

THEORY AND METHODS OF PREPARING WATER RESOURCES BALANCE SHEET

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Abstract: The preparation of water resources balance sheet is an important measure for water resources environmental protection. This article systematically combs the development process of comprehensive accounting of water resources environment at home and abroad, draws on advanced international experience, analyzes the theoretical basis and technical methods for preparing water resources balance sheets in my country, and discusses water resources. The determination principles of production and liabilities, table prototype design and water value accounting system have put forward solution ideas, initially constructed a technical route for water resources balance sheets that meets the actual needs of my country's water resources management, and provided a comprehensive understanding of the role of water resources balance sheets in comprehensive water resources management. An extended discussion of the role of management. These studies are expected to help explore ways to prepare water resource balance sheets.

Keywords: Water resources balance sheet; Comprehensive accounting of resources and environment; Water accounting; Water resources management

1 RESEARCH PROGRESS AT HOME AND ABROAD

China has more people and less water, and the spatial and temporal distribution of water resources is uneven. The contradiction between water resources constraints and economic and social development has become increasingly prominent. At present, my country's total water consumption has exceeded $6100 \times 108 \text{ m}^3$, the national water shortage has reached $500 \times 108 \text{ m}^3$, and nearly two-thirds of cities have varying degrees of water shortage [1]; the annual wastewater discharge is nearly $800 \times 108 \text{ t}$, and water functional zones have reached standards. The rate is 51%; ecologically sound rivers and lakes account for 16%, and the groundwater overexploitation area is $32 \times 104 \text{ km}^2$ [2]. The reason is that the degree of water resource development and utilization in some areas has approached or even exceeded the control red line, causing a series of ecological and environmental problems such as water shortages, ecological degradation of rivers and lakes, and land subsidence. In March 2016, the Fourth Session of the 12th National People's Congress included "exploring the preparation of natural resource balance sheets and establishing physical accounting accounts" as specific measures to accelerate the improvement of the ecological environment, improve the ecological security mechanism, and improve the ecological environment protection system. Outline of my country's "13th Five-Year Plan". According to the actual needs of natural resource protection and management, we should conduct preliminary accounting of land, forests and water resources and explore the preparation of balance sheets as a pilot project [3]. This is the first time that my country has proposed the preparation of a national-level natural resource asset statement [4]. It is one of the important tasks of the country's comprehensive deepening of reform. It is also a major breakthrough in the theory, methods and means of integrated water resources management [5]. Its great theoretical and practical significance is obvious.

The preparation of natural resource balance sheets and resource and environmental accounting are of the same origin, and are both products of the sustainable development theoretical system [6]. Under the guidance of the concept of sustainable development, it has been widely recognized that the depletion of natural resources and environmental degradation should be included in the System of National Accounts (SNA) [7]. This can avoid the illusion of a country's growth. That is, economic prosperity is accompanied by serious environmental and health hazards [8].

Water environment damage and ecological water consumption caused by economic and social water use, and reflects the negative impact of the economy on the environment. Obviously, it is inextricably linked with national economic accounting and resource and environmental accounting [9]. It is a more advanced and complex accounting work [4].

1.1 Foreign Research Progress

Resource and environmental accounting can be traced back to 1946, when British economist John Hicks first proposed the idea of green GDP. He emphasized the need to change the concept of pure economic growth. In 1993, the United Nations Statistics Division established a framework for systematically accounting for environmental resource stocks and capital flows, namely the System of Integrated Environmental and Economic Accounting (SEEA-1993), which is mainly used to account for environmental factors. The implementation of national economic accounting under affected conditions is a supplement to the SNA account system [10] and is a milestone in the research process of natural resource accounting. Subsequently, the United Nations revised and improved the SEEA system several times. The latest version is SEEA-2012, which provides internationally recognized concepts and definitions of environmental and economic accounting.

Therefore, it has become an important tool for collecting comprehensive statistical data, developing consistent and comparable statistical indicators, and measuring reliable A powerful tool for the sustainable development process [11]. Its contribution is reflected in four aspects: 1. Redefining assets, covering natural resources and ecosystems; 2. Determining the scope of environmental assets. The environment is composed of 7 unique components (land, timber resources, aquatic resources, etc.), these are environmental assets measured by establishing specialized assets or resource accounts; 3. Provides analysis methods for natural resource depletion and degradation, and expands research on the value of natural resources; 4. Maintains consistency with other international standards, recommendations and classifications Consistent and complementary to each other, ensuring the coordination and consistency of environmental resource accounting results and corresponding indicator results of other standards [4,7]. It is worth noting that the United Nations has further promulgated the System of Environmental Economic Accounting for Water (SEEA for Water-2012, referred to as SEEA2012) for the accounting of water resources. It has standardized the concepts and methods of water accounting. The conceptual framework provided by this system is not only It helps organize economic and hydrological information, and can also help analyze the contribution of water in the economy and the impact of economy on water resources in a consistent manner [12]. Domestic scholars such as Gan Hong and others [6] summarized the mutual interaction between these The relationship between . Unfortunately, SEEA2012 does not provide a definition of water resources liabilities, nor does it have a clear liability item, which is the difference between it and the natural balance sheet of water resources (BSW). Looking at the examples of resource and environmental accounting in various countries around the world, the British resource and environmental accounting adopts an internationally accepted framework account. Most of the data in the environmental accounting account use physical measurement units (volume or mass), and some use monetary units. The British environmental accounts mainly perform statistical accounting on oil and gas reserves, energy consumption, atmospheric emissions and material flows. However, some mobile resources are difficult to measure directly, such as widely used water resources, which are rarely involved [13]. Canada's resource and environmental accounting can currently only establish monetized stock accounts for energy, minerals, timber and land resources in the natural resource category, and the natural resources included in the National Balance Sheet Account (NBSA) system are only the above four categories. The above four types of resources have clear ownership, and the owners can obtain certain economic rights and interests through these resources. Such attributes make them meet the economic asset standards set by SNA2008. Other categories of natural resources, such as water resources and ecological resources, do not fully meet the asset definition standards due to unclear property rights and have not yet been included in the natural resource asset accounts [14]. The Australian Bureau of Statistics (ABS) has been conducting environmental asset accounting and national balance sheet preparation for nearly 20 years. So far, the most widely used one is the water accounting physical flow account released since 2000 [15]. Australia's water resources assets and water resources liabilities are all accounted for by enterprises. The water supply situation of enterprises is determined in accordance with accounting standards, and a corporate water resource balance sheet of physical quantities is prepared. However, the disadvantage is that the liabilities reflect the amount of water within the economy. Occupation (creditor's rights, debt relationships) does not reflect the debt relationship between the economy and the environment. In addition, the Australian Bureau of Meteorology (BOM) uses the Australian Water Resources Assessment Model to assess the country's water resources. This model is a system model for evaluating surface water and groundwater. It provides the water storage and flow required for national water resources accounts [16]. SEEA promulgated by the United Nations

- 2012 also lacks the most direct assets and liabilities items [12], and cannot intuitively show the impact of the extraction and use of water resources in human economic activities on the ecological environment. There is still a certain distance from the water resources balance sheet. In summary, there are currently no systematic research examples of natural resource balance sheets or balance sheets for a specific natural resource in the world. Most countries carry out natural resource asset accounting based on the method of comprehensive environmental and economic accounting. Only Australia A corporate water balance sheet with physical quantities was prepared, but it did not reflect the liability relationship between the economy and the environment.

1.2 Domestic Research Progress

At present, the assets in my country's current national economic accounting cannot cover all natural resources and environment. Only those natural resources and environment that are in line with economic assets are included in non-production assets. In this way, non-asset natural resources and environment are not considered. [17-18], this defect makes it difficult to comprehensively describe the relationship between economy and resources and environment. Obviously, the improvement and perfection of this work cannot be separated from resource and environmental accounting. my country's water resources accounting research started late but is developing rapidly. Although research and pilot projects were carried out in the 1980s, work on water resources accounting really began in the 21st century. In 2006, the Ministry of Water Resources and the National Bureau of Statistics jointly implemented the "Research on Environmental Economic Accounting of Water Resources in China", which also received technical support from the United Nations Statistics Division and became a pilot project for water resources accounting worldwide. This project combines my country's national conditions and has achieved innovative results in aspects such as water resource depletion, water environment degradation, water resource value and water economic accounting framework [19-20]. In November 2013, the Third Plenary Session of the 18th Central Committee of the Communist Party of China made a major decision to “explore the preparation of natural resource balance sheets, implement natural resource asset

departure audits for leading cadres, and establish a lifelong accountability system for ecological and environmental damage liability” [21]. There is an upsurge in studying natural resource balance sheets in China. In view of the key points and difficulties of natural resource accounting, Feng Zhiming et al. [22] proposed a possible path for compiling natural resource balance sheets in my country: physical objects first, then value, stock first, then flow, classification first, and then synthesis. Li Jinhua[4] discussed the theoretical basis, core concepts, general expressions and calculation methods of resource asset depletion in China's natural resource balance sheet. Based on the characteristics of water resources, Gan Hong et al. [6, 23] sorted out the difficulties and problems existing in the theory, methods and applications of preparing water resources balance sheets under current conditions, and put forward solutions and directional suggestions.

1.3 Development Trends in this Field

In terms of natural resource environmental accounting research, the international community has been exploring for nearly half a century, and China started late. Up to now, there are still many controversies about the definition and connotation of water resources assets and liabilities. The construction of the theoretical system of water resources balance sheet has not yet been completed. There is no real example of the preparation of water resources balance sheet in the world. Despite this, some generally recognized views and ideas have been achieved [24-28]: First, the preparation of water resources balance sheets should be based on the United Nations SNA, SEEA and SEEA-W, and explore ways to prepare China's water resources balance sheets. Methodological system; Second, the prerequisite and necessary condition for preparing a water resource balance sheet is to redefine water resources liabilities and set up liability items, breaking through the concept that natural resources have no liabilities in SNA2008; Third, whether from a theoretical or practical perspective, The valuation of assets and liabilities is a difficult point in the preparation of a natural resource balance sheet. Starting with physical quantity accounting and adopting a solution that is easy first and then difficult is a possible way to prepare a water resource balance sheet.

2 KEY ISSUES AND SOLUTIONS

2.1 Water Resources Assets and Liabilities

It is impossible to avoid the concept of liabilities when preparing a water resource balance sheet, but the connotation of liabilities cannot be copied from the SNA definition. The solution is to combine water resources liabilities with the "three red lines" of my country's most stringent water resources management system, and use the three red lines of "water resources development and utilization control, water use efficiency control, and water functional zone restriction pollution control" as a measure of whether water resources are in debt. standards. Specifically, when preparing the water resources balance sheet, you can compare the actual annual water consumption of water resources, the actual water use efficiency index, and the actual water quality compliance rate of water functional areas with the red line. If the red line management value is exceeded, the difference will be a liability. The exploitation or loss of water resources in this year exceeds the standard; if it does not exceed the red line value, then the development and utilization of water resources in this year reaches the standard and there is no liability. Liability is a balance value, but for water resources, this balance is not cumulative.

2.2 Prototype Design of Water Resources Balance Sheet

Water Resources Balance Sheet Prototyping is the key to preparing a Water Resources Balance Sheet. It must not only have the commonality of a natural resource balance sheet, but also need an independent equity-bearing entity and a clear breakdown of assets, liabilities and owner's equity. At the same time, it is also necessary to consider the renewable, random and fluid characteristics of water resources themselves, clarify the principles and methods for dividing water resource stock assets and flow assets, and reasonably divide the impact of human factors and natural factors on water resources assets. At present, there is no complete example of water resources balance sheet in the world. There is no complete set of accounting tables that can express the economic, social and environmental functions of water resources. This accounting table needs to be composed of multiple tables. . The sequence of table design can be followed: first physical object, then value, first inventory, then flow.

2.3 Water Resource Valuing Technology

Water resources accounting does not only stop at the stage of water resource statistics supply, use, consumption and discharge. SEEA and SEEA-W established on the basis of SNA must fundamentally solve the valuation problem of water resource asset stocks and flows, otherwise it can only As a satellite account, it can supplement some physical quantity statistics and cannot be included in the national balance sheet. It cannot realize the integration of water resources consumption, water environment damage, and water ecological benefits into the economic and social development evaluation system. It cannot realize the adjustment of GDP, national wealth and other issues. To achieve the highest goal of preparing a water resource balance sheet, water resource valuing technology is both the key and the difficulty. Overall, an estimate of the total value of water should include all use and non-use values. The former refers to the direct use of consumptive water resources, such as agricultural, industrial, and domestic water. The latter refers to

the indirect environmental services provided by water. Such as waste assimilation, habitat and biodiversity protection, etc. Most of the valuation methods used directly are already relatively complete, mainly because these methods are close to market activities. The valuation of indirect uses, such as waste disposal services (cost approach to damage prevention actions and benefit approach to damage prevention), is also well established. However, there are more disputes over the valuation and non-use value of other indirect services such as habitat protection and related cultural values [12]. The consumption value of water resources in economic activities can be obtained through the consumption of water resources in economic activities in the current year and shadow prices. Water environmental damage can be calculated using the protection cost method or the restoration cost method; the value assessment of water ecological water expropriation attempts to use the emergy method [29] analysis.

3 TECHNICAL ROUTE

Draw lessons from advanced international experience and combine it with my country's water resources management system and accounting system to clarify the basic concepts, connotations and functional positioning of water resources balance sheets, build the basic framework, account system and basic expressions of water resources assets, and study the valuing of water resources Techniques, Explore Preparing Water Resources Balance Sheets. The research work is carried out step by step using the technical approach of "finding out the background, prototyping, technological breakthroughs, and typical trial calculations". The "stock and flow, quantity and quality" of water resources require the use of professional knowledge such as hydrology, river dynamics and remote sensing. "Prototyping" and "technological breakthroughs" require comprehensive accounting, statistics, economics and water resources management. knowledge in various fields and promote the innovation of theories and methods under the cross-integration of multiple disciplines.

4 RESEARCH PROSPECTS

The water balance sheet not only focuses on water resources that "enter" economic activities, but also focuses on water resources that do not enter economic activities. On the basis of the existing national economic statistics system, we can further expand the scope and content of water resources accounting, reveal the stock and changes of water resources in a certain area and within a certain period of time, and account for the increase or decrease in water resources assets and changes in water quality, and ultimately be able to Comprehensive reflection of the "family wealth" of water resources assets at a certain point in time. Its importance not only promotes the reform of the water conservancy statistics system, but also significantly improves, supplements and improves the shortcomings of the traditional national economic accounting system that lacks resources and environmental factors. It is one of the objective evaluation bases for the cadre resignation assessment system. At the same time, it also has the following extended functions:

(1) Provides boundary conditions and key indicator thresholds for the evaluation of water resources carrying capacity. Through the preparation of water resources balance sheets, water resources consumption, water environment damage, and water ecological benefits can be incorporated into the economic and social development evaluation system, and the mutual feedback mechanism of "water resources-economic society-ecological environment" can be studied to reveal water resources as economic resources. The explicit input-output relationship of economic activities also reflects the invisible negative impact, reflecting whether water resources have sustainable characteristics under the current level of economic activity and consumption intensity. This can be used as a comprehensive evaluation of the sustainable development of regional economic and social development. in accordance with. Obviously, the water resources balance sheet has broken through the bottleneck that was difficult to quantify between "water resources-economic society-ecological environment" in past studies on the evaluation of water resources carrying capacity [30, 31], and innovatively established elements that include the liability of the economy to the environment. carrying capacity theory.

(2) Provides a basis for water conservancy development planning and evaluation of the effectiveness of water ecological civilization construction. According to the requirements of my country's most stringent water resources management and the "three red lines", the shadow price method, marginal cost method and emergy analysis method are used to quantify water resource environmental issues such as water resource consumption, water environment damage, and water ecological water occupation. By preparing the water resources stock and change statement, water resource quality and change statement, water resource supply and use statement, and the final water resources balance sheet, a dynamic account of assets and liabilities such as water resources, water environment, and water ecology is established. Scientifically understand the benefits and impacts of water conservancy development, promote the paid use of water resources and the formulation of water ecological compensation standards, so as to better formulate water conservancy development strategies and adjust planning layout.

The preparation of the water resources balance sheet involves many disciplines such as hydrology, water resources, accounting, statistics, and environmental science. Due to the renewable, fluid and random characteristics of water resources, the water resources balance sheet Compilation has different problems from other natural resources (such as forests, land, etc.) and faces many theoretical, methodological, cognitive and institutional challenges, which require unremitting efforts to solve.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

REFERENCES

- [1] Chen Lei. Comprehensively implement dual control actions on the total amount and intensity of water resources consumption to ensure sustained and healthy economic and social development. *China Water Conservancy*, 2016 (23):21-24.
- [2] Wang Jianhua. Some thoughts on the carrying capacity and regulation of water resources//. Report of the 2016 Academic Annual Meeting of the Water Resources Professional Committee of the China Hydraulic Society, 2016.
- [3] National Bureau of Statistics. *Natural Resources Balance Sheet Trial Compilation System (Compilation Guide)*. Beijing: National Bureau of Statistics, 2015.
- [4] Li Jinhua. On the method of preparing China's natural resources balance sheet. *Research on Financial Issues*, 2016(7): 3-11.
- [5] Wei Fengnian, Dong Mingrui. How to scientifically compile the water resources stock and change table - interviews with Gan Hong, a professor and senior engineer at the China Academy of Water Resources and Hydropower, and Wang Dangxian, a professor and senior engineer at the General Institute of Water Resources and Hydropower Planning and Design of the Ministry of Water Resources. *China Water Conservancy*, 2016(7): 1-6.
- [6] Gan Hong, Wang Lin, Qin Changhai, etc. A preliminary understanding of the balance sheet of water resources. *China Water Conservancy*, 2014(14): 1-7.
- [7] United Nations. *Integrated environmental and economic accounting (handbook of national accounting)*. New York: United Nations Publication, 1993, 2000, 2003, 2006, 2012.
- [8] Prudham WS, Lonergan S. Natural resource accounting: A review of existing frameworks. *Canadian Journal of Regional Science*, 1993, 16(3): 363-386.
- [9] Chai Xuerui, Huang Xiaorong, Xi Yuanyuan, etc. A brief analysis of the preparation of water resources balance sheet. *Journal of Water Resources and Hydroengineering*, 2016, 27(4):44-49.
- [10] Holub HW, Tappeiner G, Tappeiner U. Some remarks on the system of integrated environmental and economic accounting of the United Nations. *Ecological Economics*, 1999, 29(3): 329-336.
- [11] United Nations, European Union, Food and Agriculture Organization of The United Nations International Monetary Fund, Organization for Economic Co-operation and Development, and the World Bank. *System of environmental - economic accounting 2012 - central framework*[2012-03-02]. http://unstats.un.org/unsd/publication/seriesf/seriesf_109e.pdf.
- [12] United Nations Statistics Division. *System of environmental economic accounting for water (SEEA - Water)* [2007-04-02] <http://unstats.un.org/unsd/envaccounting/seeaw>.
- [13] Office for National Statistics. *UK environmental accounts, The blue book: 2008 edition*[2013-08-15]. <https://data.gov.uk/publisher/office-for-national-statistics>.
- [14] Friend A M., Rapport DJ. The evolution of information systems for sustainable development. *Ecological Economics*, 1991, 3(1): 59-76.
- [15] Australian Bureau of Statistics. *Australian system of national accounts: Concepts, sources and methods*[2015-01-30]. <http://www.australia.gov.au/about-australia/facts-and-figures/statistics>.
- [16] Huang Xiaorong. Some thoughts on the preparation of water resources balance sheets//. Report of the 2016 Academic Annual Conference of the Water Resources Professional Committee of the Chinese Hydraulic Society, 2016.
- [17] Cao Keyu. A preliminary study on China's comprehensive economic and resource and environmental accounting system. *Economic Research Reference*, 2001(2):21-27.
- [18] Gao Minxue. SEEA's inheritance and sublation of SNA. *Statistical Research*, 2006(9): 18-22.
- [19] China Academy of Water Resources and Hydropower. *China Water Resources Environmental Economic Accounting Research Report*. 2009.12.
- [20] Jiao Ruoqing, Geng Jianxin, Wu Xiaoying. A preliminary study on the method of compiling water resources balance sheet suitable for my country. *Water Supply and Drainage*, 2015, 41(S1), 214-219.
- [21] The Third Plenary Session of the 18th CPC Central Committee. *Decision of the Central Committee of the Communist Party of China on Several Major Issues Concerning Comprehensively Deepening Reform*. *People's Daily*, 2013-11-16(1).
- [22] Feng Zhiming, Yang Yanzhao, Li Peng. From natural resource accounting to natural resource balance sheet preparation. *Proceedings of the Chinese Academy of Sciences*, 2014, 29(4): 449-456.
- [23] Gan Hong, Wang Lin, Qin Changhai, et al. Some problems and solutions in the preparation of water resources balance sheet//. *Natural Resources Balance Sheet Theory and Practice Workshop*, 2015.
- [24] Chen Yanli, Gong Rui, Zhao Hongyun. Preparation of natural resource balance sheet: theoretical basis, key concepts, and framework design. *Accounting Research*, 2015(9): 18-26 + 96.
- [25] Hu Wenlong, Shi Dan. Research on China's natural resource balance sheet framework system - an idea based on SEEA2012, SNA2008 and the national balance sheet. *China Population-Resources and Environment*, 2015, 25(8): 1-9.
- [26] Feng Zhiming, Yang Yanzhao, Chen Yue. Research progress on national balance sheets and their implications for the preparation of natural resource balance sheets. *Resource Science*, 2015, 37(9): 1685-1691.
- [27] Gao Minxue. Extended natural resource accounting - focusing on the natural resource balance sheet. *Statistical Research*, 2016, 33(1):4-12.

- [28] Geng Jianxin, Hu Tianyu, Liu Zhujun. A preliminary study on the preparation and application of my country's national balance sheet and natural resource balance sheet - analysis using SNA2008 and SEEA2012 as clues . *Accounting Research*, 2015(1): 15-24.
- [29] Wang Ling, He Qing. A review of research on ecosystem value based on emergy theory. *Ecological Economy*, 2015, 31(4): 133-136 + 155.
- [30] Wang Zhongjing, Weng Wenbin. Research on planning methods for sustainable utilization of water resources in arid inland areas. *Journal of Tsinghua University (Natural Science Edition)*, 1998, 38 (1): 33-36.
- [31] China Academy of Water Resources and Hydropower, Tsinghua University. Special study on national comprehensive planning of water resources - Research on evaluation methods and applications of water resources carrying capacity. Beijing: China Academy of Water Resources and Hydropower, 2007.