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A method of green GDP accounting based on eco-service and a case study of Wuyishan, China

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Abstract

Green GDP is an effective economic indicator of urban environmental management. This paper introduces a new method of accounting Green GDP, which puts the value of direct ecosystem services into GDP. Direct ecosystem services are weighted by their virtual prices and aggregated in the same way as market goods and services in GDP. They are components of nature, directly enjoyed, consumed, or used to yield human well-being. They belong to ecosystem services. In order to choose direct ecosystem services reasonably, two principles are put forward. That is, when calculating the value of ecosystem services for Green GDP, the differences between services for human beings and services for other living beings must be considered. And the green GDP of Wuyishan city of China is accounted, considering the direct ecological services value of urban ecosystem as environmental benefit. The results show that the value of direct ecosystem services in Wuyishan City in 2005 has reached 2.3 billion yuan RMB, and the green GDP is 15.3 billion yuan RMB.

*Keywords:*Green GDP; ecosystem service; Wuyishan

1. Introduction

The Gross Domestic Product (GDP) is a very important indicator to show the economic development level of a country, which is accounted as a total valuation of the end production and salary. Since 1960's, the global environmental pollution and ecological destroy issues have become the great obstacle to urban sustainable development. From then on, people found that it was essential to value natural capital and put it into economic accounting system. This was originally green GDP. Another reason to measure green GDP is that environmentalists want to track the provision of nature's benefits over time, in order to hold goverments accountable or to compare their environmental conditions with those of another county(Boyd, 2007).

According to the different accounting systems, green GDP has been classified as two main types (Yue and Xu, 2008, 2009). Type I green GDP accounts GDP minus the cost of environmental pollution and resources depletion,

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but it ignored the value of natural ecosystem services. As Heal (2007) pointed out that the national accounts need to present us with income statements and balance sheets that reflect the values of ecosystem services. In this context, more and more scholars of both domestic and abroad begin to account the valuation of ecosystem services and plus it into GDP accounting, which is type II green GDP in this paper.

In fact, the original thought of type II green GDP accounting came from the research of Costanza in 1997. He compared the value of global ecosystem services with the global GNP, that year and also created a new idea of GDP accounting to include eco-service valuation into traditional economic accounting system (Costanza, 2000), which is Subtotal Ecological-economic Product(SEP) (Sutton and Costanza, 2002). It can be described as following:

$$SEP = GDP + ESP \qquad (1)$$

Here, ESP is the abbreviation for Ecosystem Services Product, namely the value of ecosystem services. Although SEP is not green GDP, this research has formed a new accounting system further, which is similar with type II green GDP. In addition, Costanza also provided the calculation method with the amount of light energy (LE) emitted when he calculated the world's ecosystem services in 1997 to account ESP (Costanza et al., 1997). The result from this method will be more objective and reasonable than that from national statistics.

In 2005, Ecosystems and Human well-being Synthesis considered the ecosystem services as the basis for global environmental accounting (Millennium Ecosystem Assessment, 2005), hence ecosystem services has become the hot topic in environmental economic field, which also drove the research of the type II green GDP accounting gradually. Type II green GDP can benefit the protection performance of the natural ecosystem especially in those cities with better natural environment condition. Although the scholars do a lot of research on the type II green GDP recently, most studies still stay on the research of accounting methods, but little application. Moreover, the accounting approach just make a simple sum up between the value of ecosystem services and GDP, ignoring the possibility of double counting.

In China, the green GDP accounting system has included the value of ecosystem services (SEPA, 2006), but the accuracy and reasonability of ecosystem services accounting at present cannot meet the requirements of green GDP accounting. Moreover, only the parts of the ecosystem services value which is not included in GDP are useful for green GDP accounting. So the key issue of type II green GDP accounting is to determine what kind of ecosystem services should be included in the accounting system. In fact, most studies just make simple sum up between the value of ecosystem services and GDP without making the useful part clear. For example, Gao(2005) put forward the method of green GDP accounting for agricultural production based on the agro system services. That is

$$Green\ GDP = Traditional\ GDP + Ecological\ GDP \qquad (2)$$

$$Ecological\ GDP = Ecosystem\ services\ value - Ecological\ cost \qquad (3)$$

In this research, five kinds of ecosystem services were brought into the context of GDP accounting system, which were climate regulation, air clean, soil conservation, fecundation value, pests control, biodiversity and cultural recreation, but the criteria or rule to choose ecosystem services has not been discussed specifically.

In 2007, some academics proposed the definition of the final ecosystem services, and suggested that it should be brought into green GDP accounting as the ecological units of account. A goal of these units is comparability with the definition of conventional goods and services found in GDP and the other national accounts (Boyd and Banzhaf, 2007). This study indicates the implementation phase of type II green GDP comes on the scene. Boyd(2006) and Banzhaf(2005) come up with another thought of green GDP accounting, that is

$$Green\ GDP = GDP + ESI \qquad (4)$$

Where, ESI stands for Ecosystem Services Index, which represents the value of final ecosystem services. As the kind of ecosystem services depends on where and when the demand for, it must be counted at fine spatial and temporal scales (Boyd and Banzhaf, 2007).

Overall, the type II green GDP accounting is in the initial stage, presently. The difficulties focus on accounting ecosystem services value. Foreign scholars' research concentrates on the methods, but the practice is inadequate. While, domestic scholars have calculated the type II green GDP for some area, but their research is just accounting the value of ecosystem services, not bringing them into GDP accounting system. This also indicates that if ecosystem services are applied to GDP accounting systems, they must clear the selection rules and avoid double counting which are always ignored. According to the character of each region, how to determine the ecosystem services' types that are added to the type II green GDP accounting is still a problem now.

This paper brings the value of direct ecosystem services into GDP accounting, studies Wuyishan City as a case and accounts its type II green GDP. For a city, the GDP comes from green GDP which refers to GRP (Gross Regional Product). Considering the consistency of terminology, the following discussion of the Wuyishan City is still using green GDP.

2. Methodology

Green GDP accounting, based on the value of ecosystem services, is a way of putting the value of ecosystem services into the GDP accounting system. This method can bring external economy into the market regulation in order to internalize external costs. For the sake of avoiding double counting some ecosystem services, the green GDP accounting system is divided into four components, which are economy system, social system, resource system and environmental system. Specifically, the type II green GDP accounting could be expressed with the following formula:

$$GreenGDP_2 = k_1 GDP + k_2 GDP + k_3 GDP + DES \tag{5}$$

$$k_1 GDP + k_2 GDP + k_3 GDP = GDP \tag{6}$$

$$DES + ES_1 + ES_2 = ESP \tag{7}$$

Where, type II green GDP indicates the type II green GDP; DES stands for direct ecosystem services. In this paper, the idea of DES corresponds to the final consumption of GDP, which calculated by expenditure method. k_1, k_2 and k_3 represents the proportion of GDP generated by economy system, social system and resource system respectively; ESP stands for ecosystem services product; ES_1 shows ecosystem welfare to other creature; ES_2 shows ecosystem welfare to future generations.

Therefore, the formula (5) can be abbreviated to formula (8)

$$GreenGDP_2 = GDP + DES \tag{8}$$

As there are some differences in the proportion of each component when account GDP and the value of ecosystem services for different cities or regions, so k_1, k_2, k_3 is not a constant here but need to be determined according to characters of different cases. Because direct ecosystem services are a part of ecosystem services, we need to determine the type of direct ecosystem services (see Figure 1), the selection principles expressed as below:

(1) Natural ecosystem offers a variety of ecosystem services for creature on earth, which means human beings enjoying these services, together with other creature. Therefore, in green GDP accounting, the ecosystem services to human and other creature should be treated separately.
(2) The type II green GDP accounting, based on GDP accounting system, is added on the value of ecosystem services. Therefore, the ecosystem services must meet the requirements of GDP accounting system, that is, the end product consumed by human in a period of time. The object is human being, and the time is specific, not unlimited extension.

Fig 1 shows the relationship between different types of ecosystem services and GDP accounting system. According to the different object, the ecosystem services are divided three parts: Contemporary people's welfare, Future generation's welfare and All creature's welfare. Based on GDP accounting's requirement that the objects of accounting must be the end products valued by contemporary people, the future generation's welfare can be excluded and all creatures' welfare should be included by GDP partly. Otherwise, the parts which have been

counted in GDP should be excluded, such as food production, water supply and raw material supply. The figure is the general division in accordance with ecosystem, and for different regions or different time the division can be changed.
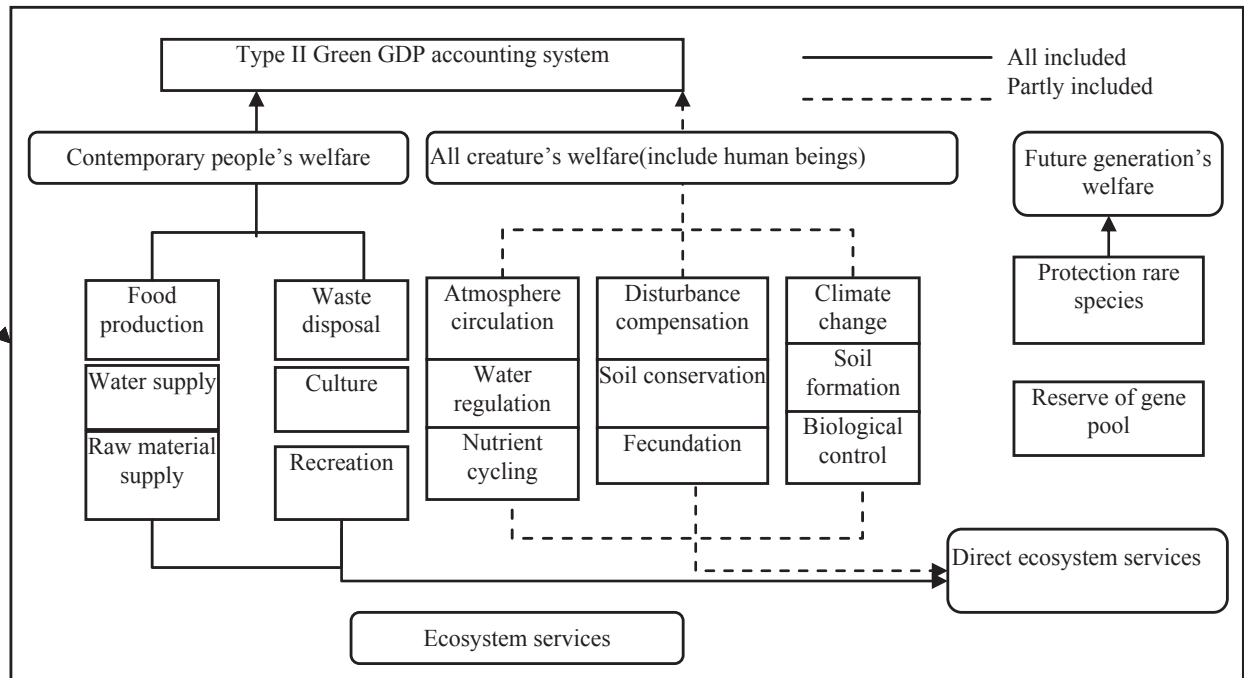

Fig1 Type II Green GDP accounting system

3. Case study

3.1. Study Area

Wuyishan City is located in the northwest Fujian Province, under the Nanping City, which consists of three streets, seven towns, and the total area is about 2813.91 km^2. It is the only tourism city named after the famous mountain. It is rich in natural tourism resources, and the most famous areas are Wuyishan Scenic Spots and Nature Reserve, both of which were included in the 《 List of World Natural and Cultural》 . Wuyishan Nature Reserve is the world's most typical area of the same latitude, with the largest existing area and best preserved in the subtropical native forest ecosystems.

Wuyishan City considers tourism as its pillar industries, but the level of industrial development is low. Choosing Wuyishan City as the case is due to its good natural ecosystem. In order to protect the ecological environment, Wuyishan City gives up developing industries that can bring pollution but much GDP at the same time, which is adapt to using the type II green GDP accounting system..

3.2. Types of the direct ecosystem services in Wuyishan City

The outer area comparing superiority analysis method is used to analyse the leading industries in Wuyishan City. The method is an important means for selecting the regional leading industries (Chen and Zhang, 2006). The standard is the degree of regional specialization, also known as specialization rate, which indicates the proportion of

an industry in its regional industrial structure in proportion with the proportion of the industry in the national industrial structure. The formula is expressed as follows:

$$SV_{ij} = (V_{ij}/V_i) \div (V_{ij}/V)$$

(9)

where，SV_{ij} —the added value rate of specialization;；

V_{ij} —the added value of j industry in i region；

V_i —total added value of i region；

V —national total added value

If SV_{ij} >1, indicates that j is the leading industry in i region. The larger the value of SV_{ij} is the more likely for j to become the regional dominance, and vice versa.

For Wuyishan City, the results of SV_{ij} for its primary industry, secondary industry, tertiary industry , industry , construction and tourism are shown in Table 1 :

Table 1 SVij of each industry in Wuyishan City

item	nation(10^8 yuan)	Wuyishan City(10^4 yuan)	SV_{ij}
GDP	182321	302848	—
Primary industry	22718	71743	1.901172
Second industry	86208	72286	0.504799
Industry	76190	43236	0.341633
Construction	10018	29050	1.74573
Tertiary industry	73395	157789	1.294262
Tourism	7686	155100	12.14852

As is shown in table 1, Tourism has the maximum value of SV_{ij}, which also agrees with that tourism is the pillar industry in Wuyishan City. At the same time, the value of SV_{ij} of Primary industry and Tertiary industry is greater than 1, which means Primary industry and Tertiary industry might have become the mainstay industry. The value of SV_{ij} of Second industry is less than 1 and Industry is the minimum, which verifies that industrial development is on the lower level. The main reason is that Wuyishan City, as an important source of water and shelter, is the world double inheritance that needs higher environment protection. So for Wuyishan City, green GDP accounting should consider its characteristics, choose the type II green GDP accounting ideas, in order to reflect the changes of local residents and eliminate the welfare market externalities.

According to the ESI choosing methods, ecosystem characteristics and local residents' willingness determine the types of direct ecosystem services of Wuyishan City. Researchers conduct the questionnaire survey to see the ecological environment consciousness of the residents in Wuyishan City, which lasts for 15 days in March and September, 2006, respectively. The total number of questionnaires is 361 and the people who filled in were chosen from different towns of Wuyishan City randomly. Through the third and fourth problem in the questionnaire, the attitudes and understanding of local residents for ecosystem services can be known (see figure 4). The survey showed that 35.3% residents hope that local tourism can be developed, and 31.5% residents believe that vacant lots should be built parks. It indicated that local residents more concerned recreation services provided by Wuyishan Scenic Spots and Nature Reserve.

The questionnaire survey showed that most local residents support the tourism development, which indicates tourism can bring benefits for local residents. According to investigation, local residents' welfare provided by ecological system are determined, such as the harvest, water supply, amenities, health protection, avoiding disposal and scientific culture. But not all above 6 types of welfare were brought into GDP accounting system. It is necessary to consider whether these services have already been in GDP accounting system. Studies show that resources'

function and water supply have been included in GDP accounting system, while other welfare need to be brought into. The composition of direct ecosystem services is formed as Fig 3 shown.
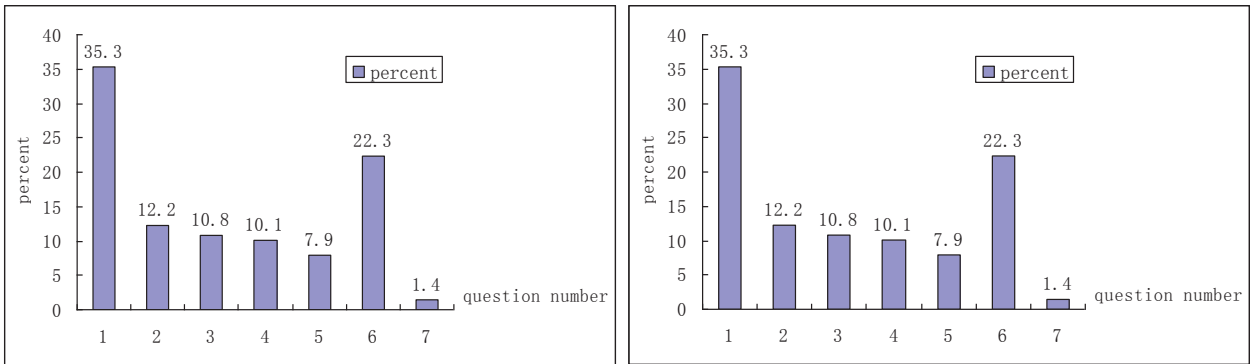
Q3. Which do you prefer continuous development in Wuyishan City after five years:
1.Tourism 2.Industry 3.Agriculture 4.Service industry 5.Transportation 6.Education 7.Others

Q4. If you have a vacant lot in Wuyishan City, what will you build?
1.Park 2.House building 3.Factory 4.Farmstead 5.others 99.not sure
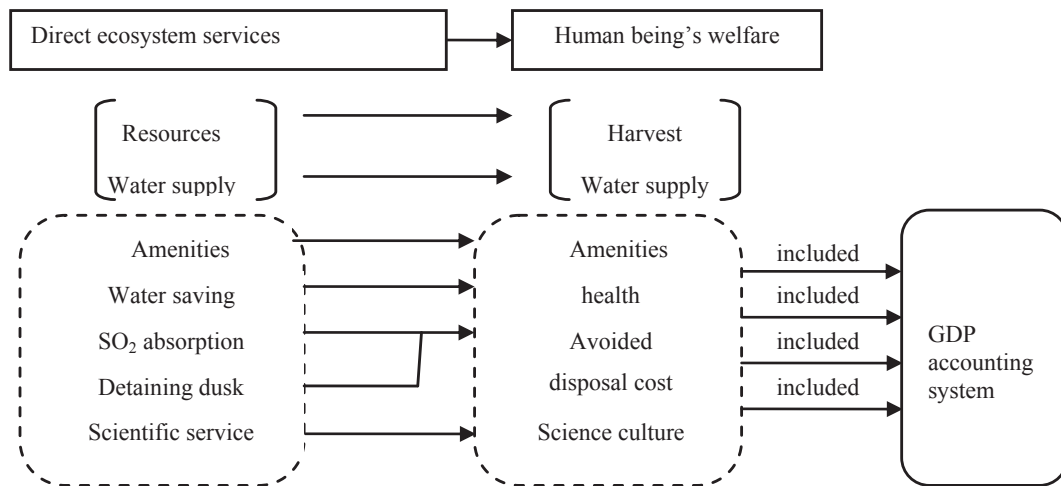
Fig 2. the 3nd and 4th questions in questionnaire

Fig3 direct ecosystem services of Wuyishan City

3.3. The Green GDP accounting of Wuyishan

After collecting relevant data, using feasible valuation methods (see table2), we can calculate the value of direct ecosystem services of Wuyishan City. In 2005, the total forest area of Wuyishan City is 1323075hm^2, so we get the subtotal value of direct ecosystem services in table 3.

Table 2 the accounting methods of each direct ecosystem services in Wuyishan City

DES	Price technology		Formula
Amenities value	Hedonic price		Trees can make the real estate prices increased by 5% to 10%, which can be the basis for accounting, accounting aesthetic value.
Water saving value	Market price		$DES_1 = k_4 (1 - \theta) \times L \times E_4$ Where, DES_1 stands for the value of water conservation of per unit area of ecosystem, yuan/ ($hm_2 \cdot a$) ; N_4 stands for water conservation of per unit area, m^3 / ($hm^2 \cdot a$) ; L stands for the average rainfall,mm / a;θ is the evapotranspiration proportion; k_4 is a constant; E_4 stands for water shadow price.
Air Clean value	SO_2 absorption	Shadow price	$DES_2 = Q\ d_7 \times Cd_7$ where,DES_2 stands for the value of absorbing SO_2 of per unit area of ecosystem, yuan/ ($hm^2 \cdot a$) ; Q dr stands for ability of SO_2 absorption of per unit area of ecosystem, t/ ($hm^2 \cdot a$); Cd_7 stands for the engineering cost for reducing SO_2.
	Detaining dusk	Hypothetic market price	$DES_3 = Q\ d_8 \times Cd_8$ where,DES_3 stands for the value of detaining dusk of per unit area, yuan/ ($hm^2 \cdot a$) ; Q d_8 stands for the ability of detaining dusk of per unit area, t/ ($hm^2 \cdot a$) ; Cd_8 stands for the cost for reducing the dusk.
Scientific service	—		The average value of global temperate forest ecosystem scientific culture is 99 yuan/ ($hm^2 \cdot a$).

Table 3 the value of direct ecosystem services in Wuyishan City in 2005

Type	Total value(10^4yuan)
Amenities	35241
Water saving	677256
Air cleaning	506169
Scientific service	13098
Tota value	1231764

4. Conclusion

In this study, we introduce the value of direct ecosystem services to GDP accounting system, and calculate the type II green GDP of Wuyishan city. As Table 3 shown, the direct ecosystem services value is 12.32 billion yuan, and GDP is 3.02 billion in Wuyishan City in 2005. After adding the two values, type II green GDP of Wuyishan city in 2005 is 15.32 billion yuan RMB, which is 5 times than GDP.

The accounting results indicate that Wuyishan City has great value of direct ecosystem services. Among them, water saving value is the largest with 55%, followed by air cleaning. This shows that the natural landscape of Wuyishan City is not only to promote local tourism development but more important to provide a lot of services for residents. The value of direct ecosystem services in GDP accounting system can not be ignored. Therefore, the development of local tourism industry should also strengthen the protection of the natural environment.

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