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Ecological Accounting: A Research Review and Conceptual Framework

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Abstract

Where sustainable development is concerned, there is an urgent need to establish new information systems that integrate economic, social and ecological factors. The emergence of demand for this information makes the development of ecological accounting possible. Yet, most current research on ecological accounting focuses on two aspects: (1) the theoretical aspect, including background, concepts and models and (2) specific research on ecological accounting. Some scholars have proposed a conceptual framework, but this is not systematic or thorough enough. Seizing the opportunity of sustainable development in a key strategic location of the world, this paper begins by analyzing the logical evolution of ecological accounting, summarizes the existing ecological accounting theory, and combines the mature theoretical study of resources accounting with environmental accounting. All of these efforts result in this paper forwarding a framework of ecological accounting that aims to provide a guideline for future development.

Keywords

Sustainable Development, Logical Evolution, Ecological Accounting, Basic Framework

1. Introduction

Accounting mainly refers to a period of commercial development and is closely related to economic development [1] [2]. Developing along with social progress, accounting plays an important role that should not be underestimated. Like other disciplines, accounting must be combined with related subjects and evolve toward becoming an interdisciplinary science in order to meet the needs of social development [3]. Under the economic

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and social forms of self-sufficiency, as well as under the conditions of a simple commodity exchange barter, accounting records the production, consumption and resulting balance of goods and is an important part of economic management [4]. Accounting provides important information for internal and external stakeholders in an economic system. As the allocation of social resources improves and a market economy emerges, the available accounting content continues to expand, and the importance of the role of accounting also continues to expand. Crises in capitalist economic systems were the impetus for the development of social accounting starting on an historical stage [5]. The rising status of social accounting is inevitable, and social accounting has gradually become understood and accepted by theoretical accountants. Subsequently, after hundreds of years of the development of a capitalist market economy, some business enterprises have come to regard the pursuit of profit as the only guide to their decision making, ignoring the public interest, including factors such as consumer interest and ecological and environmental pollution. Thus, social responsibility accounting has emerged in order to prevent, eliminate and compensate for these risks [6]. Some developed countries, such as the United States, Germany and the United Kingdom, set off a wave of research on social responsibility accounting. Due to the worldwide acceptance of sustainable development strategy, many accounting scholars and experts have begun to think about the relationship between resources and accounting. Resource accounting has absorbed the principles and method of resource economics, ecological economics, sustainable development economics and other disciplines [7]. At present, resource accounting has gradually subdivided into new branches, such as forest resource accounting and marine accounting.

Since the late 1980s, population, resources, environment and development have become four major problems faced by the international community. In order to meet the urgent and important needs of accounting in the economic society, the accounting of the economic activities of enterprises has extended its focus to the environment systems associated with enterprises to form a new branch called environmental accounting. Environmental accounting identifies and measures environmental costs, environmental liability and environmental benefits [8]-[13]. After decades of development, environmental accounting has become divided into environmental financial accounting and environmental management accounting. Its theoretical research has been applied in practice to promote the sustainable development of enterprise. With the unrestrained exploitation and utilization of natural resources by humans, natural resources, the environment and ecosystem have been severely affected. Environmental accounting has being unable to fully measure the outside impact of human activity, thus some scholars have put forward the concept of ecological accounting [14].

Ecological accounting is not a new concept, and it developed slowly over nearly ten years. However, it is a new field and discipline. Social accounting and social responsibility accounting, resource accounting and environment accounting have an inherent relationship with ecological accounting. Relatively speaking, the perspective of ecological accounting is more open; it is not limited to environmental pollution, and it considers the collective relationship among resources, environment and economic performance. Although the development and application of accounting among commercial enterprises still has many shortcomings and deficiencies, the related principles and methods form important theoretical support for ecological accounting [15]-[18].

2. The Research Progress of Ecological Accounting in Major Countries

Since the 1990's, a large amount of literature has emerged about "resource accounting" and "environmental accounting." Many enterprises also have participated in the practice of this accounting [19]. Resource and environmental accounting have made significant achievements in the theory and practice. However, many complex problems in areas including resources, the environment and ecological health have emerged that have prompted scholars to widen the study of environmental pollution accounting to the entire ecological field [20]. At present, these studies of ecological accounting are still underway, and no unified viewpoint has yet been formed.

2.1. Progress in the United States and Canada

The analysis of enterprise environmental problems using the environment cost method is the original concept of ecological accounting. So far, scholars generally have four kinds of understanding about the concept of ecological accounting. Frank Birkin thinks ecological accounting is based on the integration of ecological and economic concepts, measurement methods, and values, providing performance evaluation, control, and information for decision-making and reporting purposes, and for taking the meaning of ecological accounting [21]-[25]. In some literature, ecological accounting reflects the meaning of accounting or ecological statistics [26]-[30]. Some

scholars regard ecological accounting as an information system that describes, calculates and measures the information related with the ecological environment [15] [31] [32]. Some scholars think that ecological accounting is an alias for life cycle assessment [33]-[35]. In addition to the concept of no uniform identification standard, there are also different views about theoretical model study. Birkin proposed a burden-based model and pointed out that most of the assets and economic activities have been included in the "burden-based" relationship and that people measure these basic functions with "load capacity" [36]. Also, Birkin and Ranghieri developed an ecological accounting system model called the "Overpass" model, which included conceptual framework and a matrix containing the EU-funded project known as "the sustainable development of tourism environment protection system."

There are many scholars interested in the background. Some economists have expressed a new understanding of the economic system, and they tried to expand their cost basis to include social and environmental costs, as well as the design of monetary and welfare measures [37]. Some accountants and scholars have advocated a new idea and application of the enterprise environmental report and environmental management accounting, and have confirmed corporate environmental costs and liabilities in published reports [38] [39]. Ecological accounting is an embryonic development based on ecological philosophy and economic values [40].

With the in-depth research of ecological accounting, many scholars have paid more attention to the ecological footprint. Canadian ecological economist Ress first proposed the ecological footprint concept, and his doctoral student M. Wackemagel explained it from different angles [41]-[45]. The ecological footprint is a ratio of measuring human use of resources and the influence of this usage on ecosystems [46]. People's need for natural capital varies with their different levels of societal development, cultural practices, and wealth; thus, it is difficult to calculate an average ecological footprint across the entire human race.

2.2. Progress in the European Union

Wide-ranging research on the environmental and ecological aspects of the EU has been important for many years, including queries about such things as eco-taxes. Adjusting and innovating the existing tax distortions, and introducing eco-taxes, can achieve green tax reform, and the reform of eco-taxes can promote environmental quality. If the energy tax rate is lower than the rate of labor, the reform of eco-taxes can promote employment [47]. Many members considered eco-taxes as an environmental policy tool that produced good results. Eco-taxes cover a wide spectrum, as EU members have imposed taxes on fuel, products and actions that endanger the environment, such as when Sweden imposed taxes on natural gas and carbon, and Germany began levying a water pollution tax [48].

The implementation of eco-taxes made a significant reduction in gas emissions for the ecological environment, and to a certain extent, promoted the innovation of environmental technology. In terms of social practice, members of the EU instituted ecological initiatives; for example, eco-industrial parks and the establishment of an ecological compensation mechanism [49]. Beginning in the 1990s, in response to the great loss caused by various ecological disasters, EU members actively developed ecological industry in the form of eco-industrial parks that varied from the establishment of Holland's Amsterdam Park to the expansion of Denmark Fort [50]. Owing to the institution of various ecological compensation mechanisms, agriculture and forest in the EU have recovered to a remarkable degree. In 2005, the EU Council adopted its 1698th/2005 article which regarded an auction as a tool for the payment of agricultural eco-environmental protection. The EU imposed ecological agriculture production-related subsidies by enacting the "Common Agriculture Policy, CAP."Regardless of how a system was constructed or put into practice, the EU's forest ecological compensation is advanced. Through a combination of eco-labeling and sustainable forest management, the European Union has formed a relatively complete system of forest ecological compensation.

2.3. Progress in Japan

Unlike the United States and the European Union's eco-environmental protection campaign, Japan—one of the earliest countries to develop a circular economy—considered the actual situation of a limited land area and the scarcity of natural resources and put forward the developmental mode of the circular economy. The idea of a circular economy's development concurs with the connotation of ecological accounting. The mode of circular economy promoted the development of ecological accounting in Japan to a certain extent. At the macro level, researchers focused on eco-industrial parks or social material circulation problems from the perspective of the

recycling industry. In addition, another type of study aimed at a certain special material in the loop of the society. For example, Seiji Hashimoto described the six indicators of the socio-metabolism material cycle from the perspective of material flow analysis [51] using Japanese wood as an example, and Yuichi Morgachi described the six material circulation indices of the social metabolism.

Studies of ecological accounting in Japan can be traced back to the 1970's, when Professor Kiyoshi Kurosawa proposed the idea of eco-accounting in his close study of numerous environmental pollution problems caused by the destruction of the environment, and first used the term of ecological accounting. Based on this foundation, Kawano Masao and others considered the problem from three viewpoints, including the economic aspect of environmental accounting, the enterprise level of environmental accounting, and resource accounting studied from the perspective of ecological accounting [52]. After nearly ten years of researches, they expanded and modified the research content of ecological accounting, incorporating environmental and sustainability reporting, as well as environmental accounting [53]. The Ministry of the environment put forward the construction of ecological accounting for studying social, economic and environmental problems. Subsequently, they conducted a survey which covered many social problems, such as the rationalization of water projects and the way that businesses balances the water resource cost burden against the maintenance of waterway facilities and environmental capital. Kawano Masao studied economic problems such as the burden of costs and capital maintenance caused by the supply of rivers, and developed in-depth research on economic, social and environmental issues according to the principles of ecological accounting [54].

2.4. Progress in Australia

In the area of the research and practice of ecological accounting, Australia is loath to lag behind. Stefan Schaltegger and Roger Burritt built a systematic and complete framework of the micro-environmental accounting in a book titled “Contemporary environmental accounting: issues, concepts and practice” in 1992 [55]. In this framework, micro environmental accounting is divided into two parts, including the differences in environmental accounting and ecological accounting. The authors thought that following the principle and method of traditional accounting, ecological accounting was the process that used biological and physical units to collect, classify, analyze and transfer environmental information. Based on the above theory, ecological accounting is a subsystem of environmental accounting, and the most obvious distinction between it and environmental management accounting is manifested in recording, tracking and measuring the environmental impact by physical unit [56]. In 1992, Australia signed an important document called “the Australian government environmental agreement” which signified that Australia has entered a new stage of integrating economic, environmental, ecological and sustainable management. In the promulgation of the “Financial information quality characteristics,” the Australia Accounting Standards Board asked enterprise to measure and to disclose the relevant and reliable environmental impact.

2.5. Progress in China

With the further development of accounting theory, some scholars have noted defects in the current accounting system with regard to sustainable development. Because of the government’s demand for accounting information about the ecology, economic stakeholders and environmental stakeholders, the appearance of ecological accounting has become possible and necessary [57]. In addition, some scholars have expounded the possibility and necessity of the generation of ecological accounting standards in the national macro strategic perspective [58]. Sustainable development requires ecological accounting and can construct ecological accounting according to environmental accounting experience [59]. Sustainable development put forward the new request and challenge on ecological accounting from the three levels: governments, businesses and society [60]. Under certain conditions, ecological accounting is related to the development of the current accounting theory and requires the support of a specific background.

Domestic research is still at the preliminary stage. Ecological accounting reflects the exchange of material and energy between the main body of accounting and the natural environment; it also must meet the information needs of the accounting system [61]. Some scholars have put forward the framework of ecological accounting measured by goals, elements, and assumptions.

A review of the research literature at home and abroad finds two main perspectives: theory and practical application, and three levels: macro view, middle and micro view. Among them, American and Canadian theory

on ecological accounting ranges widely, and some specific aspects of the theory have been developed. However, most American and Canadian ecological accounting is the representative of the meaning of accounting that differs from the proposed ecological accounting in this paper. In the macro and middle view of the practice of ecological accounting, the EU has obtained many achievements; for example, compared with United States and Japan, the construction of the eco-industrial park is richer, and the names have more variety. In contrast, Japan's research of ecological accounting began earlier and formed a systemic and complete theoretical system that progressed the development of environmental accounting. As an ecological power, the ecological concept of Australia reflected all aspects, such as city traffic construction and education and the water resource accounting. Due to the guidance of national policy in recent years in China, ecological accounting has become a hot spot in academic research, but problems such as a relatively weak theoretical foundation and slow progress have meant that most research is still in the conceptual and exploratory stage.

3. The System Design of Framework on Ecological Accounting

Although the study of ecological accounting has gained many achievements, it has not formed a systematic theory. According to China's situation, this paper puts forward a system of ecological accounting to promote the development of ecological accounting. Because scholars have confused the meaning of ecological accounting, resource accounting and environmental accounting, and have classified ecological accounting as a sub system of environmental accounting, it is necessary to distinguish among resource, environment and ecology to illustrate that ecological accounting cannot be replaced. Then, the logic of ecological accounting based on resource accounting and environmental accounting can be explained.

3.1. The Concept Discrimination on Resource, Environment and Ecology

The 18th Central Committee of the Communist Party of China clearly put forward the connotation of the protection of the natural ecological civilization and stated that we must bring the ecological civilization construction into the pattern of economic construction, political construction, cultural construction and social construction in order to cope with the grim situation of resource constraints, environmental pollution and ecosystem collapse [62]. The "resource constraints," "environmental pollution" and "ecological collapse" as concepts were elaborated separately from the terms "resource," "environment" and "ecology."

The resource, environment and ecology are the three natural elements of the survival and development of humankind, and they reflect different functional relationships between the human and nature [63]. Among them, the resource generally refers to the natural resource and is divided into five kinds: water, land, minerals, forests and oceans. According to the definition of the United Nations Environment Programme on natural resource, natural resource can produce economic benefits to improve the present and future natural factors and conditions at a certain time and under certain conditions. The so-called environment generally refers to the natural environment and specifically means various natural and artificial modification of natural factors that relate to human survival and development. From the perspective of functional relationships between man and nature, the relationship between humans and the environment is the subject and the object, the so-called ecology refers to the natural ecological system and includes three systems: the surface of the terrestrial system, the aquatic system and the atmospheric system. In a certain space range, the biological community and its environment display correlative dependence and interplay. Therefore, resources, environment and ecology are three interrelated but different concepts [64].

Based on the logic of ecology, resource accounting, environmental accounting and ecological accounting should not be confused; they developed independently and crosswise. Among them, the resource accounting focuses on resource measurement and disclosure issues, such as the buried coal and the forest. Environmental accounting measures and discloses environmental cost, such as measuring the effect of waste on the environment by industrial enterprises. But not all problems can be solved by resource accounting and environmental accounting; for example a coal mine involves resource accounting and environmental accounting because it may affect ecological service functions and the welfare of biological communities.

3.2. The Logic Framework under a Sustainable Design

The study of ecological accounting can use abstract methodology and field investigation. According to the prin-

ciples and criteria of accounting, a theory of ecological accounting can be put forward by systematically integrating related concepts from different disciplines. In addition, to carry out afield investigation, one must gain first hand information and take advantage of advanced information processing tools to integrate the collected data.

Based on the above work and according to the following procedures, we can establish the system of the micro ecological accounting (enterprise level) and the macro ecological accounting (area or entire ecosystem level):

(1) Perform normative research that points at the basic links and features of ecological cycles, analyze the relationship between ecological and economic cycles according to the idea of human sustainable development, which determines the theoretical basis for the implementation of ecological accounting;

(2) According to traditional accounting theory, perform special studies on the principle of ecological accounting, confirmation and measurement basis;

(3) Referring to the content of the system of resources accounting and environmental accounting, perform individual studies on the basic elements of ecological accounting, such as ecological assets and ecological cost, and combine them with the data obtained through field surveys to construct the econometric model;

(4) Focusing on the ecological accounting entity's economic activities, evaluate its ecological efficiency;

(5) Through the single factor analysis and the multiple-factor analysis, seek the optimum choice for the development mode and sustainable development strategy of circular economy;

(6) Perform longitudinal study on the features of each link of resource, environment and ecological cycle, and perform horizontal studies on the various accounting features of the main ecological system;

(7) Gather the above research results, construct the analysis system of ecological accounting with the function of accounting, namely evaluation, decision-making and control, providing a theoretical basis for the development of ecological accounting. The research logic is shown as **Figure 1**.

3.3. The Framework of Ecological Accounting

Through the double verification of theory and practice, ecological accounting can effectively solve the problems encountered by the enterprises and organizations in the process of sustainable development. According to the development of modern ecology, in addition to individual organisms, populations and communities, the ecosystem including the society belongs to its scope. So the population, the resources, the environment and other issues confronted by human are included in ecological research. Along with the logic of ecology, resource accounting,

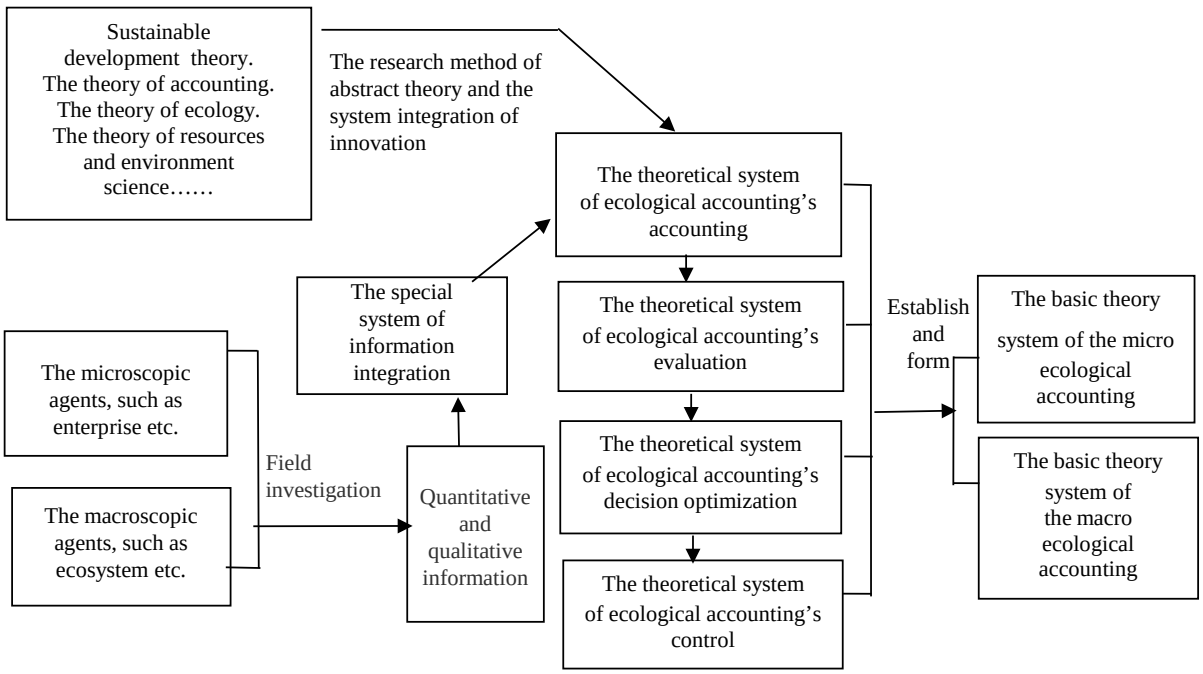

Figure 1. The logic framework under a sustainable design.

environmental accounting and ecological accounting must overlap, and this point is similar to the view of Japanese scholars like Kawano Masao. Except for the studies on resource accounting and environmental accounting, eco-efficiency, eco-compensation costs, education, medical benefits and other issues should also be reflected in the system of ecological accounting. From the perspective of ecology, this paper tries to define the scope of accounting, and divides the ecological accounting into micro ecological accounting and macro ecological accounting. Micro ecological accounting is divided into individual ecological accounting and population ecological accounting; macro ecological accounting is divided into community ecological accounting and system ecological accounting. Among them, the individual ecological accounting aims to provide information about different subjects of inflow and outflow and to measure the impact on the environment of a single organization, such as the enterprise or the group. With the concept of population ecology, population ecological accounting has been proposed and includes the role of the recognition, measurement and disclosure of the influence on the environment of an industry chain. The community ecological accounting measures the resource, environmental, social and eco-efficiency of all enterprises in a certain area, such as industrial parks. The systemic ecological accounting is the most widely used, which is ecological accounting of the generalized dimension. It can carry out the accounting, evaluation and disclosure by means of energy, material, value and information flow, including all the organizations.

Through some basic accounting functions, ecological accounting provides information which is closely related to accounting entities. According to **Table 1**, ecological accounting mainly relates to the measurement of ecological assets, liabilities, cost and benefit. Among them, ecological assets are assets owned or controlled by an accounting entity to create ecological benefits, such as the machinery and equipment for waste water treatment, and the measurement of ecological assets mainly uses the method of historical cost. Ecological debt is the obligation and responsibility assumed for the realization of ecological benefit by an accounting subject, such as the ecological tax taken by European Union. Some liabilities can be quantified in monetary units or volume estimates, while others must use a narrative description. The various costs called ecological costs consist of, for example, the salaries of staff who work in the ecological environment; the accounting entity shall take the actual paid cost as the basis of the ecological cost's measurement. From the above definition, ecological assets, liabilities and costs around ecological benefits exist and expand. The ecological benefit is obtained by measuring the success of protecting the natural resources and the environment, such as increased biodiversity. Because of the complexity of the connotation of ecological benefit, it can account for ecological benefits in both quantitative and qualitative aspects, and the qualitative analysis includes four dimensions: resources, environment, ecology and social. The method of combining quantitative and qualitative measure is suitable for the vast majority of the accounting entity's accounting and many scholars also have conducted related research.

3.4. Methodology Study of Ecological Accounting from the Perspective of Management Accounting

From the angle of financial accounting, ecological accounting can be divided into three dimensions: recognition, measurement and disclosure. From the angle of management accounting, it can be divided into four dimensions: accounting, evaluation and analysis, optimization, and control. According to the logic of management accounting research, this paper studies specific methodologies based on different unit levels.

Table 1. The basic framework of ecological accounting.

The Accounting Unit	Method	The quantitative measurement	The qualitative analysis		
			The resource	The ecology	.....
The individual ecological accounting	Enterprise ……				
The population ecological accounting	The chemical industry ……				
The community ecological accounting	Industrial Park ……				
The system ecological accounting	The national economy ……				

In **Table 2**, the "Δ" represents the calculated application; the "○" represents the application that was not calculated. Among them, many methods of each dimension are involved; because of limited space, we select a representative method to discuss in detail. The framework of ecological accounting generally consists of four dimensions: accounting, evaluation, decision optimization and control; specific applications for each methodology at different enterprise levels are as follows:

Because there is no overall ecological accounting framework and the accounting system is not fully established, the specific calculation method is still being explored. SNA and SEEA can provide scientific references for ecological accounting. SNA is jointly issued by the United Nations, the European Union, the Organization for Economic Cooperation and Development, the International Monetary fund and the World Bank, and provides a macroeconomic account with comprehensive, consistent, flexible features for decision making and economic analysis. According to strict accounting rules, SNA is a set of internationally-recognized standards based on the economic principle of measuring economic activity. SEEA is SNA's satellite account system, and is the product of sustainable development. It is mainly used for considering the influence of environmental factors under the condition of the implementation of national economic accounting. The SEEA mainly discusses the basic concepts of the environmental and economic accounting system and frame structure, resource depletion and environmental degradation estimation method, and focuses on the calculation results applied to the adjustment of the traditional index. From five main aspects, the SEEA extends the concept and system of SNA (as shown in the **Figure 2** below). Thus, the SEEA is modified on the basis of SNA and reflects the concept of sustainable development by considering the environmental factors, which is the principle of ecological accounting. Therefore, ecological accounting can draw lessons from the accounting methods and ideas of the SEEA to build a new accounting system.

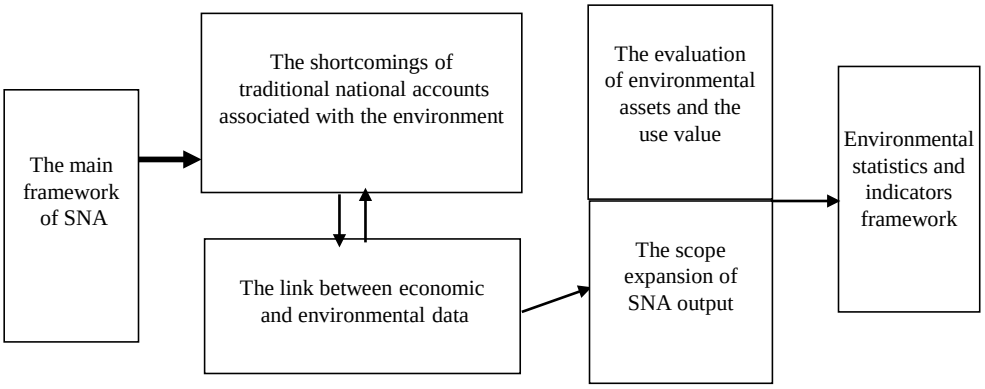

Figure 2. The framework of the SEEA.

Table 2. The summary of ecological accounting' methods.

Method / The Accounting Unit	System of National Accounting (SNA)	the System of Environmental-Economic Accounting (SEEA)	The method of ecological footprint	The Comprehensive evaluation of resource circulation analysis	The fuzzy and comprehensive analysis method	The material flow analysis	The method of energy analysis	The method of industrial added value	Standard (goal or project) cost control method	The method of life cycle cost control	Green supply chain Cost management
Enterprise			Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
The industry			Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
Industrial Park			Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
The regional	Δ	Δ	Δ		○	○		Δ			
The national economy	Δ	Δ	Δ		○			Δ			Δ
Dimensions	Accounting			Evaluation			Decision Optimization		Control		

The evaluation level of ecological accounting mainly refers to the ecological efficiency; in other words, the ratio of the accounting subject's ecological performance and financial performance. One example of this is Canadian scholars' use of the ecological footprint to evaluate ecological efficiency, a method that has a wide range of applications. Setting different indicators—such as the resource circulation of input, consumption, export and circulation—the comprehensive evaluation of resource circulation analysis synthetically evaluates the enterprise's resource circulation. A particular subject's performance evaluation involves many aspects and one can construct the index system of ecological efficiency by selecting the relevant ecological performance indicators and financial performance indicators. One can also adopt certain technical methods or models on this basis, like the fuzzy comprehensive analysis method, to evaluate the comprehensive ecological efficiency of the accounting entity. Due to the uncertainty of the environment itself, the fuzzy comprehensive evaluation method is an evaluation of environmental quality using a mathematical fuzzy set theory as a comprehensive evaluation method. The key to this method is to compute an evaluation factor. Material flow analysis derived from Germany has been widely applied in Japan, can provide decision optimization for the services provided by the ecological and economic system, and is suitable for enterprise and industrial park practice. The following chart **Table 3** compares the different evaluation methods.

The methods of the decision optimization dimension of ecological accounting involve the energy analysis method and industrial added value, etc. The energy analysis is a quantitative analysis of the structural function of the socio-economic ecosystem, which is suitable for the enterprise and industrial parks' decision optimization. It can provide a scientific basis for the evaluation of natural resources and the harmonious coexistence between humans and nature. Industrial added value refers to industrial enterprises creating new value in the process of production; it is the final result of industrial production during a given period in monetary terms. The scope of industrial added accounting is an independent legal study in the field of industrial enterprise; the principle is based on the final results of measuring the current production and determining its value in monetary terms. This method is more suitable for an enterprise's decision optimization.

For ecological accounting, there are methods like standard cost control, target cost control, plan cost control and life cycle cost control, etc. The three methods mentioned above are very much the same, and all involve setting certain benchmarks, then evaluating and controlling the enterprise's behavior by comparing these benchmarks against the standard. These methods are more suitable for an enterprise's internal control activities. The method of life cycle cost control emphasizes the whole process control from starting point to destination and pays attention to the concept of sustainable development. This method can help an enterprise establish overall cost consciousness, as well as control environmental cost. This can allow an enterprise to consider the whole cost when evaluating its capital budget. Finally, the life cycle cost control can help an enterprise implement control, and it is suitable for enterprises and industrial parks.

4. Conclusions

Western countries have conducted extensive theoretical research on ecological accounting, and some specific theories have risen to the level of practical guidance. Developing countries like China learn from the ideas and experience of developed countries. On the one hand, foreign institutions, whether they are governmental, institutional,

Table 3. The comparison of ecological accounting evaluation methods.

The method	The characteristics	The deficiencies
The ecological footprint	Simple and clear, reflecting the human impact on the earth vividly, and having strong maneuverability and repeatability.	The evaluation result is not absolute and some theoretical assumptions are difficult to achieve.
Comprehensive evaluation of resource circulation analysis	Considers the specific key resource flow conditions before and after optimization, or posits the circular economy as a form of index.	Without a thorough solution to the qualitative index quantitative.
The fuzzy comprehensive analysis method	The result is clear and systemic and strong and can solve the problems that are fuzzy and difficult to quantify.	The computation is complex and the subjectivity is strong, which decides the index of weight vector.
The material flow analysis	Based on material flow routes, and an in-depth analysis of the object of material flow strength and path.	Dimension is not uniform, and cannot reflect the relationship between the environment and the economy.

or scholarly, have expounded theoretical research about ecological accounting from multiple perspectives. This discussion has provided a theoretical basis for the practice of micro market strategies by companies and organizations that are actively involved in implementing new ideas; this practical activity has in turn become a reference for academic research, which has generated new theories to be tested in practice, and so on and so on, in an interlocking cycle. On the other hand, the study of ecological accounting in developing countries lags behind. Most scholars tend to study the western literature without considering the breakthroughs and innovations occurring in the developing world; thus their research is unable to meet the current need for economic transition in developing countries. Due to the considerations of cost benefit, the domestic industrial subject does not actively participate in the practical application of new concepts, making it difficult for academics to study the structural framework of ecological accounting in China.

In general, ecological accounting in various countries has been developing rapidly and extensively, but it has some deficiencies and defects; namely, it lacks a specific theoretical framework, and it lacks systems for accounting, evaluation, optimization and control, and simplistic research. In order to break through the current research difficulties and provide more support for sustainable development, this paper suggests the following:

1) Construct a specific theoretical framework. Various aspects of ecological accounting have come a long way, but the lack of a framework may hinder their use in practice. A specific theoretical framework can provide broad guidelines that can be applied to specific objects.
2) Further improvement of the system so that it contains functions like accounting, evaluation, optimization and control. Ecological accounting derives from environmental accounting, which is formed by combining accounting with environmental management, environmental economics and other disciplines into a complex system. Improving a system so that it includes functions like accounting, evaluation, optimization and control can provide theoretical and practical support for sustainable accounting management.
3) Enriching the related research methods and increasing the variety of empirical study. Currently, domestic research is largely empirical; this limits the usefulness of related ecological accounting research and hampers further research. Using mature statistical methods and measurement methods, such as structural equation modeling, may allow research to break through the current limitations of ecological accounting research.

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References

[1] Chatfield, M. (1974) A History of Accounting Thought. Dryden Press, Oak Brook, 6-14.

[2] Wang, N. (2011) Research on the Application and Development Prospects of Accounting. *Communications in Computer and Information Science*, **231**, 233-237. http://dx.doi.org/10.1007/978-3-642-23993-9_34

[3] Schaltegger, S., Bennett, M. and Burritt, R. (2006) Sustainability Accounting and Reporting: Development, Linkages and Reflection. An Introduction. *Sustainability Accounting and Reporting*, **21**, 1-33.

[4] Alver, J. and Alver, L. (2009) Development of Accounting and Implementation of International Financial Reporting Standards in Estonia. *Accounting Reform in Transition and Developing Economies*, 101-113.

[5] Reyes, A. (1995) A Theoretical Framework for the Development of a Social Accounting System. *Critical Issues in Systems Theory and Practice*, 173-178. http://dx.doi.org/10.1007/978-1-4757-9883-8_23

[6] Jain, S.C., Sen, D.K., Khan, M. and Bala, S.K. (2007) An Analytical Study on Social Responsibility Performance Evaluation as an Accounting Measure of Management Efficiency. *AI & SOCIETY*, **21**, 251-266.

http://dx.doi.org/10.1007/s00146-006-0057-2

[7] Lone, O., Nyborg, K. and Aaheim, A. (1993) Approaches to Environmental Accounting. *Contributions to Economics*, 446-457. http://dx.doi.org/10.1007/978-3-642-49977-7_24

[8] Uno, K. and Bartelmus, P. (1998) Environmental Accounting in Theory and Practice. Economy & Environment (Book 11), Springer, Dordrecht.

[9] Franz, A. and Stahmer, C. (1993) Approaches to Environmental Accounting. Contributions to Economics. *Proceedings of the IARIW Conference on Environmental Accounting*, Baden (near Vienna), 27-29 May 1991.

[10] Barbier, E.B. (1992) Taking Nature into Account: Proposed Scheme of Resource and Environmental Accounting. *Environmental and Resource Economics*, **2**, 435-437. http://dx.doi.org/10.1007/BF00304971

[11] Teizzi, S. (1999) External Effects of Agricultural Production in Italy and Environmental Accounting. *Environmental and Resource Economics*, **13**, 459-472. http://dx.doi.org/10.1023/A:1008299301169

[12] Bartelmus, P. (1998) The Value of Nature: Valuation and Evaluation in Environmental Accounting. *Economy & Environment*, **11**, 263-307. http://dx.doi.org/10.1007/978-94-017-1433-4_16

[13] Kopp, R.J. (1999) Economic Valuation of Environmental and Natural Resource Assets: Applications to Environmental Accounting. *Fondazione Eni Enrico Mattei* (*FEEM*) *Series on Economics, Energy and Environment*, **12**, 53-71. http://dx.doi.org/10.1007/978-94-011-4836-8_3

[14] Common, M.S. and Norton, T.W. (1994) Biodiversity, Natural Resource Accounting and Ecological Monitoring. *Environmental and Resource Economics*, **4**, 29-53. http://dx.doi.org/10.1007/BF00691931

[15] Lei, K., Zhou, S. and Wang, Z. (2014) Ecological Energy Accounting for Macao's Socioeconomic and Ecological Systems. In: Lei, K., Zhou, S. and Wang, Z., Eds., *Ecological Energy Accounting for a Limited System*: *General Principles and a Case Study of Macao*, Springer, Berlin, 27-66. http://dx.doi.org/10.1007/978-3-642-45170-6_2

[16] Wackernagel, M. (2006) Ecological Footprint Accounting—Comparing Earth's Biological Capacity with an Economy's Resource Demand. In: Keiner, M., Ed., *The Future of Sustainability*, Springer, Dordrecht, 193-209. http://dx.doi.org/10.1007/1-4020-4908-0_10

[17] Heister, J. and Schneider, F. (1993) Economic Progress and Environmental Concerns: A Publications of the Egon-Sohmen Foundation. Springer, Berlin, 25-48.

[18] Kröger, G., Pietsch, J. and Ufermann, K. (1999) Environmental Accounting on a Communal Level: A Tool to Support Environmental Management and Decision-Making by Communal Executives. *Environmental Science and Pollution Research*, **6**, 170-174. http://dx.doi.org/10.1007/BF02987622

[19] Uno, K. and Bartelmus, P. (1998) Environmental Accounting in Theory and Practice. Economy & Environment, Vol. 11, Springer, Dordrecht. http://dx.doi.org/10.1007/978-94-017-1433-4

[20] Common, M.S. and Norton, T.W. (1995) Biodiversity Conservation Ecology. *Economy & Environment*, **4**, 87-110.

[21] Birkin, F. and Woodward, D. (1997) Management Accounting for Sustainable Development. *Management Accounting*, **75**, 52-54.

[22] Birkin, F. (2000) The Art of Accounting for Science: A Prereouisite for Sustainable Development? *Critical Perspectives of Accounting*, **7**, 324-331.

[23] Birkin, F., Edwards, P. and Woodward, D. (2003) Accounting's Contribution to a Conscious Cultural Evolution: An End to Sustainable Development. *Critical Perspectives of Accounting*, **4**, 78-84.

[24] Birkin, F. (2000) Health Not Wealth as an Institutional Performance Goal. *Environmental Management and Health*, **11**, 307-317. http://dx.doi.org/10.1108/09566160010372734

[25] Birkin, F., Edwards, P. and Woodward, D. (1997) Changed Rules Theory and the Evolution of Accountancy. *Critical Perspectives of Accounting*, **9**, 47-53. http://dx.doi.org/10.1006/cpac.1996.0113

[26] Smith, E.P. and Cairns Jr., J. (1993) Extrapolation Methods for Setting Ecological Standards for Water Quality: Statistical and Ecological Concerns. *Ecotoxicology*, **2**, 203-219. http://dx.doi.org/10.1007/BF00116425

[27] Patil, G.P. (1995) Editorial: Statistical Ecology and Related Ecological Statistics—25 Years. *Environmental and Ecological Statistics*, **2**, 81-89. http://dx.doi.org/10.1007/BF00680295

[28] Service, M.W. (1993) Ecological and Statistical Publications. In: Service, M.W., Ed., *Mosquito Ecology*, Springer, Dordrecht, 914-924.

[29] Liu, Q. and Bråkenhielm, S. (1995) A Statistical Approach to Decompose Ecological Variation. *Water, Air, and Soil Pollution*, **85**, 1587-1592. http://dx.doi.org/10.1007/BF00477207

[30] Steele, B.M. (2001) Sampling Design and Statistical Inference for Ecological Assessment. In: Jensen, M.E. and Bourgeron, P.S., Eds., *A Guidebook for Integrated Ecological Assessments*, Springer, New York, 79-91. http://dx.doi.org/10.1007/978-1-4419-8620-7_7

[31] Garmestani, A.S. (2014) Sustainability Science: Accounting for Nonlinear Dynamics in Policy and Social-Ecological Systems. *Clean Technologies and Environmental Policy*, **16**, 731-738. http://dx.doi.org/10.1007/s10098-013-0682-7

[32] Stahmer, C. (1993) System for Integrated Environmental and Economic Accounting (SEEA) of the United Nations. In: Franz, A. and Stahmer, C., Eds., *Approaches to Environmental Accounting*, Contributions to Economics, Physica-Verlag, Heidelberg, 511-540. http://dx.doi.org/10.1007/978-3-642-49977-7_28

[33] Klöpffer, W. (1997) Life Cycle Assessment. *Environmental Science and Pollution Research*, **4**, 223-228. http://dx.doi.org/10.1007/BF02986351

[34] Duda, M. and Shaw, J.S. (1997) Life Cycle Assessment. *Society*, **35**, 38-43. http://dx.doi.org/10.1007/s12115-997-1054-x

[35] Rebitzer, G., Loerincik, Y. and Jolliet, O. (2002) Input-Output Life Cycle Assessment: From Theory to Applications 16th Discussion Forum on Life Cycle Assessment Lausanne. *The International Journal of Life Cycle Assessment*, **7**, 174-176. http://dx.doi.org/10.1007/BF02994053

[36] Birkin, F. (1996) The Ecological Accounting: From the Cogito to Thinking Like a Mountain. *Critical Perspectives of Accounting*, **3**, 93-101.

[37] Bradley, P.P. and Jakes, P.J. (1995) Measuring Forest Ecosystem Sustainability: A Resource Accounting Approach. *Environmental Management*, **19**, 685-692. http://dx.doi.org/10.1007/BF02471951

[38] Isenmann, R. and Marx-Gómez, J. (2004) How to Provide Customized Environmental Reports Properly. In: Scharl, A., Ed., *Environmental Online Communication*, Advanced Information and Knowledge Processing, Springer, London, 173-182. http://dx.doi.org/10.1007/978-1-4471-3798-6_18

[39] Fichter, K., Loew, T. and Clausen, J. (1999) Competitive Advantages through Voluntary Environmental Reporting. In: Hitchens, D.M.W.N., Clausen, J. and Fichter, K., Eds., *International Environmental Management Benchmarks*, Springer, Berlin, 173-185. http://dx.doi.org/10.1007/978-3-642-58442-8_14

[40] Birkin, F. (2003) Ecological Accounting: New Tools for a Sustainable Culture. *International Journal of Sustainable Development and World Ecology*, **10**, 49-61. http://dx.doi.org/10.1080/13504500309469785

[41] Rees, W.E. (1992) Ecological Footprint and Appropriated Carrying Capacity: What Urban Economics Leaves out. *Environment and Urbanization*, **4**, 121-130. http://dx.doi.org/10.1177/095624789200400212

[42] Wackernagel, M., Onisto, L., Bello, P., Linares, A.C., Falfán, I.S.L., García, J.M., *et al.* (1999) National Natural Capital Accounting with the Ecological Footprint Concept. *Ecological Economics*, **29**, 375-390. http://dx.doi.org/10.1016/S0921-8009(98)90063-5

[43] Wackernagel, M. and Ress, W.E. (2000) Our Ecological Footprint: Reducing Human Impact on the Earth. New Society Publishers, Gabriola Island, 53-88.

[44] Monfreda, C., Wackernagel, M. and Deumling, D. (2004) Establishing National Natural Capital Accounts Based on Detailed Ecological Footprint and Biological Capacity Assessments. *Land Use Policy*, **21**, 231-246. http://dx.doi.org/10.1016/j.landusepol.2003.10.009

[45] Wackernagel, M., Monfreda, C., Ebr, H., Haberlb, H. and Schulzb, N.B. (2004) Ecological Footprint Time Series of Austria, the Philippines, and South Korea for 1961.1999: Comparing the Conventional Approach to an Actual Land Area Approach. *Land Use Policy*, **21**, 261-269. http://dx.doi.org/10.1016/j.landusepol.2003.10.007

[46] Ewing, B. and Goldfinger, S. (2010) Ecological Footprint Atlas. *Global Footprint Network*, **10**, 45-49.

[47] Cho, C.H. and Patten, D.M. (2013) Green Accounting: Reflections from a CSR and Environmental Disclosure Perspective. *Critical Perspectives on Accounting*, **24**, 443-447. http://dx.doi.org/10.1016/j.cpa.2013.04.003

[48] Schneider, A. (2015) Reflexivity in Sustainability Accounting and Management: Transcending the Economic Focus of Corporate Sustainability. *Journal of Business Ethics*, **127**, 525-536.

[49] Chan, H.K., Wang, X. and Raffoni, A. (2014) An Integrated Approach for Green Design: Life-Cycle, Fuzzy AHP and Environmental Management Accounting. *The British Accounting Review*, **10**, 344-360. http://dx.doi.org/10.1016/j.bar.2014.10.004

[50] Allen, B.G. (2014) What's New about New Accounts? Assessing Change Proposals for Social and Environmental Accounting. *Accounting Forum*, **38**, 278-287. http://dx.doi.org/10.1016/j.accfor.2014.03.001

[51] Haxhimoto, S. and Moriguchi, Y. (2004) Proposal of Six Indicators of Material Cycles for Describing Society's Metabolism: From the Viewpoint of Material Flow Analysis. *Resources, Conservation and Recycling*, **9**, 26-30.

[52] Masao, K. (1998) The Theory of Ecological Accounting. *Moriyama Bookstore.*

[53] Masao, K. (2006) The Development of Environmental Accounting and International Deployment. *Moriyama Bookstore.*

[54] Miyazaki, N. (2006) The JEPIX Initiative in Japan. A New Ecological Accounting System for a Better Measurement of Eco-Efficiency. *Sustainability Accounting and Reporting*, **21**, 339-354. http://dx.doi.org/10.1007/978-1-4020-4974-3_15

[55] Schaltegger, S. and Burritt, R. (2000) Contemporary Environmental Accounting: Issues Concepts and Practice. Greenleaf Publishing, Sheffield.

[56] Cho, C.H. and Patten, D.M. (2013) Green Accounting: Reflections from a CSR and Environmental Disclosure Perspective. *Critical Perspectives on Accounting*, **24**, 443-447. http://dx.doi.org/10.1016/j.cpa.2013.04.003

[57] Zhang, Y. and Zhang, W. (2011) The Preliminary Exploration of Ecological Accounting. *Financial Communications*, No. 2, 78-79. (In Chinese)

[58] Yu, Y. (2014) Study of Ecological Civilization Based on the Establishment of Ecological Accounting. *Theory Research*, No. 1, 3-9. (In Chinese)

[59] Lin, W. and Xiao, X. (2006) The Introduction to Environmental Cost Management. China Financial and Economic Publishing House, Beijing, 8-21. (In Chinese)

[60] Shen, H. and Liao, J. (2014) The Accounting and Ecological Civilization System Construction. *Accounting Research*, No. 7, 12-17. (In Chinese)

[61] Geng, J. and Cao, G. (2007) On Ecological Accounting Concept. *Accounting*, No. 2, 3-5. (In Chinese)

[62] http://www.greenchina.tv/news-4468.xhtml

[63] Lin, Z. (2013) Study on Resources, Environment, Ecological Based on the Relevant Statements in the Eighteen Report. *Forestry Economy*, No. 2, 11-15. (In Chinese)

[64] Lu, T. (2014) "Two-Oriented" Lading the Development of Ecological Civilization to Build a Green Fortress. *Economic Research Guide*, No. 18, 311-312. (In Chinese)