaged water ecosystem under the premise of following the natural laws of water resources. Water ecological restoration is not a simple technology, but a complex system engineering, which includes not only the development, design, establishment and maintenance of new water ecosystems, but also water ecological restoration, water ecological renewal and water ecological control.

Because water ecological restoration is mainly an investment of economic capital and labor, and rarely involves the physical amount of liabilities, this study measured the value of liabilities of water ecological restoration, which mainly include three project expenses such as water ecological restoration project expenditure, water ecological landscape construction expenditure and water ecological replenishment. Expenditures for water ecological restoration projects refer to the expenses invested in water ecological restoration of rivers, lakes, reservoirs and other water bodies in the accounting area; expenditures for water ecological landscape construction are supporting projects of water ecological restoration projects, which are based on the restoration of water ecological environment. Ecological environment greening, beautification and improvement projects, such as ecological river course construction, aquatic habitat construction, etc. Water ecological with water replenishment project expenditure refers to the construction of river and lake water system connection projects and other water replenishment projects to improve and enhance the water quality of rivers and lakes and the expenditure on the water ecological environment, such as large-scale water ecological water replenishment projects

such as “diverting the river to Han” and “diverting the river to the Tai”. The formula for calculating the value of water ecological restoration liabilities is as follows:

$$V_{\text{Value of water ecological restoration}} = \sum_{i=1}^n TG_{\text{Restoration } i} + TG_{\text{Landscape } i} + TG_{\text{Project } i} \quad (4)$$

$V_{\text{Value of water ecological restoration}}$ is the total value of water resources liabilities for water ecological restoration in the accounting area (hundred million-yuan); $TG_{\text{Restoration } i}$ is the expenditure of the i water body ecological restoration project in the accounting area (hundred million-yuan); $TG_{\text{Landscape } i}$ is the expenditure of the i water ecological landscape construction project in the accounting area (hundred million-yuan); $TG_{\text{Project } i}$ is the expenditure of the i water ecological hydration project in the accounting area (hundred million-yuan).

3.2.3. Water ecology maintenance

Water ecological maintenance refers to the necessary expenditures to maintain the health of the water ecological environment and maintain the balance of the water ecology, mainly including river maintenance costs, water quality testing costs, and water ecological project operating costs. The measurement of water ecological maintenance liabilities is mainly value accounting, and basically does not involve physical accounting. Therefore, this paper only measures its value. Its basic calculation formula is as follows:

$$V_{\text{Value of water ecological maintenance}} = \sum_{i=1}^n TG_{\text{Watercourse } i} + TG_{\text{Quality } i} + TG_{\text{Operation } i} \quad (5)$$

$V_{\text{Value of water ecological maintenance}}$ is the total value of water resources liabilities for water ecological maintenance in the accounting area (hundred million-yuan); $TG_{\text{Watercourse } i}$ is the cost of the i watercourse maintenance project in the accounting area (hundred million-yuan); $TG_{\text{Quality } i}$ is the cost of the i water quality detection project in the accounting area (hundred million-yuan); $TG_{\text{Operation } i}$ is the cost of the i water ecological engineering operation in the accounting area (hundred million-yuan).

3.3. Water disaster liability

3.3.1. River flood

River flood is a major form of water disaster liability, which refers to the flow of water that rises above a certain level, threatening the area concerned, and causing disasters. River floods would cause huge damage to the normal life of human society, which belong to high-incidence natural disasters. The measurement of liabilities of water disaster can refer to the method of contingencies. According to the occurrence or non-occurrence of disasters as the criterion for determining whether a liability is formed, if a water disaster occurs in the accounting area during the accounting period, it should be measured in the water resources

liabilities. If it appears, it may not be calculated. Because the physical quantity involved in water disasters is too large, this paper advocates that only the value of water disasters is calculated, and the data is equal to the direct economic losses caused by water disasters. The formula for calculating river flood water resources liability is as follows:

$$V_{\text{Value of river flood}} = \begin{cases} TZ_{\text{River flood}} & Q_{\text{Occurrence}} \\ 0 & Q_{\text{Non-occurrence}} \end{cases} \quad (6)$$

$V_{\text{Value of river flood}}$ is the total value of water resources liabilities for river flood disasters in the accounting area (hundred million-yuan); $TZ_{\text{River flood}}$ is the direct economic loss caused by river flood disasters in the accounting area (hundred million-yuan).

3.3.2. Torrent

Torrents refer to flash floods that occur in mountain streams and gully. Like river floods, the generation of liabilities is determined by whether or not mountain torrents occur, and the value is equal to the direct economic losses caused by mountain torrents. Its calculation formula is as follows:

$$V_{\text{Value of torrent}} = \begin{cases} TZ_{\text{Torrent}} & Q_{\text{Occurrence}} \\ 0 & Q_{\text{Non-occurrence}} \end{cases} \quad (7)$$

$V_{\text{Value of torrent}}$ is the total value of water resources liabilities for mountain torrent disasters in the accounting area (hundred million-yuan); TZ_{Torrent} is the direct economic loss caused by the mountain torrent disaster in the accounting area (hundred million-yuan).

3.3.3. Dam break flood

Dam-breaking flood refers to the flood caused by the sudden rupture of dams or other water-retaining structures and the sudden discharge of water bodies, mainly referring to the dam-breaking of artificial reservoirs. Like river floods, the generation of its liabilities is based on whether the dam break flood occurs in the accounting area as the criterion, and the value is equal to the direct economic loss caused by the dam break flood disaster. Its calculation formula is as follows:

$$V_{\text{Value of dam break flood}} = \begin{cases} TZ_{\text{Dam break flood}} & Q_{\text{Occurrence}} \\ 0 & Q_{\text{Non-occurrence}} \end{cases} \quad (8)$$

$V_{\text{Value of dam break flood}}$ is the total value of water resources liabilities for dam failure and flood disasters in the accounting area (hundred million-yuan); $TZ_{\text{Dam break flood}}$ is the direct economic loss caused by the dam break and flood disaster in the accounting area (hundred million-yuan).

3.3.4. Debris flow

Debris flow refers to a special torrent that is caused by natural disasters such as heavy rain and snowstorm and

carries a large amount of sediment and rocks. Debris flow is a catastrophic geological phenomenon with powerful energy and great destructiveness. It occurs most frequently in the mountainous areas of southwest my country. The measurement of its value is equal to the direct economic loss caused by the debris flow disaster. Its calculation formula is as follows:

$$V_{\text{Value of debris flow}} = \begin{cases} TZ_{\text{Debris flow}} & Q_{\text{Occurrence}} \\ 0 & Q_{\text{Non-occurrence}} \end{cases} \quad (9)$$

$V_{\text{Value of debris flow}}$ is the total value of water resources liabilities for debris flow disasters in the accounting area (hundred million-yuan).

$TZ_{\text{Debris flow}}$ is the direct economic loss caused by the debris flow disaster in the accounting area (hundred million-yuan).

3.3.5. Urban waterlogging

Urban waterlogging refers to the phenomenon of water accumulation in cities due to heavy or continuous precipitation exceeding the drainage capacity of the city. Every year after the flood season in my country, due to heavy rainfall, urban rainwater cannot be discharged smoothly, causing serious waterlogging in some cities and posing a great threat to people’s lives and life safety. This is also one of the highest probabilities of water disaster liabilities. The value of the urban waterlogging disaster liability is equal to the direct economic loss caused by it, and its calculation formula is as follows:

$$V_{\text{Value of urban waterlogging}} = \begin{cases} TZ_{\text{urban waterlogging}} & Q_{\text{Occurrence}} \\ 0 & Q_{\text{Non-occurrence}} \end{cases} \quad (10)$$

$V_{\text{Value of urban waterlogging}}$ is the total value of water resources liabilities for urban waterlogging disasters in the accounting area (hundred million-yuan).

$TZ_{\text{Urban waterlogging}}$ is the direct economic loss caused by urban waterlogging disasters in the accounting area (hundred million-yuan).

4. Presentation of water resources liabilities

4.1. Construction of liabilities of water resources accounting tables

The liabilities of water resources accounting statement is mainly used to measure the changes in the quantity and value of liabilities of water resources within a certain period of time by the accounting subject. This statement is the basis for compiling the water resources balance sheet. The liabilities of water resources accounting table constructed in this study is a hybrid report, which not only accounts for the physical amount of water resources liabilities, but also analyzes the value measurement of water resources liabilities. 100 million-m³ and 100 million-yuan, which is mainly measured by value. The basic table format is shown in Table 2. The structure of table is as follows: the horizontal row is divided into two sub-items, physical quantity and value quantity, according to the initial value,

Table 2
Basic table of water resources liability accounting

Account code	Water resources liability	Initial balance		Closing balance		Period change value	
		Physical quantity	Value quantity	Physical quantity	Value quantity	Physical quantity	Value quantity
1001	Water liability						
100101	Outsourced water rights						
100102	Excessive water consumption						
1002	Water ecological environment liability						
100201	Water pollution control						
100202	Water ecological restoration						
100203	Water ecology maintenance						
1003	Water disaster liability						
100301	River flood						
100302	Torrent						
100303	Dam break flood						
100304	Debris flow						
100305	Urban waterlogging						
	Total liabilities						

Agency: Agency code: Year: Unit: hundred million·m³/yuan;
Department Manager: Preparer: Telephone: Date.

end value and period change value of liabilities of water resources; vertical columns are listed according to the elements of liabilities of water resources. The accounting subjects are classified into three categories and 10 sub-subjects, namely “water volume liabilities”, “water ecological environment liabilities” and “water disaster liabilities”. The balance relationship of its statement is “end value of water resources liability = initial value of liabilities of water resources + change value of water resources liability during the period”, and the accounting is divided into physical quantity and value quantity.

4.2. Presentation of liabilities of water resources accounting tables

The data in the form is mainly based on the relevant data of the water conservancy department and the statistics department. The liabilities of water resources accounting form is a mixed form, and the unit of measurement is 100 million·m³ and 100 million-yuan. The list value quantity does not list the physical quantity. According to the availability of data and the representativeness of the research area, Zhengzhou City was selected as the object of preparation and presentation of the liabilities of water resources accounting statement, and the liabilities of water resources accounting statement was prepared by taking Zhengzhou City in 2017 as an example.

4.2.1. Outsourced water rights

Refers to the accounting subject purchasing water rights indicators through market transactions to meet their own water needs. Henan Province is a pilot province for national water rights. Zhengzhou City currently has three water rights transactions signed. In November 2015, Pingdingshan

and Xinmi City signed a water rights transaction of no more than 22 million·m³; in September 2016, Nanyang City and Xinzheng. The city signed an annual water rights index of 80 million·m³ for the South-to-North Water Diversion; in December 2017, Nanyang and Dengfeng City signed a 20 million·m³ South-to-North Water Diversion water rights index. According to the principle of accounting information and substance over form, in 2017, Zhengzhou City purchased 110 million·m³ of water rights, of which Xinmi City purchased 10 million·m³ of water rights, Dengfeng City purchased 20 million·m³ of water rights, and Xinzheng City purchased water rights. 80 million·m³, the prices are 0.87, 0.84 and 0.74 yuan/m³, respectively. After calculation, the physical amount of Zhengzhou's purchased water rights and water resources in 2017 was 110 million·m³, and the value was 84.7 million-yuan.

4.2.2. Excessive water consumption

According to the water resources bulletin, the total water intake of Zhengzhou in 2017 was 1.86541 billion·m³, which was in line with the requirement of 2.160 billion·m³ of water intake in Zhengzhou, the strictest water resource management and control target in 2017 issued by Henan Province. Hence, there is no liability for over-consumption of water resources, this item is 0.

4.2.3. Water pollution control

The discharge of water pollutants in the accounting area exceeds the pollutant-accepting capacity of the water body, resulting in the reduction of the quality of water resources or the loss of their use value. The treatment cost of serious damage to the water environment. According to the actual

situation of Zhengzhou City, the water pollution control liabilities are mainly based on the chemical oxygen demand (COD) and ammonia nitrogen discharged from the accounting area as the accounting indicators. The actual amount is the amount of water pollution discharge that exceeds the pollutant carrying capacity of the water body. According to the data from the Zhengzhou Water Affairs Bureau and the Environmental Protection Bureau, in 2017, the emissions of COD and ammonia nitrogen in Zhengzhou were 21,654.631 and 7,563.2547 tons, respectively. Drawing on the research results of Henan Institute of Water Conservancy Research, the pollutant-holding capacity of COD and ammonia nitrogen in Zhengzhou was divided into 14,698.6 and 957.6 t/a. According to formula (3), in 2017, the amount of water resources liabilities for water pollution control in Zhengzhou City was 6,956.031 tons of COD, 6,606.6547 tons of ammonia nitrogen that the value was 17.14 million-yuan.

4.2.4. Water ecological restoration

It is pointed that the restoration of damaged water ecosystems through comprehensive means. Since water ecological restoration rarely involves the physical amount of liabilities, mainly the investment of funds, this accounting only measures its value. It includes three items: water ecological restoration project expenditure, water ecological landscape construction expenditure and water ecological water replenishment project expenditure. According to the information from the statistics department and the water conservancy department, the value of ecological restoration water resources liabilities in Zhengzhou in 2017 was about 4.547 billion-yuan, of which 1.368 billion-yuan was spent on water ecological projects, 1.694 billion-yuan was spent on water ecological landscape construction, and

1.485 billion-yuan was spent on water ecological with water replenishment projects.

4.2.5. Water ecology maintenance

It is pointed that the necessary expenses to maintain the health of the water ecological environment and maintain the balance of the water ecology, mainly including river maintenance costs, water quality testing costs and water ecological project operating costs. Since, the maintenance of water ecology is mainly the investment of funds and rarely involves the measurement of the physical quantity of liabilities, only the value measurement is carried out in this accounting. The water ecological maintenance projects currently under construction in Zhengzhou mainly include the Jialu River Comprehensive Treatment Project, the Zhengzhou Huayuankou Pumping Station Reconstruction Project and the Suoxu River Comprehensive Treatment Project. According to the data of the Zhengzhou Water Resources Department, the water resources liabilities for water ecological maintenance in 2017 are estimated. The value is 1.12196 billion-yuan, including 484.39 million-yuan for river maintenance, 64.96 million-yuan for water quality testing, and 575.61 million-yuan for water ecological engineering operations.

4.2.6. Water disaster

It mainly includes river floods, mountain torrents, dam-break floods, mudslides and urban waterlogging. According to the actual situation of Zhengzhou, in June 2017, due to continuous heavy rainfall in Zhengzhou, many roads and communities in the urban area suffered serious waterlogging. According to the statistics of the statistics department, the direct economic loss was 21.76 million-yuan. Therefore,

Table 3
Statistics on water resources liability accounting in Zhengzhou City

Account code	Water resources liability	Initial balance		Closing balance		Period change value	
		Physical quantity	Value quantity	Physical quantity	Value quantity	Physical quantity	Value quantity
1001	Water liability	0.84	0.6268	1.1	0.847	0.26	0.2202
100101	Outsourced water rights	0.84	0.6268	1.1	0.847	0.26	0.2202
100102	Excessive water consumption	0	0	0	0	0	0
1002	Water ecological environment liability	0	50.2165	0	56.8610	0	6.6445
100201	Water pollution control	0	0.2839	0	0.1714	0	-0.1125
100202	Water ecological restoration	0	39.46	0	45.47	0	6.01
100203	Water ecology maintenance	0	10.4726	0	11.2196	0	0.747
1003	Water disaster liability	0	0.3319	0	0.2176	0	-0.1143
100301	River flood	0	0	0	0	0	0
100302	Torrent	0	0	0	0	0	0
100303	Dam break flood	0	0	0	0	0	0
100304	Debris flow	0	0	0	0	0	0
100305	Urban waterlogging	0	0.3319	0	0.2176	0	-0.1143
	Total liabilities	0.84	51.1752	1.1	57.9256	0.26	6.75039

Agency: Agency Code: Year: Unit: Hundred million-m³/yuan;
Department Manager: Preparer: Telephone: Date.

the value of water disaster liabilities in Zhengzhou in 2017 was 0.2176 billion.

According to the filling rules of liabilities of water resources accounting table and the calculation of various data, the liabilities of water resources accounting table of Zhengzhou in 2017 was compiled in Table 3 for details. As can be seen from the table, among various liabilities of water resources, the value of water ecological environment liabilities is the largest, and among them, water ecological restoration liabilities account for the highest proportion. The main reason for the increase of water ecological environment liabilities is due to the increase in investment in water ecological restoration projects. The amount of water resources used in Zhengzhou is within the red line allocated by the state, so there is no debt for over-consumption of water resources. The liabilities for water volume is mainly due to the liabilities caused by Zhengzhou's purchase of water rights from other cities after the middle route of the South-to-North Water Diversion Project was opened. Water disaster liabilities are a type of contingencies. According to the actual situation of Zhengzhou City, due to the imperfect urban drainage system and high-intensity continuous rainstorms, urban waterlogging has occurred in Zhengzhou every year in recent years. Water disaster liabilities are also the liabilities from urban waterlogging.

5. Conclusions

Exploring the construction of the balance sheet as an important measure to promote ecological civilization construction and practice the “two mountains” theory has always been the focus of academic and government research. However, due to that it is still in its infancy, scholars have no consensus on such key and difficult issues like liability recognition, measurement and tabular structure. Based on the objective existence of liabilities of water resources and the implementation of the requirements of water resources protection, this study proposes to confirm the elements of water resources liabilities through systematically sorting out the existing research findings. It defined liabilities of water resources as “the current obligations of the water accounting subject due to the excessive consumption of water resources and the destruction of ecological environment during the development and utilization of water resources”. Based on the definition of liabilities of water resources and the status quo of water resources management and utilization in my country, the categories and subjects of water resources liabilities are divided. Constructing a liabilities of water resources accounting statement, taking Zhengzhou City as an example to compile its liabilities of water resources accounting statement in 2017. Through the measurement and analysis of Zhengzhou's liabilities of water resources, it is found that the water volume liabilities and water disaster liabilities in Zhengzhou's liabilities of water resources are relatively relative. The proportion of water ecological environment liabilities is relatively high. The value of water ecological restoration liabilities is the largest, which realizes the measurement and identification of water resources liabilities on the basis for the construction of water resources balance sheet and the formulation of water resources development and protection policies. The implementation laid

the theoretical and data foundation. There are still many problems and deficiencies in this study, which limited by the author's subjective consciousness and objective factors. On the one hand, the accounting and measurement of liabilities are mainly based on the quantity and value of water resources. The quality of different water resources is not considered for the measurement of liabilities. On the other hand, this study only proposed the definition, measurement model and statement construction theory of liabilities of water resources based on certain assumptions. It did not fully consider water resources, the actual characteristics of resource liabilities and the influence of the evolution mechanism of water resources assets and liabilities on the measurement of liabilities. These problems are all difficult issues that must be faced and solved in the in-depth study of the balance sheet of water resources, which are the key points worthy of further exploration in the future.

Author contributions

Y.J. proposed the research ideas and methods of the manuscript and was responsible for data collection and writing. H.W put forward the revise suggestion to the paper.

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Conflicts of interest

The authors declare no conflict of interest.

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