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Case Study of Comprehensive Benefit Evaluation and Management of Forest Ecosystem Services in Zhalantun City of Inner Mongolia, China

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Abstract

Based on official statistics and on-site investigation, this paper firstly used Direct Market Evaluation Method (DMEM), Indirect Market Evaluation Method (IMEM) etc. evaluated the comprehensive benefits for forest ecosystem services in 2016 in Zhalantun City in Inner Mongolia, China. The results indicate that the stock value of Zhalantun forest ecosystem is RMB 42.787 billion, of which the forest land stock value amounts to RMB 27.318 billion, and forest standing timber stock value amounts to RMB 15.469 billion. The flow value, that is the annual comprehensive benefit of forest ecosystem services is RMB 515.864 billion, of which the economic benefits, capitalized the value of forest land, forest standing timber, and forest product, is RMB 23.292 billion, the forest ecological benefit is RMB 490.249 billion, and the social benefit is RMB 2.323 billion. The annual benefit is approximately 31 times of GDP values of Zhalantun of that year recorded as RMB 16.567 billion. The paper also exploratory constructed the balance sheet and calculated the asset-liability ratio of forest ecosystem services in 2016 in Zhalantun City. The results show that the development of Zhalantun forestry and forest management is sustainable, and the asset-liability ratio of forest ecosystem services is calculated at 11.499%, far below the alert level of 50% according to the international accounting standards. This paper finally suggested that Zhalantun should be maximum raising the economic benefits by full utilization of forest ecosystem services and strengthen management etc.

Keywords: balance sheet, comprehensive benefits, decision making, evaluation, forest ecosystem management, sustainable development

Introduction

Research Development of Home and Abroad

Ecosystem is referred the general designation of all the living things and their living surroundings in a specific environment (Daily, 1997). Forest ecosystem is an important component of the ecosystem, which is the comprehensive natural body with a certain structure and function formed by the forest communities and their environment. Forest ecosystem mainly contains tropical rain forest ecosystem, evergreen broad-leaf forest ecosystem, deciduous broad-

leaf forest ecosystem, and cold temperate coniferous forest ecosystem and so on (Ehrlich, Ehrlich, & Holdren, 1977). Forest ecosystem services are referring all the obtained benefits from the forest ecosystem by human beings, including supply of service, regulatory service, cultural service and support service and so on (United Nations, 2005). It is indispensable and crucial no matter for the survival or welfare of the human beings, which are extensively accepted worldwide as a kind of natural capital of the human society. While forest ecological benefit is mainly referred as the beneficial influence and useful effect upon human's production, life and environmental conditions resulted from forest ecosystem service, which is also the *positive* influential part caused by human's production, life and environmental conditions owing to forest ecosystem services, without including the *negative* influential part. Therefore, its content is less than that of forest ecosystem service (Zhang & Shi, 2015).

Since Daily (1997) raised the concept of ecosystem service in 1997, the content of the ecosystem service had been further described in details in *The Millennium Ecosystem Assessment, MA* conducted by multiple global agencies of the United Nations in 2005 (Brander et al., 2012; United Nations, 2005).Ghermandi, Van Der Bergh, Brander, Groot, & Nunes (2010) divides ecosystem services into 4major categories, 22 types of services. Costanza et al. (1997) fall into 17 categories. About the evaluation method of ecosystem service, Brander; Florax, and Vermaat (2006) and Brander et al. (2012) used meta method to evaluate the European wetlands and estimated the welfare effects of ecosystem change at the larger geographical scale in 2006 and 2012. And Helliwell (1969) made a fundamental research on the valuation of ecosystem. In addition, many Chinese scholars have also done relevant researches, such as Ouyang, Wang, & Miao (1999), Chen & Zhang (2000), and He (2005) etc. They have done a lot of case studies and the application exploration of ecosystem evaluation methods. These studies provide a basis for evaluating forest ecological system services and better service management decision making (Liu, Li, & Zhao, 2009; Xie, Zhang, Zhang, & Chen, 2015).

Significance of the Research

Along the incessantly expediting process of industrialization and urbanization, China has got the globally noticeable developments. However, it causes quite serious destruction on environmental and ecological system in the meantime. In order to improve environmental treatment and ecosystem restoration, it is put forward the new concept about natural resource balance sheet for the first time in *Central Government's Decisions on Several Important Issues about Thorough Intensification Reform*, to truly reflect the total accumulation of natural resource and its variation as well as utilization in the course of social economical development (Xue, Bao, & Li, 1999; Zeng, Li, & Yao, 2014).In terms of the research and exploration of the construction of natural resources balance sheet, from the simple to the sophisticate, from the easy to the difficult (Li & Zhang, 2013). We try to evaluate the forest resources asset taking Zhalantun city in Inner Mongolia, China as an example, and then try to compile a balance sheet for forest resources in order to provide better service for ecosystem services management and decision making.

Forest resource is the important components of natural resources, providing not only all kinds of wood and products but also ecological system services. Comprehensive benefit evaluation of forest ecosystem services not only can reflect the value of forest ecosystem services, raise people awareness of ecosystem protection, but also to strengthen the forest resources management, better service for management decisions (Liu,Wang, Peng, & Li, 2014). Therefore, carrying out

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this research cannot only provide the reference value for sustainable development and forest ecosystem management, but also can do benefit for the share of the research results and experience into national economic accounting system at home and abroad (Fung, Sharma, Zhan, & Su, 2017; Verutes et al., 2017).

Methodology and Data

Zhalantun city is located in the east of Inner Mongolia Autonomous Region, to the south of Hulunbeier, situating at the transition area between Daxinganling Mountain and Songneng Plain. The landform mainly is dominated by mountains and hills in Zhalantun, of which climate is attributed to the middle temperate continental semi-moisture climate zone.

The forest resource in Zhalantun city is very rich, with forest coverage rate at 67.8%. Forest resource is mainly located in the east and north of this area. The dominant tree species are *Xingan Larix Spp*., *Xylosma Racemosum*, *Betula davurica Pall*, *Betula platyphylla Suk*, *Pinus Sylvestris*, *Pinus Koraiensis*, *Fraxinaus mndshurica Rupr*, *Populus Davidiana* etc.

In addition, there are 5 forestry bureaus in the administrative region of Zhalantun city, they are Zhuoer Forestry Bureau, Aershan Forestry Bureau, Chaihe Forestrry Bureau, Nanmu Forestry Bureau, and Wuchagou Forestry Bureau, they are in charge of forestry production and management within the administrative region.

Methodology

The evaluation method of forest ecosystem services is basically similar to the common ecosystem service evaluation. It can be summarized as three major categories, which are Direct Market Evaluation Method (DMEM), Indirect Market Evaluation Method (IMEM), and Hypothetical Market Evaluation Method (HMEM) (Ouyang et al., 1999).

(1) DMEM is suitable for ecosystem services with actual market transactions, of which the market value is set as an economical price for ecosystem service, such as food, raw material, wood etc. DMEM is often described using the following formula:

$$V_0 = \sum_{i=1}^{n} N_0 Q_0 \qquad (1)$$

Where, V_0 is the sum of the forest ecosystem services market values, N_0 is defined as unit values of forest products or services and Q_0 is the quantity, n is the number of types of forest products or services.

Moreover, in DMEM, some stock capital, such as forestland, forest standing timber etc. evaluated using the following formula (Zhao, Xiao, & Wu,2000), that is

$$V_0 = \sum_{t=0}^{T} N_t Q_t /(1+r)^t \qquad (2)$$

Where, V_0 is the present value of the forestland, forest standing timber, which is the sum of the expected net revenue flows $N_t Q_t$, discounted at nominal or real interest rates *r* for the life *T* of the forest asset, N_t is defined as the total unit value of the forest resource less the costs of extraction, development, exploration and Q_t is the quantity exploited during the period *t*. It is noticeable that although Faustmann has made an outstanding work in this valuation (Faustmann,1995), to simplify the calculation we used the formulae for estimation of standing timber according to the methods described in *System of Environmental Economic Accounting (SEEA) and Millennium Ecosystem Assessment of UN* (United Nations, 2005; 2014).

(2) IMEM is suitable for the valuation of ecosystem services that have no actual market transactions but have alternative market values. For substitute market, by calculating the cost for applying certain technical means to obtain certain forest ecosystem service with the same result, indirectly evaluating the forest ecosystem service value (Banzhaf et al., 2016).In IMEM, substitute method is used very often, which using some corresponding goods or services in the market to reflect the values of substituted ones. Beyond that, the opportunity cost method, traveling cost method, shadow project approach etc. is also often used (Westman, 1997).

(3) HMEM is suitable for ecosystem services with neither actual market transactions nor substitute market transactions, evaluating ecosystem service value by adopting artificial virtual market. Contingent Valuation Method (CVM) is the substantial actualizing method for HMEM, estimating the economic value through surveying the willingness to pay (WTP) or willingness to accept (WTA) for certain ecosystem service. HMEM mainly includes bidding game approach, trade-off game and costless choice (Perman, Ma, McGilvray, & Common, 2003).

In our study, the valuation methods are shown as Table 1.

Table 1. Valuation Methods for Forest Ecosystem Services

No.	Forest ecosystem services	Valuation methods
1	Forestland	Market transaction price
2	Standing timber	
(1)	Young forests	Plantation cost
(2)	Middle-aged forests, Close- mature forests, mature forests and over- mature forests	Net present value
3	Forest products	Market transaction price
4	Forest ecosystem services	
(1)	Water resource conservation	Substitute method
(2)	Soil maintenance and cultivation	Substitute method
(3)	Accumulation of nutrients	Substitute method
(4)	Atmospheric purification	Substitute method
(5)	Farmland and grassland protection	Substitute method
(6)	Species maintenance and conservation	Forest biodiversity protection expense
(7)	Carbon sequestration and oxygen release	Carbon emission permit trading price
(8)	Forest travel and recreation	Travel cost method (TCM), using travel revenue substituted
(9)	Providing employment opportunities	Substitute method
(10)	Forest science and cultural values	Travel cost method, Contingent Valuation Method (CVM)

***Source**: Zhang, Lu & Han, 2015.*

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As is shown in the Table1, the evaluation of Zhalantun forest ecosystem services mainly consists of forestland and forest wood assets, which can be divided into standing timber, forest products and forest ecosystem services. Valuation methods are various in the different forest ecosystem services. Here shows the valuation method for the forest land. With regard to forestland evaluation, it is usually to obtain forest land price through the expecting price of annuity capitalization, and the substantial calculation formulas are:

$$V = \frac{a}{1+r} + \frac{a}{(1+r)^2} + \frac{a}{(1+r)^3} + \cdots + \frac{a}{(1+r)^n} \tag{3}$$

As $n \to \infty$, the formula is simplified as

$$V = \frac{a}{r} \tag{4}$$

In this formula,

- V—Forest land expected value
- a—Average expectation of forestland rent
- r—Discount Rate

The specificcalculation formulas for standing timber, forest products and forest ecosystem services are not listed here. In the calculation, the carbon emission permit trading price is also about $ 20/t C according to the EU's carbon emission permit trading price (Zhang et al.,2015).

Data Collection

The study data are mainly from forest inventory of Zhalantun in 2012 and 2016, State Economy and Social Development Statistics Report, 2011-2016 Governmental Work Report in Zhalantun, the 12th and the 13th five-year plan of Zhalantun, the Inner Mongolia Autonomous Region Principal Functional Area Plan, Forest Ecological Protection and Economy Transition Development Plan of Zhalantun, the governmental websites of Zhalantun Forestry Bureau, Zhalantun Statistic Yearbook, and the relevant data and materials from Zhalantun Water Resource Bureau, Agriculture and Husbandry Bureau, and Environmental Protection Bureau etc. The required material for social benefit evaluation is mainly from the relevant data provided by Zhalantun Forestry Bureau, and Statistics Bureau as well as the survey on the sites and responses of the questionnaires (Zhang et al., 2015). Some social benefit data, such as the employment ratio, and the income per person in Zhalantun, mainly from the questionnaire and the statistics published on website. Specific questionnaires may refer to relevant research reports (Zhang & Shi, 2015).

Findings

Based on the above methods and data, some basic results are obtained.

In 2016, the stock value of Zhalantun forest ecosystem is RMB 42.787 billion, of which the forest land stock value amounts to RMB 27.318 billion, and forest standing timber stock value

amounts to RMB 15.469 billion. The flow value, that is the annual comprehensive benefit of forest ecosystem services is RMB 515.864 billion, of which the economic benefits, capitalized the value of forest land, forest standing timber, and forest product, is RMB 23.292 billion. The forest ecological benefit is RMB 490.249 billion, and the social benefit is RMB 2.323 billion. The annual benefit is approximately 31 times of GDP values of Zhalantun of that year recorded as RMB 16.567 billion (Table 2).

Table 2. Forest Ecosystem Services Evaluation in Zhalantun in 2016

Category	**Content**	**Stock value (RMB billion)**	**Flow value (Annual benefit) (RMB billion)**
Economic benefits	Forestland	27.318	0.040
	Standing timber	15.469	1.130
	Forest products	-	22.123
	Subtotal	42.788	23.292
Ecological benefits	Water resource conservation	-	15.085
	Soil maintenance and cultivation	-	60.539
	Accumulation of nutrients	-	0.058
	Atmospheric purification	-	138.603
	Farmland and grassland protection	-	9.802
	Species maintenance and conservation	-	8.947
	Carbon sequestration and oxygen release	-	257.215
	Subtotal		490.249
Social benefits	Forest travel and recreation	-	0.547
	Providing employment opportunities	-	0.374
	Forest science and cultural values	-	1.402
	Subtotal		2.323
Total			515.864

Forest resources are important ecological assets, which represent how much wealth a company owned (Li & Zhang, 2013; Makoujy, 2010). We can use a balance sheet shows what a company's assets are. The exploratory establishment of the balance sheet of forest ecosystem services in Zhalantun city is shown in Table 3.

The results show that the development of Zhalantun forestry and forest management is sustainable. From the accounting results, it is known that the equity of forest land is RMB 40 million, that is the net value of forestland in Zhalantun increased of about RMB 40 million from 2015 to 2016. Also, the whole assets in 2016 are RMB 515.864 billion, and ecological benefit of the forest ecosystem services is higher than the social benefit of it. Similarly, in Liabilities, the resources depletion is RMB 2.854 billion, including logging RMB 2.194 billion and tree mortality RMB 0.660 billion. Investment in ecological construction and protection is RMB 56.467 billion. The asset-liability ratio of forest ecosystem services in 2016 in Zhalantun city is calculated at 11.499%, far below the alert level of 50% according to the accounting standards (Makoujy, 2010), which means the exploitation and utilization of forest ecosystem services and its management is sustainable in Zhalantun city at present (Table 3).

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Table 3. The Balance Sheet of Forest Ecosystem Services in Zhalantun City

Assets	Content	The equity in 2016 (RMB billion)
Assets	Forestland	0.04
	Standing timber	1.130
	Forest products	22.123
	Ecological benefits	490.249
	Social benefits	2.323
	Subtotal	515.864
Liabilities	Resources depletion	-2.854
	In which: logging	-2.194
	Tree mortality	-0.660
	Investment in ecological construction and protection	-56.467
	Subtotal	-59.321
Net Worth		456.543
The asset-liability ratio(%)		11.499

***Note**: The liabilities often use"-" to indicate in specific statistics.*

We know that in management, a pareto chart is always used to graphically summarize and display the relative importance of the differences between groups. The left-side vertical axis of the pareto chart is labeled Frequency (the number of counts for each category), the right-side vertical axis of the pareto chart is the cumulative percentage, and the horizontal axis of the pareto chart is labeled with the group names of your response variables (Liu et al., 2014). In order to better manage the comprehensive benefit of forest ecosystem services in Zhalantun city, we constructed the pareto chart of ecosystem services as showed in Figure 1.

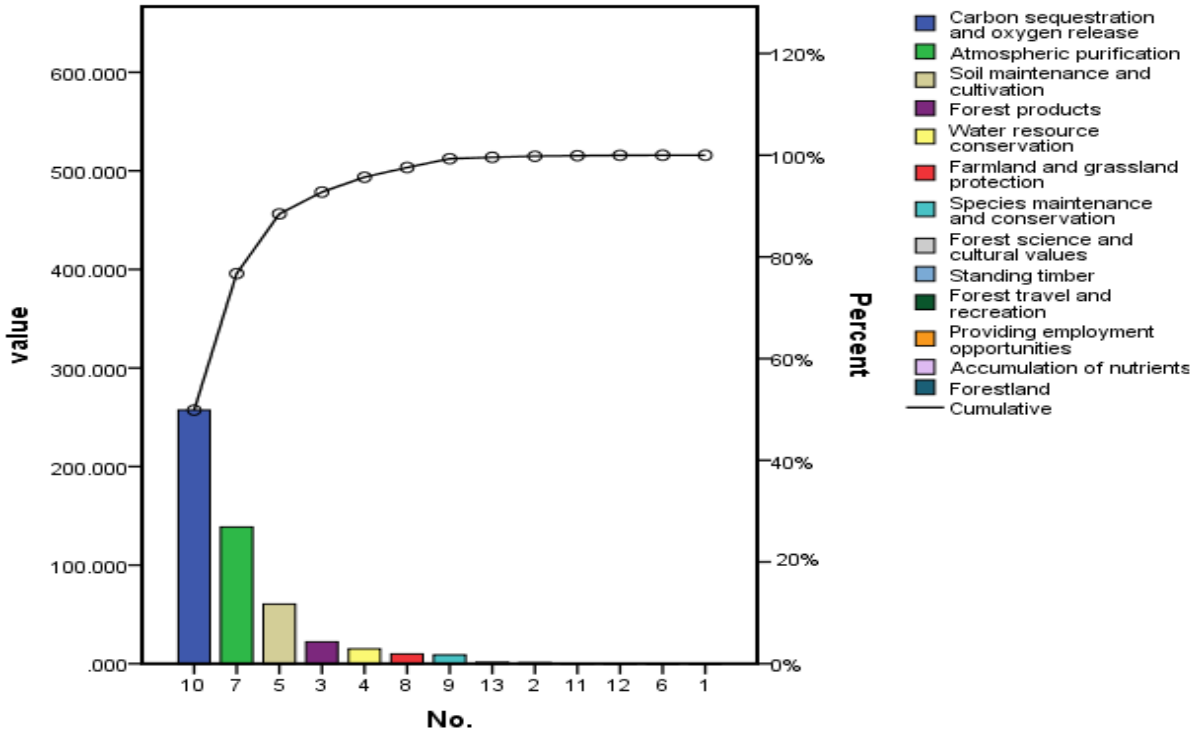

Figure 1. A Pareto chart of forest ecosystem services in Zhalantun City in 2016

From Figure 1, it reveals that the carbon sequestration and oxygen release are the fundamental and main services for forest ecosystem, providing indispensable environmental conditions for the survival of human beings. The second is atmospheric purification, the third and fourth are soil maintenance and cultivation and forest products respectively etc. The least important is forestland. Therefore, we should pay more attention to these important ecosystem services, such as make forest carbon sequestration, atmospheric purification and other services development and utilization, in order to completely realize the value of ecosystem services and promote the development of ecosystem management.

And also, in ecosystem services, we've noticed that the service value of forest carbon sequestration and oxygen release is highest, at RMB 247.215 billion, next is the value of atmospheric purification, at RMB 138.603 billion, while the value of forest accumulation of nutrients is lowest, only at RMB 58 million, of which percentage is shown as Figure 2.

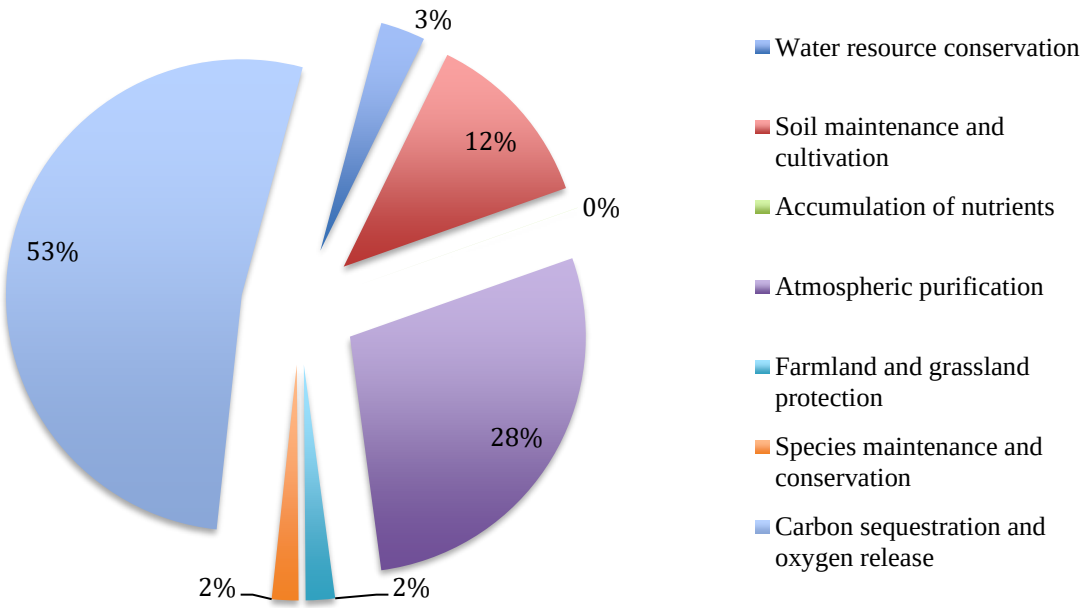

Figure 2. Forest ecosystem services value percentage in Zhalantun City in 2016

From Figure 2, it illustrates that the importance of carbon sequestration and oxygen release and atmospheric purification etc. in climate change. In particular, at the current time with environmental problems that becomes more serious day by day. We should even have full apprehension about the value and importance on forest ecosystem service, establishing and strengthening ecological environment protection, achieving the sustainable utilization of forest resources and social economic sustainable development, and make full sense of destruction of forest is equalized to self-ruin.

Discussion

The most effective way to manage an ecosystem is to evaluate the ecosystem services effectively. This paper taking Zhalantun city in Inner Mongolia, China as an example evaluated the comprehensive benefit and tried to management of forest ecosystem services, but there are some issues that have to be discussed.

The key to evaluation of ecosystem services is the determination of the evaluation method and the price of evaluation. The evaluation of ecosystem service is a process of monetization, and the different theories and methods have great influence on the evaluation results. Evaluation should be based on some theories and principles of natural resources and environmental economics (Perman et al., 2003), and using some standard methods and classifications to evaluate (United Nations, 2014), so as to analyze and comparable the evaluation results at home and abroad, and to better service for decision making and ecosystem management. Usually, the System of Environmental-Economic Accounting 2012— Central Framework of the United Nations is a good ecosystem service evaluation standard, and it is very helpful to ecosystem service management (United Nations, European Union, Food and Agriculture Organization of the United Nations, Organization for Economic Co-operation and Development, & The World Bank, 2014). In our study, the average annual comprehensive benefit of forest ecosystem of Zhalantun city in 2016 is evaluated about RMB 515.864 billion, among which the economic benefit is RMB 23.292 billion, ecological benefit is RMB 490.249 billion, and social benefit is RMB 2.323 billion. Hopefully these evaluation results will be useful for ecosystem management.

Some information and concepts of forest ecosystem management should be used. Forest ecosystem services evaluation is aimed at ensuring sustainable production of high-quality forest ecosystem, alongside with the needed supplying timber and food etc. functions of forests. This needed is based on general forest management plans, specific plans of forest ecosystem management and some district plans of forest development. No matter which kind of plans should consist of trees of different species, silviculture practices, rotation, the forest structure, the costs of the development, analogue and digital maps etc., in particular, some information and concepts of ecological environment statistics should be adopted. As thus, it is convenient for forest resource and environmental statistics and better to evaluate forest ecosystem services and furthermore to promote the management and development of forest ecosystem. In our study, due to lack of some basic data of forest ecosystem services evaluation, this kind of work needs to be further improved (Moiseev, Von Gadow, & Krott, 1997; United Nations, European Union, Food and Agriculture Organization of the United Nations, Organization for Economic Co-operation and Development, & The World Bank, 2017).

Balance sheet should be used in the comprehensive benefit evaluation and management of forest ecosystem services. In government and industry, balance sheet utilization is often mismanaged (Makoujy, 2010). The balance sheet not only examines some of the problems faced by executives in the pursuit of financial gain and representatives furthering flawed, but also provides a lot of management information of companies. Forest ecosystem is a kind of natural capital, should use this income statement tool to reflect the *profit and loss statement* of *ecosystem*. It is a useful tool to measure and understand the change of the ecosystem services, which are comparable over time (Gao, Zhen, Wang, & Zhang, 2017).

Of course, companies (or individuals) are different from governments or industries, have assets of varying kinds in addition to real estate. These include cash, inventory, equipment, and patents etc. We owe money in forms other than expenses, such as taxes, bills, investments, and payroll. Net worth, or equity, is calculated by subtracting total liabilities from total assets, this is a balance sheet (Liu et al., 2009). As a result, we can easily use a balance sheet to reflect the ecosystem's *profit and loss*, as well as easily to manage it. In this study, we have conducted an exploratory research and hope it to have some reference for ecosystem management.

Conclusions

According to the above research, the comprehensive benefits of the forest ecosystem in Zhalantun city of Inner Mongolia in 2016 are evaluated. The benefit is RMB 515.864 billion, which is 31.14 folds of GDP about RMB16.567 billion that year. It indicates that the benefits play an important role in the social and economic development of Zhalantun. The Liabilities in 2016 is RMB 59.321 billion, including the resources depletion is RMB 2.854 billion and the investment in ecological construction and protection is RMB 56.467 billion. The asset-liability ratio of forest ecosystem services in 2016 is calculated at 11.499%, far below the international alert level of 50%, which show that the development and utilization of forest ecosystem services need to be strengthened.

The research also pointed out that Zhalantun should emphasize the forest carbon sequestration, atmospheric purification and other key services development and utilization, maximumly raising the economic benefits by full utilization of the forest ecosystem based on the principles of ecosystem management.

This result also, to a certain extent, reflects that the development of forestry human resource capital should be enhanced, improving the forestry employment opportunity, because of the benefit of providing employment opportunities for social benefits is still relatively low, at RMB 0.374 billion. In fact, the development of human resource capital is the essential path of improving forest resource value, achieving forest resource protection, utilizing and developing *Win-Win* strategy. Also, it plays an important role on harmony, stable and sustainable development of society. We should build a solid foundation for the realization of forestry human resource capital development in ecosystem services management.

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