Empirical Experiences of Environmental and Economic Accounting in China

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Abstract: This paper reviews the history and context of the accounting system in China, introduces the framework and methodology of environmental and economic accounting, displays the empirical data with the perspective of different categories of pollutant and industries, analyzes the situation of the year 2004 with regard to the three major types of costs, illustrates the pollution adjusted indexes of 2005 and 2006 are 2.1% and 2.0% respectively, compares the environmental accounting system among different countries, and discusses the feasibility and prospects of Green GDP Accounting system.

Keywords: framework technical approach pollution adjusted index industries experience of other countries

1 Background

In the past 30 years of development since reform and opening-up, China has made -great achievement in the development of economy which attracted worldwide attention with the annual GDP growth rate of 9.5%. However, negative impacts brought by mere pursuit of economy growth and utilization of limited GDP indicator have become more conspicuous.

Currently, China is in face of serious environmental issues. The highly disharmonious relationship between human and Nature, and the projecting problem of environment and natural resource have affected the basis for the country in achieving sustainable development. China is now in the stage of mid-industrialization featured by large percentage of heavy industry, high resource consumption and pollution emission. Unlike the cases of developed counties in their industrialization process where different environmental issues emerged and were solved in different stages, China is faced with an explosive outbreak of environmental issues during the past 30 years since reform and opening-up. The severity of the environmental problem in China is not only reflected by the increasing amount of pollution, the widening range of ecological destruction and the striking conflict between supply and demand of resources, but also represented by the interaction among resources, environment and social economic development. Every single income obtained in China is at the cost of natural resources consumption and environmental pollution. Numbers of Evidences have shown that the natural resources and ecological environment can no longer support the extensive mode of economic development, which has become a key restrictive factor for social economy development.

In the meanwhile, GDP is generally used by Chinese government at local level as an important indicator of official achievements. Guided by this, pursuit of GDP growth is over-emphasized. Activities that brings large environmental growth, rapid image change and greater influence to the public are preferred by the local officials, instead of those are slow in returns and affects long-term

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interests. The so-called “achievements” made under such conception are, in most cases Unreasonable and near-sighted.

In order to implement comprehensive, coordinated and sustainable concept of development, the President Hu Jintao put forwarded that "researching the green national accounting, developing the evaluation system that take resource depletion, environmental cost and benefit into the account of economy, keeping the balance between the human and Nature", in the 2004 workshop on the population, resources and environment hosted by the central government of China. Thus, the State Environmental Protection Administration (SEPA) and the National Bureau of Statistics (NBS) jointly launched the Research Project “China Green National Accounting (Integrated Environmental and Economic Accounting, or Green GDP Accounting) Study” focusing on pollution in March 2004, and in 2005 carried out surveys and pilot works in ten provinces and municipalities of China. Two ministries in September 2006 for the first time published *China Green National Accounting Report 2004.* The technical team of this project summed up local experiences and suggestions, and based on this, expanded the accounting scope and refined accounting approaches. The accomplishment of *China Green National Accounting Report 200*5 indicates that the study on annual green national accounting has been progressing and improving. The world bank granted the study as well.

2. Accounting Framework and Methodologies

2.1 Framework for Chinese environmental and economic accounting in short-term

Because of the immature theoretical approaches for green national economic accounting and relatively weak research base for accounting of ecological damage cost, the future development of the Green National Accounting System of China will put emphasis on the accounting for environment and natural resources but, in the interim, without regard to physical accounting and monetary accounting for ecological damage. The System of Integrated Environmental and Economic Accounting (SEEA) of China includes physical accounting of environmental pollution, monetary accounting of environmental pollution, and accounting of environmentally adjusted domestic product (EDP). Its framework is as shown in Fig.2-1.

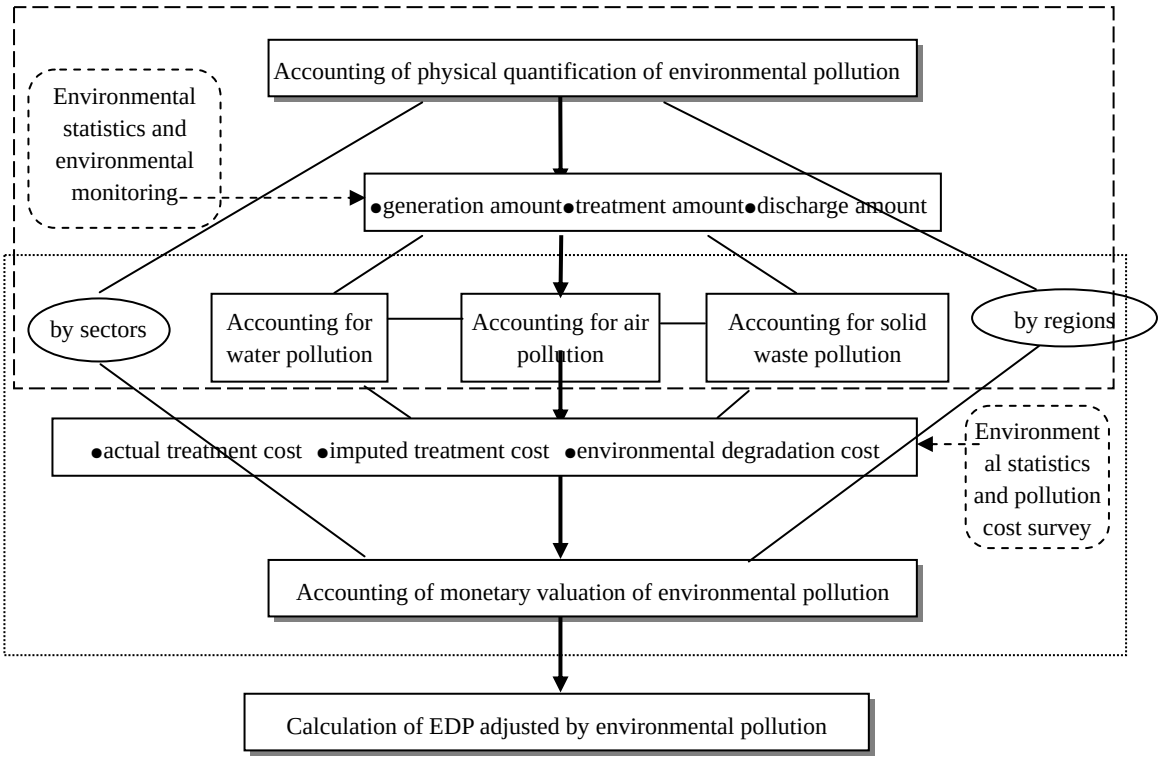
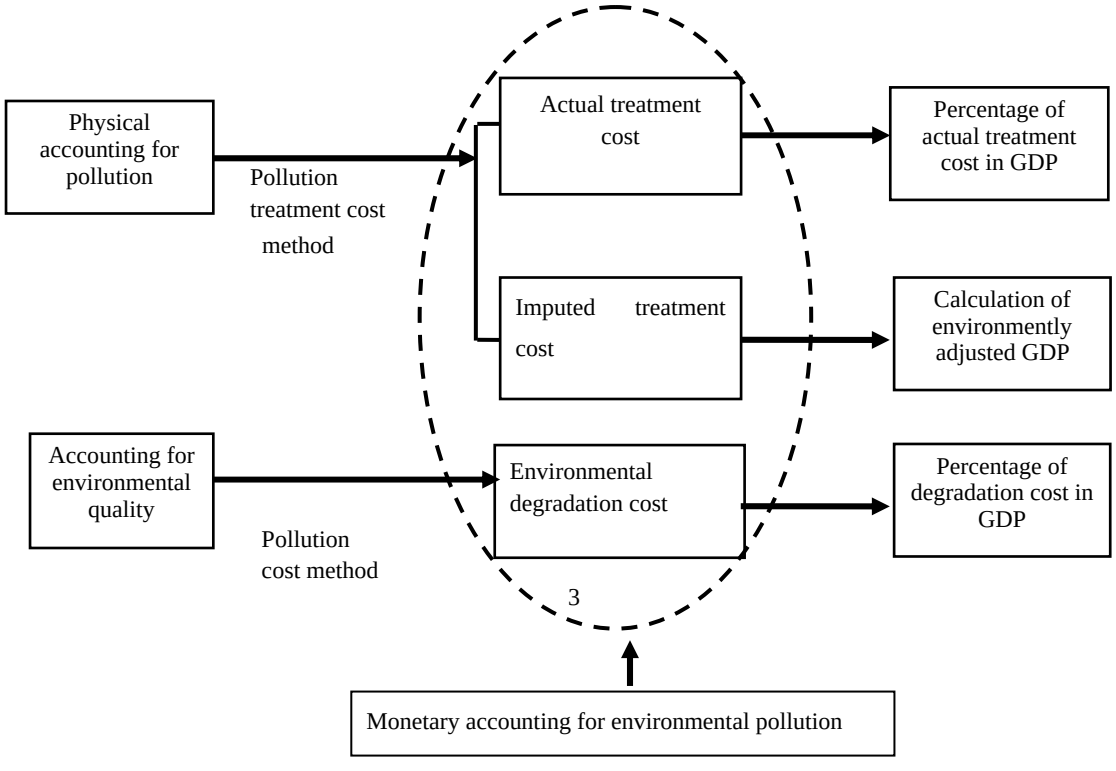


Fig.2-1 Framework for Chinese Environmental and Economic Accounting in Short-term

Chinese environmental and economic accounting will be conducted at both the national and local levels. Through pilot accounting in Beijing City, Anhui Province and Guangdong Province, accounting approaches are tested and related experiences are accumulated for the whole accounting system. The physical quantification and monetary value of environmental pollution is for the accounting period 2004; for the industrial sectors, environmental and economic accounting was conducted 39 industrial sectors (See Annex 1) from primary industry and secondary industry and 42 sectors from tertiary industry and households, using national economic industries classification system.

2.2 Technical approaches for environmental and economic accounting

Technical approaches to be adopted in accounting are shown in Figure 2-2. Its calculation can be



divided into three steps: 1) Physical accounting of pollution consisting of the amount of generation, treatment and pollution emitted; 2) Monetary accounting of pollution which refers to calculation of the actual cost and imputed cost for pollution control by using pollution control cost method and making calculation on environmental degradation cost caused by pollutants discharge by using environmental cost method; 3) Accounting of environmentally adjusted GDP (by imputed abatement cost) (EDP) and proportions of imputed abatement cost and environmental degradation cost in GDP.

The project adopts two approaches to evaluate environmental cost: The first one is to calculate the necessary treatment cost to abate untreated pollutant discharge in the process of production and consumption by means of the treatment cost approach, the result of which is called *imputed treatment cost* in CEEA. The second one is to calculate the economic loss caused by the pollutant discharge that has led to the environmental deterioration such as, the impact on human health by air pollution, using the pollution cost estimation method to quantify those impacts in monetary terms, the result of which is called *environmental degradation cost* in CEEA.

Fig.2-2 Technical Approaches for Chinese Environmental and Economic Accounting

2.3 Accounting contents

2.3.1 Physical accounting of environmental pollution

Physical accounting of environmental pollution mainly includes accounting for physical quantity of water pollution, air pollution, industrial solid wastes in different regions and accounting for physical quantities of water pollution, air pollution, and industrial solid wastes in different sectors.

I. Water pollution

i. Accounting scope: waste water discharged from plant production, stockbreeding, industrial sectors, tertiary industry and domestic sewage.

ii. Accounting objects: sewage and major pollutants in wastewater—COD, NH_3-N, cyanide, heavy metals and oil.

iii. Accounting indicators: sewage discharge amount, wastewater discharge amounts of meeting standards and exceeding standards, generation amount, abatement amount and discharge amount of pollutants in wastewater. For industrial wastewater, generation, abatement and discharge amounts of COD, NH_3-N, cyanide and oil and discharge amount of heavy metals should be considered in the accounting; while for wastewater from farming, stock raising, tertiary industry and households, only generation, abatement and discharge amounts of COD and NH_3-N should be accounted in the accounting.

vi. Accounting methods for sewage discharge amount, wastewater discharge amounts of meeting standards and exceeding standards: accounting for physical quantification of industrial wastewater is based on the data of industrial wastewater discharge amount from different regions and different industries in the environmental statistics and amended rate of sewage discharge amount attaining the required standards; accounting for physical quantification of urban wastewater from households and public sectors is indirect use of environmental statistical data; and water-consumption coefficient method, wastewater generation coefficient method for livestock and poultry and per capita wastewater from households and public sectors generation coefficient method are adopted in the accounting for wastewater generated from crop production, stockbreeding and urban households.

v. Accounting methods for generation amount, abatement amount and discharge amount of pollutants in wastewater: corresponding with the accounting methods for industrial wastewater discharge amount, accounting for pollutants of industrial wastewater are also based on the amended physical quantity data in the environmental statistics; accounting for pollutants of urban wastewater from households and public sectors is indirect use of environmental statistical data; and per unit pollutants source strength coefficient method, pollutants discharge coefficient method for livestock and poultry and per capita domestic pollutants generation coefficient method are adopted in the accounting for pollutants in the wastewater generated from crop production, stockbreeding and urban households.

vi. Data source: State Environmental Statistic Report, China Urban Construction Statistic Yearbook, China Water Resources Bulletin and Water Resources Bulletin in different provinces, China Statistic Yearbook, China Stockbreeding Yearbook.

II. Air pollution

i. Accounting scope: waste gas from agriculture, industry, tertiary industry and households.

ii. Accounting objects: SO_2, soot, industrial dust and nitrogen oxide.

iii. Accounting indicators: Regarding industrial sectors, generation, abatement and emission quantities of SO_2, soot, industrial dust and NOx should be considered in the accounting; regarding tertiary industry and households, generation, abatement and emission quantities of SO_2, soot and NOx should be accounted for in the accounting; regarding agriculture and rural household, generation and emission quantities of SO_2, soot and NOx should be accounted.

iv. Accounting methods: environmental statistic and energy consumption balance and discharge coefficient are combined into use in the accounting.

v. Data source: State Environmental Statistic Report, China Urban Construction Statistic Yearbook, China Energy Statistic Yearbook, China Statistic Yearbook.

III. Solid waste pollution

i. Accounting scope: solid wastes generated from industrial sectors and urban households.

ii. Accounting objects: general industrial solid wastes, hazardous wastes of industry and household wastes.

iii. Accounting indicators: generation amount, integrated utilization amount, storage amount, disposal amount and deposit of industrial solid wastes and hazardous wastes; generation amount, sanitary land-filling amount, compost amount, incineration amount, simple treatment amount and deposit amount of urban domestic wastes.

iv. Accounting methods: environmental statistical data are used for accounting of general industrial solid waste and hazardous wastes while statistical data in the Urban Construction Yearbook are used fro accounting of urban domestic wastes.

v. Data source: State Environmental Statistic Report, China Urban Construction Statistic Yearbook.

2.3.2 Monetary accounting of environmental pollution

Monetary accounting of environmental pollution includes the following contents: accounting for monetary evaluation of water pollution, air pollution, industrial solid wastes, urban domestic wastes and economic loss by pollution accidents in different regions; and accounting for monetary

valuation of water pollution, air pollution, industrial solid wastes and economic loss by pollution accidents in different sectors. Among these, the damage cost approach could only be applied in accounting at the regional level.

I. Actual pollution treatment cost

i. Actual pollution treatment costs for industrial wastewater and waste gas uses statistical data from the State Environmental Statistic Report of China.

ii. Actual treatment costs for wastewater of stocks breeding, industrial solid wastes, urban households wastes and households waste gas uses a model approach to accounting. In theory, it is relatively simple to account for the actual pollution treatment costs, i.e. to multiply pollutants treatment quantity by per unit operation cost for treatment. The basic formula is as follows: Actual pollution treatment cost = pollutants treatment(abatement) quantity ×per unit actual treatment cost.

Treatment or abatement quantities of pollutants could be available through physical accounting of environmental pollution. Therefore, the key to the physical accounting is validating per unit operation costs for each treatment. The per unit actual treatment cost adopted in the report is based on survey data from the pilot regions.

II. Imputed pollution treatment cost

The accounting method for imputed treatment cost is the same as the accounting method for actual treatment cost, that is, the cost to be paid for treatment of all the pollutants discharged into the environment could be available through physical accounting on pollutants discharge amount and per unit imputed treatment cost. The basic formula is as follows: Imputed pollution treatment cost = pollutants discharge amount×per unit imputed treatment cost.

It is the most difficult to identify per unit imputed treatment cost in the accounting for imputed pollution treatment cost. In order to simplify the accounting, the report adopts the same per unit imputed treatment cost and per unit actual treatment cost.

III. Environmental degradation cost

In the report, the cost calculated using the pollution cost approach is called the environmental degradation cost. This approach entails using surveys of pollution losses and specific methods to estimate the monetary values of the physical impacts caused by pollution upon the local environment, such as the impacts upon crops output, health and ecological environment, and then convert those impacts into monetary values and identify environmental degradation cost caused by pollution. Environmental degradation cost is generally evaluated only at the regional level; adjustments of GDP is therefore also only at aggregate regional level. It is currently difficult to break down environmental degradation cost generated by the different sectors. However, theoretically, the damage of pollution represents an actual environmental degradation cost, and only the accounting for pollution damage could embody the benefits of pollution treatment.

In terms of pollution accounting, environmental degradation cost covers economic loss caused by air pollution, water pollution and solid waste pollution; while in terms of terminal hazards by pollution, it includes economic losses of human health, agricultural and industrial production (crop planting, forestry, stockbreeding and fishery), water resources and materials, and economic losses caused by infertilization of land and the impacts on human health. Environmental degradation cost in this research comprises 10 pollution cost items: i. health cost caused by air pollution; ii. agricultural loss caused by air pollution; iii. material losses caused by air pollution; iv. economic losses caused by water scarcity due to pollution; v. health losses by water pollution; vi. agricultural losses by water pollution; vii. defensive expenses by industrial sectors caused by

water pollution; viii. urban households economic losses by water pollution; ix. losses caused by land occupation due to solid wastes deposit; x. losses by pollution accidents. The calculation methods of items i, ii. iii. iv. vii. greatly refers to the models developed in ECM project[2].

2.3.3 Accounting for environmentally adjusted GDP

The imputed treatment cost calculated using monetary accounting of environmental pollution is used to adjust the traditional GDP to derive the environmentally adjusted GDP (EDP) and the proportion of environmental degradation cost in the GDP. Environmental degradation cost is calculated out by region.

Environmentally adjusted GDP (EDP) is calculated by aggregating the accounting results from monetary accounting for water pollution, air pollution and solid waste pollution by industrial sector and by region.

There are three accounting approaches:

1) production approach: EDP = gross output - intermediate input – imputed treatment cost;

2) income approach: EDP = compensation for laborer + taxes less subsidies on production + Depreciation of fixed capital + operation surplus with deduction of imputed treatment cost;

3) expenditure approach: EDP = final consumption + capital with deduction of imputed treatment cost + net export.

Since value system of environmental degradation cost differs from that of traditional GDP, the report only calculates proportion of environmental cost in the GDP instead of directly deducting environmental degradation cost from GDP.

3 China Environmental and Economic Accounting in 2004

3.1 Physical Accounts of Environmental Pollution

According to the calculation result of physical pollution accounting, the total amount of discharged wastewater is 60.72 billion tons across the country in 2004, the discharged amount of COD is 21.093 million tons, the discharged amount of ammonia nitrogen is 2.232 million tons; the total emission amounts of SO_2, soot, dust and nitrogen oxides are 24.502 million tons, 10.955 million tons, 9.051 million tons and 16.466 million tons respectively; the discharged amount of industrial solid wastes is 17.608 million tons while the deposit amount of household wastes 66.675 million tons.

3.2 Imputed Abatement Cost

3.2.1 Abatement cost for water pollution

In 2004, the gross domestic product of all the industries (by production approach) amount to 15987.8 billion yuan in China. The actual abatement cost for wastewater across the country is 34.44 billion yuan, accounting for 0.22% of the GDP while the imputed abatement cost for wastewater is 180.87 billion yuan, accounting for 1.13% of the GDP in China. It can be concluded

[2]W.B. project Environmental Cost Model. The study report of ECM project has not been published.

that the imputed abatement cost for wastewater is 5 times as much as the actual abatement cost.

3.2.2 Abatement cost for air pollution

In 2004, the actual abatement cost for air pollutants across the country is 47.82 billion yuan, accounting for 0.29% of the GDP of all the industries at that year. While the imputed abatement cost for air pollutants is 92.23 billion yuan, accounting for 0.55% of the GDP in China. In conclusion, the imputed abatement cost for air pollutant is 1.93 times as much as the actual abatement cost.

3.2.3 Abatement cost for solid wastes

In 2004, the actual abatement cost for solid wastes across the country is 18.28 billion yuan, accounting for 0.11% of the GDP of all the industries at that year. While the imputed abatement cost for solid waste is 14.35 billion yuan, accounting for 0.09% of the GDP in China. In conclusion, the imputed abatement cost for solid waste is 0.79 times as much as the actual abatement cost.

3.2.4 Integrated analysis on imputed abatement cost

i. The input for environmental pollution control is insufficient seriously and great input gap still exist in waste water pollution prevention and control

According to the calculation result, the actual abatement cost and imputed abatement for environmental pollution total up to 387.98 billion yuan while the actual abatement cost accounts for 26% of the total abatement cost. It is shown that the input for environmental pollution control is seriously insufficient. Among of that, the total abatement costs for water pollution, air pollution and solid wastes are 215.3 billion yuan, 140.04 billion yuan and 32.63 billion yuan respectively, accounting for 55.5%, 36.1% and 8.4% of total abatement cost for environmental pollution.

In 2004, the actual abatement cost for environmental pollution reaches 100.53 billion yuan, among which actual abatement costs for water pollution, air pollution and solid wastes pollution are 34.44 billion yuan, 47.82 billion yuan and 18.27 billion yuan respectively, accounting for 34.3%, 47.6% and 18.2% of the total actual abatement cost; while the imputed abatement cost for environmental pollution totals up to 287.44 billion yuan, among which imputed abatement costs for water pollution, air pollution and solid wastes pollution are 180.87 billion yuan, 92.23 billion yuan and 14.35 billion yuan respectively, accounting for 62.9%, 32.1% and 5.0% of the total imputed abatement cost. The imputed abatement cost for water pollution accounts for 84.0% of the total abatement cost for water pollution, 5.3 times than its actual abatement cost. In conclusion, the greatest input gap exists in the water pollution control comparing with air pollution and solid waste control.

ii. The task of pollution control for secondary industry is arduous and environmental input for urban wastewater pollution control has to be improved urgently

The calculation result shows that the imputed abatement cost for pollution of secondary industry is 179.03 billion yuan, 2.9 times that the actual abatement cost, among which the input of 100.37 billion yuan is required for industrial wastewater pollution control, accounting for 56.1% of the total imputed abatement cost for the second industry while the input for the industrial air pollution control is relative lower, only accounting for 38.4% of the total imputed abatement cost, but its absolute amount is quite big, reaching up to 68.67 billion yuan. Comparing with urban air pollution control, the disposal capacity for urban household wastewater in China still falls behind.

At present, the actual abatement cost for urban household wastewater is 4.76 billion yuan accounting for 47.1% of the actual abatement cost for air pollutants. Therefore, environmental input for urban household wastewater pollution control has to be improved urgently.

iii. Stresses of industrial pollution control vary in different industrial sectors and great gap exists in environmental inputs for industrial pollution control

In 2004, power industry is of the highest abatement cost of 59.35 billion yuan among 39 different industrial sectors, which also ranks first in the actual abatement cost list and imputed abatement cost list of industries. Paper-making, chemical, ferrous metallurgy industry and food processing industries are ranking from the second to the fifth place in the list of total abatement cost. The ranking of the above-mentioned four industries in the list of imputed abatement cost are basically same with that of total abatement cost, which shows that pollution control level of these four industries is relatively low and they require greater environmental input for pollution control.

iv. The inputs for pollution control in the central and western regions are severely insufficient and input for the eastern region should still be increased.

The eastern region of China is of dense population, high industrialization level and rapid economic growth, so its environmental pollution is also more severe. In 2004, the actual abatement cost for the eastern region is 54.51 billion yuan, accounting for 54.2% of the total actual abatement cost across the country. While the imputed abatement cost for the eastern region amounts to 112.55 billion yuan, 2 times than its actual abatement cost. It shows that the input for the pollution control in the eastern region should still be increased. The situation in the central and western regions is much worse. The imputed abatement costs in the central and western regions account for 77.0% and 81.4% of their respective total abatement costs. The actual abatement costs and imputed abatement costs in the eastern, central and western regions are as shown in Figure 3-1.

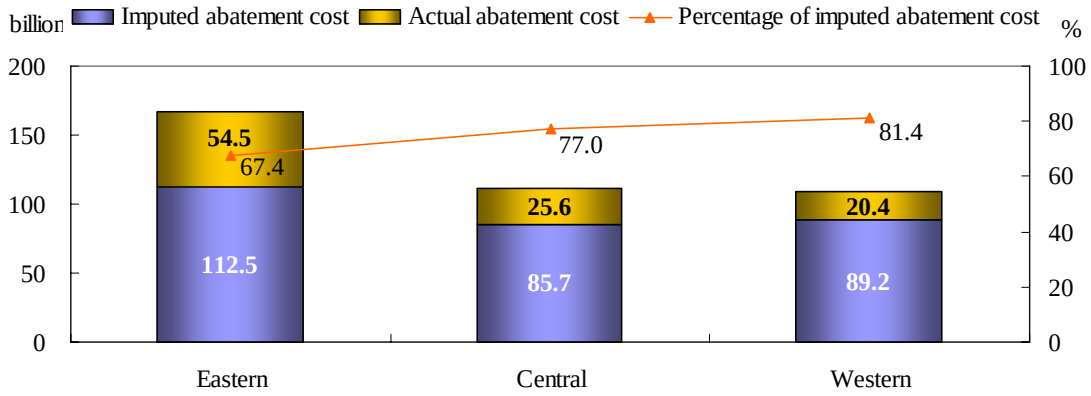


Fig. 3-1 Actual abatement costs and imputed abatement cost in three regions

3.3 Environmental Degradation Cost

3.3.1 Environmental degradation cost by water pollution

The environmental degradation cost caused by water pollution is 286.28 billion yuan in 2004, accounting for 55.9% of the total environmental degradation cost and 1.71% of the GDP of all the provinces and municipalities in that year, among which damage cost of human health in rural

areas by water pollution reach 17.86 billion yuan, economic loss of water shortage caused by water contamination is 147.83 billion yuan, additional abatement cost for industrial water use is 46.26 billion yuan, economic loss of agricultural yield decrease by water pollution is 46.84 billion yuan, and additional abatement and prevention cost for urban household water is 27.49 billion yuan.

In 2004, water environmental degradation cost in the eastern region of China amounts to 151.77 billion yuan, which is the highest among the three regions and accounts for 53.0% of the total environmental degradation cost by water pollution and 1.5% of the GDP in the eastern region. The water environmental degradation costs in the central and western regions are 77.75 billion yuan and 56.75 billion yuan, accounting for 27.2% and 19.8% of the total water degradation cost respectively, but their percentages in the local GDP are near 2.0%, higher than that in the eastern region.

3.3.2 Environmental degradation cost by air pollution

The environmental degradation cost caused by air pollution is 219.8 billion yuan in 2004, accounting for 42.9% of the total environmental degradation cost and 1.31% of the GDP of all the provinces and municipalities at that year, among which damage cost of human health in urban areas by air pollution reach 152.74 billion yuan, economic loss of crops reduction caused by air pollution is 53.78 billion yuan, and material loss by air pollution is 13.28 billion yuan.

In 2004, the environmental degradation cost by air pollution in the eastern region is the highest, which reaches 131.16 billion yuan and accounts for 60.0% of the total atmospheric environmental degradation cost while that in the central and western regions amount to 54.16 billion yuan and 34.47 billion yuan, accounting for 24.6% and 15.7% of the total atmospheric environmental degradation cost. The percentages of air environmental degradation cost in local GDP are 1.4%, 1.3% and 1.2% respectively in the central, eastern and western regions.

3.3.3 Environmental degradation cost by solid waste pollution

In 2004, the deposit amount of industrial solid wastes amounts to 17.62 million tons across the country, approximately occupying the land of 6.177 million square meters, resulting in the opportunity cost for land loss of 91 million yuan. At the same time, the deposit amount of urban household solid wastes amounts to 66.675 million tons while that of rural household solid wastes to 64.58 million tons across the country in 2004, sum of which occupied the land of 35.769 million square meters, leading to the opportunity cost for land loss of 556 million yuan. To total up, the environmental degradation cost caused by solid waste pollution amounts to 650 million yuan across the country in 2004, accounting for 0.1% of the total environmental degradation cost and 0.004% of the GDP of all the provinces in that year.

In 2004, the eastern region is of the highest environmental degradation cost by solid wastes, which amounts to 248 million yuan; the next is the central region with 213 million yuan of degradation cost by solid wastes; the western region is of the lowest, which reaches 186 million yuan. The environmental degradation costs caused by solid wastes in the eastern, central and western regions account for 38.3%, 33.0% and 28.8% of the total degradation cost by solid wastes respectively.

3.3.4 Environmental degradation cost caused by pollution accidents

There were altogether 1441 environmental pollution accidents taken place in China in 2004 with direct economic losses over 333 million yuan. In accordance with the *China Fishery Ecological*

Environmental Condition Bulletin 2004, 1020 fishery pollution accidents occurred in China in 2004 causing direct economic losses of 1.08 billion yuan while economic losses of natural fishery resources by environmental pollution amount to 3.65 billion yuan. Therefore, the environmental degradation cost caused by pollution accidents was up to 5.09 billion yuan accounting for 1.1% of the total environmental degradation cost and 0.03% of the GDP of all the provinces at that year.

3.3.5 Integrated analysis on environmental degradation cost

i. Analysis on total amount of environmental degradation cost

The total environmental degradation cost in 2004 calculated by pollution cost approach is 511.82 billion yuan, accounting for 3.05% of the GDP of all the provinces at that year, among which the environmental degradation cost caused by air pollution, water pollution, depositing solid waste and pollution accidents are 219.8 billion yuan, 286.28 billion yuan, 650 million yuan, 5.09 billion yuan, accounting for 42.9%, 55.9%, 0.1% and 1.1% of the total degradation cost respectively.

ii. Analysis on environmental degradation cost of different provinces and municipalities

The environmental degradation costs in 11 provinces or municipalities of eastern region, 8 provinces of central region and 12 provinces of western region reach up to 283.1 billion yuan, 132.2 billion yuan and 91.8 billion yuan respectively, accounting for 55.8%, 26.1% and 18.1% of the total environmental degradation cost across the country. The environmental degradation costs of three regions[3] and their percentage in local GDP are as shown in Figure 3-2.

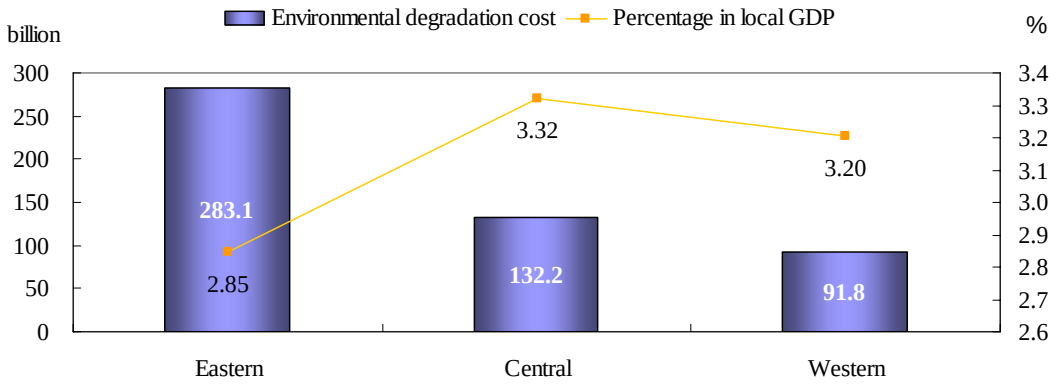


Fig.3-2 Environmental degradation costs and their proportions in local GDP in three regions

3.4 Environmental Pollution Adjusted GDP

3.4.1 Environmentally adjusted gross values of production by region

Regards the sequence of GDP and I_{EDP}^{a} of different regions of China, the I_{EDP}^{a} of the eastern region is the lowest, which is 1.13%. The next is the central region with the I_{EDP}^{a} of 2.17%. The western region is of the highest I_{EDP}^{a}, which is 3.12%. Therefore, it is shown that economic level and pollution control level of the western region are relatively low. To take a panoramic view of China, there are 21 provinces or municipalities with I_{EDP}^{a} higher than the average level of 1.8% and 10 provinces or municipalities with I_{EDP}^{a} lower than the average level. The I_{EDP}^{a} of different

[3] There are no statistical data by provinces of pollution cost for fishery pollution accident. So the total environmental degradation cost of three regions is less than the total one, 511.82 billion yuan.

regions is shown in Figure 3-3.

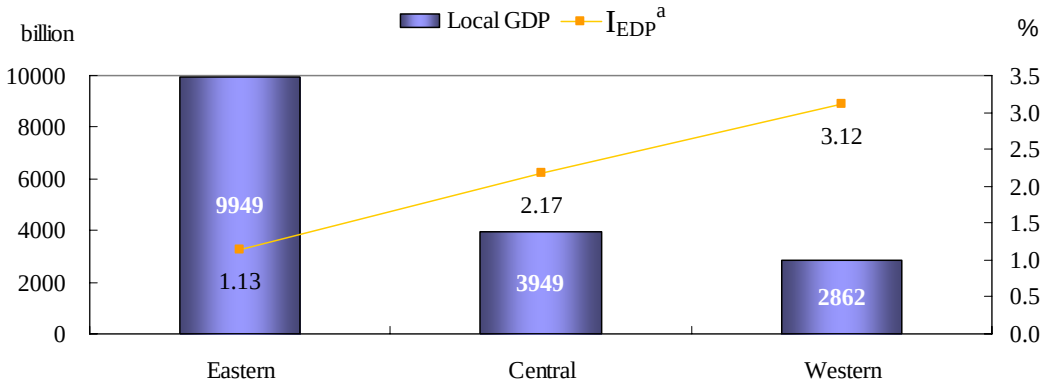


Fig.3-3 GDP and Index of Pollution Adjusted Index to GDP (I_{EDP}^{a}) in three regions

3.4.2 Environmentally adjusted added values of industries

i. Three major industries

According to the calculation result of environmentally adjusted GDP of three major industries, the imputed abatement costs of the primary industry, secondary industry and the tertiary industry are 33.07 billion yuan, 179.03 billion yuan and 75.34 billion yuan respectively. The I_{EDP}^{a} of three major industries are 1.58%, 2.42% and 1.16% respectively. The imputed abatement cost of three major industries and their proportions in the added values are shown in Figure 3-4.

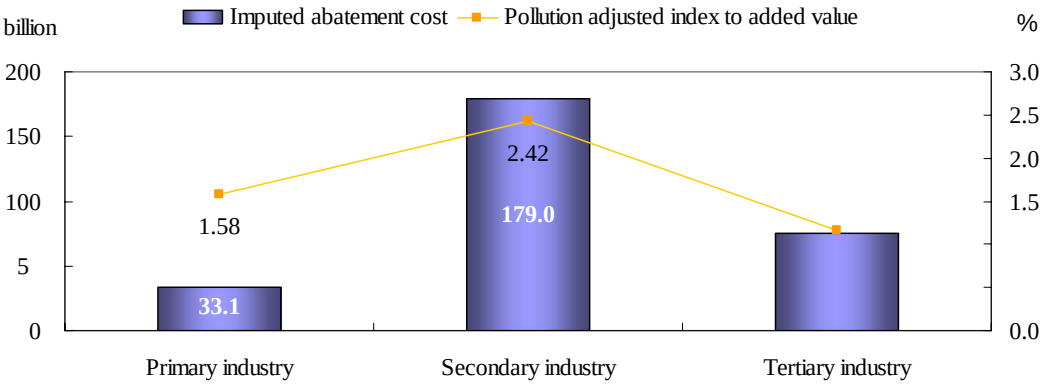


Fig.3-4 Imputed abatement costs and their proportions in the added values of three industries

ii. 39 industrial sectors

Regarding different industrial sectors, in 2004, the industry of water supply is of the lowest pollution adjusted index to added value, which is 0.04%. The following are tobacco industry and furniture manufacturing with pollution adjusted index of 0.05% to added value. The pollution adjusted index to added value of printing industry, communication industry, electrical and mechanical industry, and industry of manufacturing cultural and educational articles are not exceeding 0.1%, which shows that those industries are with less pollution discharge and cause less pollution impact. However, the pollution adjusted index to added value of paper-making and

nonferrous metal mining industries are the highest, reaching 30.13% and 11.63% respectively, which illustrates that the ratio between economic benefits and environmental effects of these two industries are the lowest and could cause severe pollution. I_{EDP}^{a} of 39 industrial sectors is as shown in Figure 3-5.

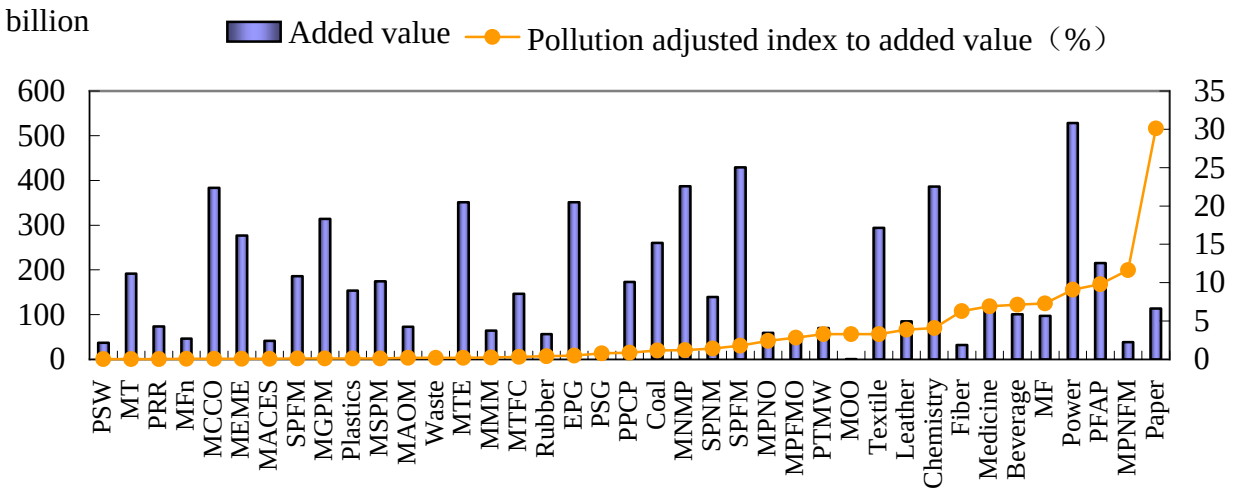


Fig.3-5 Added value and Index of Pollution Adjusted Indies to Added Value of 39 industrial sectors

3.4.3 Environmentally pollution adjusted GDP (EDP)

The Gross Domestic Product of all the industries calculated by production approach is 15987.8 billion yuan in 2004 in China while the imputed abatement cost is 287.44 billion yuan. Therefore, the pollution adjusted index to GDP （I_{EDP}^{a}）is 1.8%, which means the proportion of the imputed abatement cost in the whole GDP is 1.8%. In the perspective of abatement input for environmental pollution, the one-time direct investment is 1080 billion yuan (excluding investment which has been made), accounting for 6.8% of the GDP at that year, which should be required if all the discharged pollutants were abated or disposed in 2004 with the current available technologies.

Thereafter, with continuous research, the accounting results of 2005 and 2006 show that the numerical loss of environmental damages are 5787.9 billion Yuan and 6507.7 billion yuan respectively, accounting for 2.93% and 2.82% of the GDP. The imputed treatment costs of the year 2005 and 2006 are 3843.7 billion yuan and 4112.6 yuan individually, which make up 2.1% and 2.0% of the GDP of the industry. Namely, the pollution adjusted index to the GDP of 2005 and 2006 are 2.1% and 2.0% respectively. The costs of environmental degradation to the GDPs of the year 2005 and 2006 are almost parallel with each other; however, the costs of 2006 increases by 719.8 billion in absolute value and 12.4% in percentage. Because the decrease of pollutant in 2006, the pollution adjusted index of the year drops slightly.

4 Contrast with experiences of other countries

Resource and environmental issues have been raising extensive global attentions since the last

decade. Experts, scholars, governments and international organizations have made great efforts in pursuit of solutions. Embracing resource and environment factor into the accounting system of national economy is one of the practices. As far as the progress in international research works is concerned, economic accounting for resource and environment started from departmental accounting, either focusing on specific type of resources or specific environmental issues. Based on timely summarizing the experience of the departmental accounting, statistical agencies in international organizations started a systematic study of theoretical methods; and therefore, a complete environmental and economic accounting system is established. Since its establishment, it has been providing specific methodological guidance for the application of sector accounting.

Special attention should be given to "Integrated Environmental and Economic Accounting System" published by United Nation's Statistical Commission. It was proposed in Agenda 21 by United Nation's Conference on Environment and Development in 1992 that better approaches should be explored for the valuation of the natural resources and contributions by environment, and an integrated environmental and economic system should established. The interim version was published by UN in 1993, while the operation manual[1] and "Integrated Environmental and Economic Accounting -2003" [2] were published in 2000 and 2003 respectively. In the 1993 version, the basis and the basic concepts of the environmental and economic accounting are primarily identified; besides, the framework and contents for environmental and economic accounting are given. The 2000 version gives the explanations on know-hows, providing a more practical guidance for implementation of environmental and economic accounting. In the 2003 version, the environmental and economic accounting practices are reviewed in a systematic way. Categories more specific accounting theories to be applied are based on GDP accounting system. Meanwhile, different contents accounted are evaluated by feasibility and practical value. In 1995, a new definition and method of calculation of national wealth and actual savings were published by the World Bank in pursuit of more accurate estimations of national wealth and capacity in achieving sustainable development [3,4]. SERIEE (System for the collection of economic information on the environment), established by Statistical Bureau of EU, has Environmental Protection Expenditure Account as the core element and supported by Natural Resource Use and Management Account, Eco-Industries Recording System and Material Flow Account [5,6]. Research and implementation of green GDP accounting is carried out in many other countries worldwide. Instances of this include Norway, who started resource and environmental accounting in 1978[7]. NOREEA, the economic and environmental accounting program initiated in 1997, covers the establishment of National Accounting Matrix including Environmental Accounts (NAMEA), extraction from information pertaining to environment, embracing economic accounting and evaluation of key natural resources [8,9]. Similar applications were seen later in north European countries such as Netherland and Germany [10]. Resource and environmental accounting is attached to great importance by US and Canada [11,12]. Although green GDP accounting is not officially conducted in US, detailed databases for natural resources, pollution prevention and treatment and discharge are developed by related government departments, and evaluation methods for pollution loss has been fully taken into practice. Attentions should be given to some developing countries such as Mexico and the Philippines who take the lead in research and implementation of green GDP accounting. Indonesia, Thailand and Papua New Guinea followed later on.

Table 1 gives a brief summary of research and applications of resource and environmental accounting in major practicing countries. The following could be draw:1) accounting of natural resources and environmental pollution are given equal importance; 2) physical accounting are preferred in most practicing countries; 3) pricing and accounting approaches for nonrenewable resources including forest and mines are better established than those of environmental serving functions; 4) in most countries, accountings are conducted by governmental sectors; 5) up to now, there is no overall green accounting approach of national economy established. Since the researches are conducted under the guidance of State Environmental Protection Administration

and State Statistical Bureau, the results of green accounting of national economy mentioned in this paper should be taken as such accounting under the framework of environmental pollution. Given the fact that GDP is used in China for performance appraisal of local government official as an unbalanced evaluation functions, and China is now faced with critical conflict between resources, environment and social and economic development, China initiated Green GDP with much importance attached to monetary accounting. It is expected that as led by Green GDP, a scientific indicator, economic growth of China would be fast and stable along the right path.

Table 1 ***Contrast of environmental accounting in different countries***

Countries	Adopted system	Physical accounts		Monetary accounts	Methodologies for monetary value / Notes
		Resource depletion	Environment degradation		
Korea	SEEA	×	×	×	1. Forest and mineral value: net price method 2. land value: average market price 3. environment degradation value: maintenance cost
		forest, fishery, mineral, land and etc.	Sewage(BOD), air (CO, SO_2 and etc. of fixed and motive source), household waste		
Netherlands	NAMEA	×	×		The related data is only in physical terms.
		natural gas and crude oil and etc.	Sewage, air (CO_2, N_2O,CH_4,CFCs, NOx,SO_2,NH_3, P, N), solid waste		
Germany	SEEA	×	×		1. The environmental protection expenditure of government and industry, environmental tax revenue 2. The comparison of multinational CO_2 discharge is emphasis. 3. The related data is only in physical terms.
		forest, water, crude oil, natural gas, land and etc.	Wastewater both from industries and household, air (CO_2, N_2O, CH_4, CO, SO_2, NH_3 and dust, especially CO_2), solid waste		
Canada	CSESR	×	×	×	The environmental protection expenditure of government, industry, and household are recorded.
		forest, mineral, land and etc.	Wastewater both from industries and household, air (GHS and etc.)	Only for resources	
Philippines	SEEA	×	×	×	1. Resource depletion: net present value 2. Environment degradation value: maintenance cost
		forest, fishery, and mineral.		Excl. of resource	
	ENRAP	×	×	×	1. Resource depletion: net present value 2. environment degradation value: damage cost method 3. Soil damage cost by agriculture activities
		forest, fishery, and mineral.	Sewage(N, P and BOD), air (PM_{10}, CO, VOC, NOx and etc.)		
Mexico	SEEA	×	×	×	1. mineral and forest value: net price method 2. environment degradation value: Damage Cost Avoided method.
		Water, air, soil and forest are treated as environmental assets.	Wastewater, air (CO_2, NO, CO and suspend substance and etc.), solid waste	Excl. of solid waste	
China*	SEEA		×	×	Environment degradation value was estimated with two methods, maintenance cost method (MCM) and damage cost method (DCM). The result with MCM is called as the imputed abatement cost and that with DEM is environment degradation cost.
			Wastewater from agriculture, industries and household (COD, NH_3-N), air (SO_2, NOx, and dust), solid waste both from industries and household		

Note: NBS (National Bureau of Statistics) of China is designing resource depletion accounts, incl. of forest and water.

5 Conclusion

In researches conducted, the framework of environmental and economic accounting system is established based on the combination of SEEA and the real conditions in China. The scopes of the accounting are clearly defined, and methods for both physical and monetary accounting of water pollution, air pollution and solid waste pollution are established. GDP value adjusted by taking environmental pollution into account is conducted by regions and industrial sectors. Green GDP of 2004 adjusted by environmental pollution is calculated out. The main conclusions are as the following:

i. The framework of SEEA theory suits the conditions in China

In order to ensure scientific nature and reasonable basis by referring to the international practices, which provide stronger support to macroeconomic decision under globalization, "Framework of Accounting System for Resource, Environment and Economy in China" and "Framework of Environmental and Economic Accounting System" are developed based on SEEA. By learning from foreign and domestic experiences in economic accounting of resources and environment and taking the real conditions of China into consideration, the basic framework are established covering physical accounts, monetary accounts of environmental pollution, environmental input and output accounts, and Green GDP with the reflection of environmental concerns. Basic methodological guidance is provided for implementation of environmental and economic accounting. As proved by practical works that the framework of SEEA suits the conditions in China and environmental issues are the right breakthrough for green accounting.

ii. Physical account of environmental pollution gives a rather complete overview of current environmental pollution

Physical account of environmental pollution is established primarily based on environmental statistical data. According the accounting results, sewage discharge nationwide in 2004 reached 60.72 billion tons, 1.26 times of that of 48.2 billion tons in annual report[2]. Accounted COD discharge nationwide reaches 21.093 million tons, 1.58 times of 13.39 million tons in annual report. Accounted SO_2 discharge nationwide reaches 24.5 million tons, 1.09 times of 22.25 million tons in annual report. The difference between accounted and statistical value in water pollutant is due to the inclusion of diffuse pollution from agriculture that is not included in annual report, and the industrial sewage discharge is adjusted in accounting as well. Difference in value of air pollutant is mainly caused by application of different discharge coefficient, as well as different energy consumption.

iii. Monetary account of environmental pollution reveals the environmental cost for economic development

Abatement cost approach and damage cost approach are used in the research works for calculation of imputed abatement cost and environmental degradation cost. The former can be clearly matched with the physical account and imputed abatement costs, which are respectively calculated by region and by industry. The latter calculates the environmental degradation cost at provincial and national level based on regional environmental quality and down-to-top approach. According to the accounting results, imputed abatement cost in 2004 is 287.44 billion yuan. GDP adjusted by the imputed abatement cost reaches 15700.4 billion yuan, counting 1.8% of the total. Environmental degradation cost expressed in pollution loss reaches 511.82 billion yuan, counting 3.05% of GDP aggregated by region. Among the losses, damage to human health caused by environmental pollution should be noted as it counted for 33% of total environmental degradation cost in 2004.

iv. Accounting approach of adjusted GDP value by environmental pollution concern is

practical and feasible

Although the approach should be improved in terms of technical methods, statistical data and calculation of cost caused by ecological damage, it has proved through initial accounting practices to be a feasible way to define imputed cost by abatement cost approach and calculate GDP value adjusted by environmental pollution. The approach could be widely applied in regional statistical works and by local EPBs. The approach of pollution damage cost is used for calculation of environmental degradation cost suits the conditions in China, and could be of important reference value in the integrated environmental and economic decision-making. The approach could be applied at the national level.

v. Pricing of resource and environment and missing of statistical data are the key technical barriers

In promotion of green GDP accounting, transferring physical volume of resource and environment into monetary value is the major barrier. Currently, national account is based on market price. As environment and natural resources are part of public goods, the pricing of them are conducted in a different way. Market-based theories and the estimation tools approved in environmental economics seem to be contradictory when establishing monetary account by pollution damage approach.

Apart from that, missing of statistical data and reference materials affects the completeness of the account established. This is a common case in other countries. As far as China is concerned, while the timeliness, completeness and publicity of statistical data need to be improved, insufficient information flow among different government department has further restrained the implementation of resource accounting. The proposal made in 17th CPC Meeting to set up an integrated administrative authorities for environmental and resource management is a positive move in solution to this issue.

vi. Further attention and support are expected to be given to implementation of green GDP accounting in China

China's effort to implement green GDP accounting demonstrates her commitment to solve environmental issues actively and take responsibilities internationally. Committee for environmental-economic- accounting and relevant task forces are established jointly by United Nation's Statistical Commission and United Nation's Environmental program, in promotion of green GDP accounting in developing countries. A number of organizations including World Bank, EU, OECD, ADB and countries, such as Norway and Canada support to implement green GDP accounting in China and intent to have cooperation in this area. By taking full advantages of the platform for international cooperation, efforts shall be made for effective and efficient implementation of green GDP accounting in pursuit of an accounting system that is improving and accepted worldwide.

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Annex 1: Abbreviation of 39 Industries in Figure 3-5

Coal	Mining and Washing of Coal
EPG	Extraction of Petroleum and Natural Gas
MPFMO	Mining and Processing of Ferrous Metal Ores
MPNFMO	Mining and Processing of Non-Ferrous Metal Ores
MPNO	Mining and Processing of Nonmetal Ores
MOO	Mining of Other Ores
PFAP	Processing of Food from Agricultural Products
MF	Manufacture of Foods
Beverage	Manufacture of Beverages
MT	Manufacture of Tobacco
Textile	Manufacture of Textile
MTFC	Manufacture of Textile Wearing Apparel, Footwear, and Caps
Leather	Manufacture of Leather, Fur, Feather and Related Products
PTMW	Processing of Timber, Manufacture of Wood, Bamboo, Rattan, Palm, and Straw Products
MFn	Manufacture of Furniture
Paper	Manufacture of Paper and Paper Products
PRR	Printing, Reproduction of Recording Media

MACES	Manufacture of Articles For Culture, Education and Sport Activity
PPCP	Processing of Petroleum, Coking, Processing of Nuclear Fuel
Chemistry	Manufacture of Raw Chemical Materials and Chemical Products
Medicine	Manufacture of Medicines
Fiber	Manufacture of Chemical Fibers
Rubber	Manufacture of Rubber
Plastics	Manufacture of Plastics
MNMP	Manufacture of Non-metallic Mineral Products
SPFM	Smelting and Pressing of Ferrous Metals
SPNM	Smelting and Pressing of Non-ferrous Metals
MMP	Manufacture of Metal Products
MGPM	Manufacture of General Purpose Machinery
MSPM	Manufacture of Special Purpose Machinery
MTE	Manufacture of Transport Equipment
MEME	Manufacture of Electrical Machinery and Equipment
MCCO	Manufacture of Communication Equipment, Computers and Other Electronic Equipment
MMM	Manufacture of Measuring Instruments and Machinery for Cultural Activity and Office Work
MAOM	Manufacture of Artwork and Other Manufacturing
Waste	Recycling and Disposal of Waste
Power	Production and Supply of Electric Power and Heat Power
PSG	Production and Supply of Gas
PSW	Production and Supply of Water

Annex 2: Definition of Related Terms

1. Green National Accounting System/Resources, Environmental and Economic Accounting System/System of Integrated Environmental and Economic Accounting

Green National Accounting System is also called as the Resources, Environmental and Economic Accounting System or the System of Integrated Environmental and Economic Accounting (SEEA), which refers to a set of theoretical method for green national economic accounting.

In order to merge the environmental impact into economic analysis, UN established the System of Integrated Environmental and Economic Accounting (SEEA) which is a satellite system of the System of National Accounts (SNA). The interim version of the SEEA came up in 1993. The subsequent operational manual (UN and UNEP 2000) of the SEEA were also released in 2000. At present, the SEEA-2003 were also issued in due form. In the report, the Chinese system of Environmental and Economic Accounting is abbreviated as CEEA.

SEEA-2003 is the revision of SEEA-1993 and summarizes practical experience of SEEA-1993. It makes an overall elaboration on integrated environmental and economic accounting system, defines concepts, approaches, classification and basic guidelines to bring resources consumption, environmental protection and environmental degradation into national accounting system, and constitutes the basic framework for integrated environmental and economic accounting. It aims at providing support to comprehensive decision-making on society, economy and environment by environmentally-adjusted wealth of nation, GDP, domestic net output, capital accumulation and other macro-economic indices. SEEA-2003 is also the basic means to measure sustainable

development and provide information support for implementation of sustainable development strategy.

2. Green National Accounting

Green national accounting, also called "Green GDP" for short, includes accounting for resources and accounting for environment, which brings together economic and resources and environmental information in a common framework to measure the contribution of the environment to the economy and the impact of the economy on the environment, and provides policy-makers with indicators and descriptive statistics to monitor these interactions as well as a database for strategic planning and policy analysis to identify more sustainable paths of development.

3. Environmental and Economic Accounting

Environmental and Economic accounting is a part of green national accounting, while environmental and economic accounting includes environmental pollution accounting and ecological damage accounting. China's practice on environmental and economic accounting is only focusing on environmental pollution accounting by now with methodologies and data constraints of ecological deterioration. Environmental pollution accounting mainly includes physical quantification and monetary valuation of waste water, water pollutants, air pollutants and solid wastes pollution.

4. Accounting of Environmentally Adjusted Domestic Product (EDP)

Objectively, it is required to develop an indicator with similar function of GDP, namely as green GDP, in green national accounting. So accounting of environmentally adjusted domestic product (EDP) is to deduct environmental costs caused by economic activities including environmental degradation cost and ecological damage cost from GDP, and make some adjustments, and then educe a set of comprehensive indices centering on "Environmentally Adjusted Domestic Product". **Of note, the definition of EDP based on GDP in CEEA is different from that based on NDP in SEEA 2003 by UNSD.**

For the pilot work of national environmental and economic accounting jointly conducted by National Statistic Bureau and SEPA, the calculated "green GDP" is a partial one with many restrictions in the scientific sense. It is the GDP deducting environmental pollution cost and adjusted by maintenance cost without deducting ecological damage cost. Therefore, green GDP in true sense is a utopian accounting goal which requires long-term and joint efforts of related resources sectors, environmental protection sector and statistical sector.

5. Green GDP

The concept of green GDP is put forward officially for the first time in *"The System of Integrated Environmental and Economic Accounting (SEEA)"* issued by UN Statistical Commission in 1993. According to the concept and accounting method of green GDP by UN Statistical Commission, the relation of green GDP and GDP could be explicated as following in theory: green GDP = GDP －depreciation of fixed assets－resources and environmental costs = NDP-resources and environmental costs.

Of which, NDP refers to net domestic product. The formula shows that green GDP is corresponding to NDP not to GDP. In this project, we adopted the total value concept of green GDP corresponding to GDP instead of net value just because GDP is used more commonly than NDP when considering practical application. So in our project, green GDP=GDP－environmental costs. Therefore, the environmental cost in this report was measured by both imputed abetment cost and pollution damage cost.

Green GDP is a kind of popular wording corresponding to traditional concept of GDP, which is more suitable to be accepted by government officers, public and media. Simply speaking, green GDP is one that deducting resources consumption cost and environmental damage cost from traditional GDP. Just like traditional GDP is an important indicator of traditional national economic accounting, green GDP is also an important indicator of green national economic accounting which is widely recognized by the public.

6. Physical Accounting of Environmental Pollution

Green National Economic Accounting System consists of two aspects, physical accounting and monetary accounting. The so-called physical accounting of environmental pollution is to set up accounts for physical quantification at different levels and describe generation, treatment and discharge amounts of pollutants corresponding to economic activities in terms of physical unit under the framework of national economic accounting,

7. Monetary Accounting of Environmental Pollution

Monetary Accounting of environmental pollution is to estimate monetary value loss caused by various kinds of environmental pollution and ecological damage based on accounting for physical quantification. It consists of accounting for maintenance cost and environmental degradation cost (damage cost), so treatment cost approach and damage cost approach are applied respectively in the monetary accounting of environmental pollution, which mainly includes the following aspects: monetary accounting of water pollution, air pollution, industrial solid wastes, urban household wastes and economic loss by pollution accidents in different regions; and monetary accounting valuation of water pollution, air pollution, industrial solid wastes and economic loss by pollution accidents in different sectors.

8. Pollution Treatment Cost Approach

Pollution treatment cost approach and pollution damage cost approach are two major methods to make environmental monetary valuation. In the framework of SEEA, treatment cost approach mainly refers to making calculation of cost to be expended in order to avoid environmental pollution in the point of view of “defense” on the basis of cost evaluation method.

It is rather simple and clear to apply pollution treatment cost approach in accounting of maintenance cost, which means that environmental degradation would not be caused if all the discharged pollutants are controlled or treated very well. Therefore, economic value for environmental degradation should be the cost paid for treatment of all the pollutants.

Pollution treatment cost approach is characterized by the simplicity and intelligibility of value accounting process and objectivity of accounting basis (which is based on the physical quantification of pollution and then multiply treatment cost of per unit pollutants). Hence, it is much easier to be used by environmental protection and statistical sectors. Environmental costs calculated by pollution treatment cost approach can be divided into two parts: environmental protection expenditures and maintenance cost for environmental pollution.

9. Pollution Damage Cost Approach

In the framework of SEEA, damage cost approach refers to environmental cost valuation based on the environmental damages, which makes cost calculation of different damages caused by environmental pollution, such as effects on crops production, human health and ecological service function, in virtue of a certain technological means and pollution cost survey, and conducts economic loss evaluation of pollution by means of a certain price setting techniques. At present, the major price-setting methods are as following: human capital approach, travel cost approach, willingness-to-pay method and etc. Comparing with treatment cost approach, pollution cost approach based on environmental damages is more rational and could reflect harmfulness of

pollution.

10. Actual Pollution Abatement Cost

Actual Abatement Cost (Environmental Protection Expenditure) refers to actual pay out or that have paid for pollution control, which should include depreciation cost of fixed assets, medicament cost, labor cost, electricity cost and other operation cost in the process of pollution prevention and control.

11. Imputed Abatement Cost（Maintenance Cost）

Imputed Abatement Cost (Maintenance Cost) refers to the cost to be paid for treatment of all the pollutants discharged into the environment in accordance with current pollution control technologies. It differs from pollution control investment which is the concept of expenditure (operation cost) for environmental protection and could be deducted from GDP. Maintenance Cost could be calculated out by treatment cost approach..

12. Environmental Degradation Cost/Damage Value

Economic value calculated for environmental loss through estimation on pollution cost is called environmental degradation cost, which refers to damages on environmental function, human health, crops production and etc. caused by pollutants discharge in the process of production and consumption with the current pollution control level. In the report, environmental degradation cost is called pollution cost, termed as damage values in SEEA as well.

13. Pollution Adjusted Index to GDP, I_{EDP}^{a}

To present the percentage of maintenance cost to GDP, an index of pollution adjusted GDP short for I_{EDP}^{a}, i.e. the percentage of imputed abatement cost to GDP, is introduced in the report. It becomes easier with the index to analyze pollution control and abatement expenditure of different industries and different regions.