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International experiences with environmental and Economic accounting

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1 Introduction

Traditional national economic accounts consist of a compilation of economic data regarding two fundamental dimension of the economy; *flows* per unit of time (for example annual production and income), and *stocks* at a point in time (such as physical production capital at the end of the year) – each of which are normally measured in monetary units. The key aggregate measure of overall economic return to human and physical capital in production is the Gross Domestic Product (GDP). As has become increasingly evident, the GDP measure comes up short of providing an accurate yardstick as to whether or not a country is on a sustainable development path.[1] The main reason for this is that the depletion and degradation of the natural capital base – essential both for economic activity and human welfare – is not (or only partly) accounted for. Ignoring the depreciation of natural capital means that the traditional GDP measure will give a distorted picture of both true economic growth and the general welfare of the population.

At the end of 1960s, people had cognized some shortcomings of traditional national economic accounts system with more attention paid for the pollution and environmental problem in the developed countries. For example, increases in GDP may have depended on the consumption of the limited resources (e.g. oil and gas assets) or the unsustainable use of renewable resources (e.g. timber) and thus limiting future generational benefits. After the Stockholm Conference for Environment in 1972, some countries began to establish environmental accounting framework to reflect the environmental status and the impact on the environment caused by human activities.

For at least 25 years, researchers and practitioners have tried to alleviate this problem by coming up with alternative concepts and accounting approaches that can better incorporate the environmental data with the economic accounts, either separately in physical terms (least ambitious approach) or completely translated into economic values (most ambitious approach).

Table 1.1 presents some of the terms that have often been used for these alternative concepts and accounting approaches. The terms are often used interchangeably and, in practice, the meaning depends on the context (for example whether natural resource accounts are included as a subset of environmental accounts).

Up to date, some countries have begun the trial work of environmental accounting. But there is not an accepted environmental accounting model nor does any one country produce official environmental accounts.. The objective of this report is to summarize the international environmental accounting methodologies and put forward recommendations for the establishment of environmental accounting system in China.

[1] There are also other shortcomings of the GDP measure which are not specifically related to the environment, which need not concern us here.

Table 1.1 Summary of important terms and concepts

Terms	Definition
Environmental Accounting	The compilation of physical and monetary accounts of environmental assets and the costs of their depletion and degradation. Depending on the specific use of the term, Natural Resource Accounting (NRA) below may be included as a subset of EA.
Green Accounting	Systematic presentation of data on environmentally important stocks and flows (e.g. stocks of life-sustaining natural resources, flows of pollutants), accompanying conventional economic accounts (e.g. measures of gross domestic product) with the ultimate objective of providing a comprehensive measure of the environmental consequences of economic activity.
Natural Resource Accounting	A system of monitoring based on methodically organised accounts, representing the size of economically valuable and limited reserves of natural resources and using physical quantifiers such us tonnes or cubic metres.
Adjusted net savings (genuine savings)	A sustainability indicator building on the concepts of green national accounts. Adjusted net savings measure the true rate of savings in an economy after taking into account investments in human capital, depletion of natural resources and damage caused by pollution.
Green GDP	A measurement of national output that includes effects on the environment and natural resources.

Sources: The World Bank and the European Environment Agency websites.

2 Environmental valuation methodologies

2.1 Nature resource valuation methodologies

There are three kind nature resource valuation methodologies: direct market approach, surrogate market approach, and hypothetical market approach. The former two are so-called market methods, while the latter is based on people's willingness-to-pay (WTP) in a hypothetical market situation. The market methods are either based on observations of people's behavior (so-called revealed preferences), or through an indirect estimation of WTP by means of dose response functions or damage and resource costs. The hypothetical methods infer WTP directly through making people state their preferences in surveys. The hypothetical approach is known as the contingent valuation method (CVM). The choice of valuation method depends on various factors, especially the availability of adequate data and available budget.

2.1.1 Direct market approach

1. Market Price Method. The market price method estimates the economic value of ecosystem products or services that are bought and sold in markets. The market price method can be used to value changes in either the quantity or quality of a good or service. It uses standard economic techniques for measuring the economic benefits from marketed goods, based on the quantity people purchase at different prices, and the quantity supplied at different prices.

2. Productivity Methods. This method is used to estimate the economic value of ecosystem products or services that contribute to the production of commercially marketed goods. It is applied in cases where the products or services of resource are used, along with other inputs, to produce a marketed good. For example, if a natural resource is a factor of production, then changes in the quantity or quality of the resource will result in changes in production costs, and/or productivity of other inputs. This in turn may affect the price and/or quantity supplied of the final good.

3. Damage Cost Avoided, Replacement Cost, and Substitute Cost Methods. The damage cost avoided, replacement cost, and substitute cost methods are related methods that estimate values of ecosystem services based on either the costs of avoiding damages due to lost services, the cost of replacing ecosystem services, or the cost of providing substitute services. These methods are based on the assumption that, if people incur costs to avoid damages caused by lost ecosystem services, or to replace the services of ecosystems, then those services must be worth at least what people paid to replace them. Thus, the methods are most appropriately applied in cases where damage avoidance or replacement expenditures have actually been incurred, or

will actually be incurred. An example is valuing improved water quality by measuring the cost of controlling effluent emissions.

Because it should be based on sufficient information and explicit causality, the direct market approach is a less controversial method in estimating the value of nature resources. However, it requires lots of physical data and completes price information, which is often missing for a number of resources; thus the application of this method is limited.

2.1.2 Surrogate market approach

If the natural resource has no market price, we use as a proxy or surrogate, the value of an alternative or "next best" product to estimate the value of the resource. The major two methods are as following:

1. Travel cost approach. The travel cost method can be used to measure the demand and the value of environmental assets. The method relies on the costs incurred by visitors to arrive at the environment under consideration (Khandke *et al*. 2001). Although the method has been used commonly to estimate value of recreational sites, it has virtually no application to valuation of environmental loss or damage. Besides, since it deals with active participation, travel cost method measures the use value of the site and hence, the total economic value of the environmental asset cannot be captured. It also has a serious shortcoming in that the visitors who arrive to the areas are not always coming to visit only one place.

2. Hedonic pricing: The method is based on the assumption that any difference in wage rates or property values between normal areas and degraded areas is due to the value of the environment (Khandke *et al*. 2001). It means the method can be used to measure the value of environmental change if the environment is seen as a complement to the private good. For example, a location of a house is capitalized in the value of the house. Suppose there are two similar houses except for differences in the quality of the environment or the natural ascetic value of the location. The difference in the value can be seen and technically identified as the implicit value attached to these environmental characteristic. The basic limitation of the method is that it requires large data sets and greater statistics. Furthermore, it has very little relevance for environmental resources located in remote areas and in developing countries where competitive markets do not exist (Genanew 1999).

2.1.3 Hypothetical market approach

Hypothetical market approach estimates value of nature resource by creating hypothetical market. The main method of hypothetical market approach is willingness-to-pay (WTP) method. The method involves directly asking people, in a survey, how much they would be willing to pay for specific environmental services. In some cases, people are asked for the amount of compensation they would be willing to accept to give up specific environmental services.[2]

The method has great flexibility, allowing valuation of a wider variety of non-market goods and services than is possible with any other non-market valuation technique. It can be used to estimate both use and non-use values, and it is the most widely used method for estimating non-use values. However, because this method is based on asking people questions, as opposed to observing their actual behavior, it is also the most controversial of the non-market valuation methods.

2.2 Environmental cost valuation approach

2.2.1 Environmental cost

Environmental costs are effectively environmental inputs in the economic process. Environmental costs are the actual and potential costs related to deterioration of natural assets caused by economic activities, also namely as costs paid for exploitation of natural resources in the process of economic activities. However, there can be a variety of both concepts and approaches to how environmental costs are defined and determined (e.g. whether environmental costs are actual costs or hypothetical).

Actual environmental cost refers to actual expenditures for avoiding (protecting) and remediating the harm caused by economic activities that have deteriorated the environment. These expenditures are necessary in order to maintain the service levels of the natural environment, which are usually equivalent to the actual expenditures on environmental protection. It includes defense costs, rehabilitation costs and response costs. The defense cost is the actual cost for prevention of environmental deterioration. The rehabilitation cost is the actual cost needed for rehabilitation of damaged environment, which brings amendment to hypothetical environmental cost as the quits of hypothetical environmental cost. The response cost refers to the payment for response to environmental deterioration such as depreciation for increasing of production assets, clean-up costs and health expenditures.

Due to the challenges in measuring the monetary value of the externalities of economic activities on the environment, using actual environment-related expenditures does not adequately assess the full value of impacts on environment. Therefore, it is necessary to assess hypothetical environmental costs used in natural capital economy, which means to put all the natural assets into a hypothetical market framework, seek an appropriate method for its monetization, make assessment on the employment values of natural capital economy. This kind of cost does exist in the relation of environment and economy, but not brings actual payment behavior of parties concerned, so it is called as the hypothetical environmental cost.

[2] Essentials of Ecosystem Valuation, http://www.ecosystemvaluation.org/essentials.htm

2.2.2 Evaluation on hypothetical environmental costs

The following three kinds of methods could be adopted to conduct evaluation on hypothetical environmental costs: market price method, hypothetical valuation method and cost maintenance method (specifically see in 2.1).

3 Environmental accounting approaches

In recent years, a number of national and international studies have been conducted with the primary aim of integrating environmental data with standard economic data of national accounts and though a great deal of progress has been made, no single coherent system or standard yet exists. As a result, a number of environmental accounting approaches have emerged over the last decade. However, the Handbook of National Accounting - Integrated Environmental and Economic Accounting (commonly referred to as SEEA) (2003), soon to be published by the UN, the European Commission, the IMF, OECD and World Bank,[3] represents an important step towards international harmonization and coherency on this front. Nonetheless, critical disagreements persist, particularly regarding valuation methodologies.

Below, the most relevant accounting approaches are briefly described, primarily focusing on how each treats the monetary valuation of the environment. The primary factor differentiating these approaches is the degree to which they attempt to capture the total environmental costs.

3.1 Integrated Environmental and Economic Accounting (SEEA)

Traditional national income accounting systems (i.e. the SNA or system of national accounts) only accounts for economic activities prescribed related to the f production of goods and services. It does not take into account the value of natural resources (natural capital) nor their depletion, including land, minerals, water and forests. Only when the natural resources are in effective control of institutions, can they be brought into the accounting scope of SNA. Because the value of cost of natural capital depreciation is not included into the GDP, there are two major consequences: 1) scarce natural resources could pose threat to sustainable productivity of the economy which would be neglected, and 2) the impacts of a deteriorated natural environment on human health and welfare caused by pollution would also be ignored. In addition, the SNA treats expenditure for maintenance of environmental quality as national income and output in the SNA, rather than a proxy for the opportunity cost of degrading the environment. These expenditures should be regarded as the cost to society for the maintenance of ecosystem services that result in environmental quality. Therefore, the current system of national income accounts (the SNA) do not reflect the true economic development conditions of a country or region by ignoring the environmental impacts or costs associated with development. .

[3] The final draft which has been circulated before final editing is available online at http://unstats.un.org/unsd/envAccounting/seea.htm.

In order to merge the environmental impact into economic analysis, the UN established the SEEA which is a satellite system of the System of National Accounts.[4] It brings together economic and environmental information in a common framework to measure both the contribution of the environment to the economy, as well as the impact of the economy on the environment. It 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. The first version of the SEEA (1993) came up well short of proposing harmonized recommendations and guidelines; five versions of the guidelines were developed and each country was left to its own discretion as to the version that would best fit their needs. Although it was viewed as an important step in developing the methodology, the SEEA 1993 and its subsequent operational manual (UN and UNEP 2000) came to be viewed as an 'interim version', lacking official approval of the UN Statistical Commission (Hecht, 2005). In 2003 a new SEEA document was issued; our efforts focus on this more recent version produced by the UN and other organizations. Though the 2003 SEEA handbook is endorsed by the Statistical Commission of the UN, it still lacks the international approval which the SNA enjoys.

In this section, we provide a brief summary of the SEEA handbook while focusing primarily on monetary valuation issues, where there is still a considerable lack of consensus.

3.1.1 Context and scope of the SEEA

The SEEA 2003 establishes four categories of accounts, while providing guidance as to their inclusion in national accounts and as to their use in policy analysis:

i **Flow accounts for pollution, energy and materials**. These accounts provide information at the industry level about the use of energy and materials as inputs to production and the generation of pollutants and solid waste. These accounts consider purely physical data relating to flows of materials and energy. The flows of interest include products, natural resources, ecosystem inputs and residuals (incidental and undesired outputs from the economy).

ii **Environmental protection and resource management expenditure accounts**. These accounts identify expenditures incurred by industry, government and households to protect the environment or to manage natural resources. They take those elements of the existing SNA which are relevant to the good management of the environment and show how the environment-related transactions can be made more explicit.

iii **Natural resource asset accounts**. These accounts record stocks and changes in stocks of natural resources such as land, fish, forest, water and minerals.

[4] The SNA originated in 1953 and was revised in 1968 and 1993, and is published by the United Nations. The 1993 version was prepared in cooperation between the Commission of European Communities, the UN, the World Bank, the IMF and the OECD.

iv **Valuation of non-market flow and environmentally adjusted aggregates**. This component presents non-market valuation techniques and their applicability in answering specific policy questions. It discusses the calculation of several macroeconomic aggregates (such as GDP) adjusted for natural capital and environmental depletion and degradation costs (e.g. green GDP) and their advantages and disadvantages. It also considers adjustments concerning the so-called defensive expenditures.

SEEA emphasizes expanding the analysis capability of national income accounting without changing the original or core structure of the SNA. SEEA mainly focuses on the following issues:

i A separate and separation and detailed accounting of all natural capital stocks and flows and environmental protection and improvement expenditure data into environmental satellite accounts that are set apart (i.e. satellite) from the existing national income accounts.

ii Connection of physical accounting and monetary accounting: SEEA provides links to connect objects accounting of natural resources and environment and monetary accounting of economy.

iii Estimation of environmental costs and benefits: Comparing with natural resources accounting of SNA, the accounting for exterior environmental costs and benefits is added in the SEEA, which expands and improves SNA system in two aspects: consumption of natural resources due to production requirements of products; impacts on environmental quality caused by pollution and other factors.

iv Accounting for tangible wealth: SEEA expands the concept of the capital, which includes labor cost, natural cost and other related costs brought by reduction of natural resources and deterioration of environment.

v Adjusted incomes and related index measurement: taking the reduction of natural resources and changes of environment into consideration, the concept of EDP(Environmentally-adjusted Net Domestic Product) is introduced into total amount accounting of SEEA [EDP is sometimes noted as eaNDP (environmentally-adjusted net domestic product)]. EDP of the Green GDP is the core index of SEEA, which regards resources and environment costs as a measurement for consumption of natural resources in quality and quantity and deducts it from NDP. The calculation formula is as following:

EDP = NDP-resources and environmental costs

3.1.2 Monetary valuation and the SEEA

Assigning a monetary value to a country’s stock and depletion of natural resources and environmental degradation is a topic of ongoing research and there remains significant disagreement internationally and among those in the London Group[5] on this issue. Furthermore, largely due to these disagreements, the SEEA does not explicitly recommend the calculation of any environmentally adjusted macroeconomic indicators, leaving this choice to the discretion of the end-user of the handbook. Instead, the SEEA breaks the monetary valuation of relevant environmental costs into three components, according to the category of account, as presented above. In particular, the use of monetary valuation techniques is applicable to the latter three accounts presented above (B - D). Thus monetary valuation is applicable to; i) environmental protection and resource management, ii) the valuation of environmental assets (e.g. natural resources), and iii) environmental degradation accounting. Each is discussed in turn below.

3.1.2.1 Environmental Protection and Resource Management Expenditures (Applicable to accounts (B))

Under this heading, the SEEA simply aims at making the data available in the SNA accounts regarding environmental transactions more explicit in order to better inform policy analysis. The idea is to identify and measure society's response to environmental concerns through the demand and supply for environmental goods and services. The SEEA applies the approach of identifying and measuring the costs, as implied by production and consumption behaviour, incurred in order to prevent environmental degradation and further the sustainable management of natural resources. In particular it looks to make more explicit all relevant purchases, expenditures or changes in behaviour so as to protect the environment. Recall from Chapter 2 that that the defensive expenditure approach is a method to approximate the true environmental costs.

In terms of valuation, the measurement of protection and management expenditures are generally straight-forward, as most expenditures are generally provided by traditional SNA accounts. Thus, under this heading, the SEEA views as the main task that of accounting for the full range of relevant expenditures, while excluding those expenditures that are not relevant. We summarize the four categories of activities (Environmental Protection, Natural Resource Management and Exploitation, Environmentally Beneficial Activities, Minimization of Natural Hazards) identified by the SEEA as relevant for the measurement of expenditures aimed at protecting the environment. SEEA also recommend how to identify all relevant expenditures and the true 'environmental' cost component.

In summary, the two primary valuation concerns identified by the SEEA with respect to observable market transactions (e.g. expenditures) are;

[5] The London Group was the group with primary responsibility for the work of revising the SEEA 1993 for the 2003 publication.

- Capturing all relevant expenditures incurred with the objective of protecting environmental assets, and;
- Separating and including only those cost components that are incurred with this objective.

3.1.2.2 Valuation of Environmental Assets (Applicable to accounts (C))

Chapter 7 of the SEEA divides environmental assets into 3 classifications; natural resources (renewable and non-renewable), land and ecosystems. The SEEA whenever possible employs the same general principles of valuation as the SNA, with two restrictions (the focus of this section);

- Some pragmatic compromises must be made as to assigning a value, such as when difficulties arise in separating the value of two assets (e.g. building and a plot of land.)
- Because benefits are almost always purely internal and often very difficult to ascertain, the identification of the benefits and uses of some assets may require the use of advanced valuation techniques.

Thus, assigning an accurate monetary value to the full range of environmental assets can be quite difficult, particularly when one considers assets such as the atmosphere (global warming) or biodiversity.

According to the 1993 SNA, the market price of an asset should determine its value whenever possible, and this is also true for environmental assets. When market prices do not exist, as is often the case for environmental assets, it recommends the use of the net present value of future benefits accruing from ownership. The third option is to use the production costs of the asset as a lower bound estimate of its value. This option is however obviously incompatible with assets such as natural resources which are never produced. The SEEA thus stipulates that the net present value techniques should be applied to the resource rent (i.e. the share of gross operating surplus attributable to the natural resource[6]). Thus, the valuation of the resource becomes a four step process;

1. Estimate the resource rent. Economic rent is effectively the difference between the market price (or income earned) by a natural capital product and the costs of producing the product (i.e. bringing it to market), including an allowance for return to capital invested. Here it is recommended to use market prices where possible. In the cases where this is impossible, the SEEA recommends the use of one of two methods; perpetual inventory method and the use of capital service flow calculations. These methods are not fully described here, but both involve the partitioning of the information on economic rent for all the assets for a firm into that part pertaining to its

[6] For a full discussion regarding resource rent, see SEEA, p. 274.

produced assets and that relevant to the non-produced assets (e.g. environmental assets).[7]

- Estimate the life-span of expected rents. Here, accurate physical measurements of existing levels, extraction rates and rate of renewal are necessary.
- Estimate the pattern of resource rents. Beyond technological concerns, it is recommended that past behaviour, when available, guide statisticians with respect to expected future prices.
- Determine the discount rate. This refers to the owner's time preferences, i.e. the trade-off between income today and income tomorrow. A higher discount is employed when there exists a demand for quicker return or if risks are considered higher than average investments.

The SEEA provides specific guidance on valuation methodologies on a range of resources, including biological resources (including cultivated and non-cultivated), wooded land and timber resources, fish, land and soil, water resources, and ecosystems. In most cases, there are resource specific characteristics that must be accounted for when choosing a valuation technique. For example, when the net present value technique is employed, it may be necessary or desired to separate the value of two assets (e.g. wooded land and timber). The SEEA thus suggests and discusses a number of potential valuation methods, in order to adapt to the resource specific characteristics and arrive at a monetary value for a given resource. All of these methods have been explored and tested by researchers on many occasions. Finally, the SEEA concedes that some compromise is needed when seeking a monetary value for all environmental goods, as the benefits are generally internal and can be spread across a large population, and thus very difficult to determine.

3.1.2.3 Valuation Environmental Degradation (Applicable to accounts (D))

The SEEA 2003, advocates the use of three valuation approaches with respect to environmental degradation (described below) but comes up short of a consensus on which approach is best suited for the use in national accounts. In fact, the valuation approaches discussed in Chapter 9 of the report proved to be the most controversial aspect during the revision of the SEEA and remains the primary concern for the future work of the SEEA. This is a result of a fundamental difference between two commonly held views regarding the application of the monetary valuation of environmental degradation;

- The view that the results of monetary valuation are to be applied in the calculation and adjustment of core economic aggregates; and

[7] These methods are more fully described in the SEEA, p. 276-277.

- The view that the results should stop short of incorporation in economic aggregates and be utilized only to demonstrate the impacts of economic activities on the environment.

Thus, the choice of approaches remains as a strategic choice of the users of the SEEA. And, as a result, the SEEA comes up short on an agreement on how to treat the costs associated with environmental degradation.

Though the SEEA discusses the potential application of various approaches to monetary valuation, it only explicitly accounts for those impacts which result in market transactions (e.g. health care costs) and/or reduce productivity. Much of the monetary value of environmental damage encompassed by the SEEA can thus simply be inferred from the SNA. To be certain, the fulfilment of the requirements of the SEEA does not necessarily require a monetary valuation of losses which are not easily measurable nor accounted for in the traditional SNA accounts (e.g. losses human well-being). However, fulfilling the data requirements of the SEEA does provide for the capacity for starting on such a task. Thus, while defensive expenditures are accounted for, analysis of the impact of degradation is primarily limited to the use of 'hybrid accounts', which incorporates physical environmental data with economic monetary data.[8]

Thus, the SEEA stops short of accounting for the full costs of environmental impacts. The three monetary valuation approaches discussed by the SEEA are;

- **The damage cost approach** aims at identifying the costs of environmental damages caused by economic activities.
- **The maintenance cost approach** describes (*ex post*) the direct hypothetical monetary costs of reducing the actual pressures on the environment. This requires assumptions to be made regarding technological changes and structural economic processes.
- **The modelling approach** rejects the monetary valuation of degradation as a task of official statisticians and resembles the NAMEA approach. In this approach, the physical data are used as to analyse the economic effects of various environmental protection measures in order to analyse a more 'complete' economic impact of various environmental and economic scenarios.

Thus, a fundamental difference exists: The two former approaches assume that valuation problems can be solved, the results can be aggregated and feedback to the macroeconomic aggregate(s) is possible. The latter, on the other hand, views the challenges of monetary valuation as insurmountable and thus rejects the idea in favour of combining economic activity with physical data only. The SEEA opens for the use of any of these techniques and provides some guidance as to the applicability of each

[8] For example, whereas residuals (e.g. CO2 pollution) are recorded in the physical flow accounts, the monetary impact of these residuals is not assessed

approach, but stops short of providing clear guidance as to which should be used in practice.

3.2 World Bank's wealth of nations and genuine savings

3.2.1 Wealth of nations

In 1995, a new standard to measure the total wealth of nations and regions was promulgated by the World Bank; a more comprehensive national balance sheet that would account include an account of monetary value of produced capital, natural capital and intangible capital (i.e. human and social capital) providing decision makers with measures of the, net growth of total wealth of a country or region. The new calculation method divided the wealth of a nation into four items:

Produced capital asset, which means the value of industrial outputs of machines, factories, construction, water conservancy systems, express roads and railways;

Natural capital, which means the value of fertile lands, forests, fishery resources, purified capacity, crude oil, coal, ozonosphere, bio-earth chemical recycling and etc;

Intangible capital (human and social capital) which includes raw labor, human capital (the stock of skills and know-how embodied in the population), social capital, and other important factors such as the quality of institutions. Human resources **(capital)**, which reflects values of production ability of human beings such as in the fields of education, nutrition, medical treatment and et**c.** Social capital assets**,** which links produced asset, natural capital and human resource, is to promote the whole society to make use of above-mentioned social systems and cultural basis in an effective way.

3.2.1.1 Measurement methods of national wealth

In accordance with the definition, the measurement of national wealth should be conducted in four parts of the monetary value of produced asset, natural capital, human resources and social asset separately, which then could be summed into a monetary aggregate or total wealth estimate. The basic issue of measurement is to monetize the above-mentioned factors and describe the total wealth in monetary terms.

Because the characteristics of each of the four components of national wealth are so different, t different measurement approaches are required..

Produced assets (built or manufactured capital) have always been an important policy variable for national economic planning. In the wealth calculations the value of produced assets is based on the perpetual inventory model (Nehru and Dhareshwar 1993). These 1990 estimates have been extended to 1994 by calculating the net accumulation (initial capital stock plus gross domestic investment less depreciation). Urban land has been valued as a fixed proportion of the value of buildings and other structures. Balance sheet accounts for Canada (Statistics Canada 1985) reveal that the value of urban land is roughly 33 percent of the stock value of structures, and this percentage is used as a placeholder in the current estimates.

The first in estimating the total wealth of nations is valuing the natural capital assets. Natural capital includes the entire environmental patrimony of a country. The estimation of natural capital takes place in two steps. First, the net yearly revenue from the resource is calculated. In the second step, revenues (or rents) are projected into the future to compute their net present value. For example, in order to estimate oil stocks, the year 2000 net oil rent is calculated and future rents are estimated based on today's rent and the remaining duration of the reserves. The stream of rents is then totalled using the social discount rate (generally 4%). A similar procedure is used to estimate the other subsoil assets. The calculation of forest resources requires taking into account the sustainability of the resource rents. Unsustainable exploitation of forests is picked up by reducing the number of years over which the current income can be pursued. Over-extraction of timber may then result in higher income today, but for a shorter period of time.

The elements included in the natural capital estimates presented here include agricultural land, pasture lands, forests (timber and non-timber benefits), protected areas, metals and minerals, and coal, oil, and natural gas. For all of the elements of natural capital included in the wealth estimates, international market prices were used, adjusted by an appropriate factor to represent the rent portion of the traded price. The economic rent of any natural resource is the difference between the market price and the cost of the various inputs needed to extract, process, and market it. As such, it represents the inherent surplus value in the extraction or harvest of a resource. What is not included in the natural capital account is coastal and marine resources, and fisheries, though their value is implicitly included in the total wealth aggregate and hence ends up in the intangible capital residual. The services of ecosystems, such as hydrological functions of forests and pollination services, and the availability of water resources are indirectly included in the value of cropland and pastureland. It assumed that higher levels of services are associated with higher yields from agricultural lands.

The second step is estimating the measurement of total wealth as independent of the three other components. The calculation uses a net present value formula using a base year (e.g. 2000) and assumes a future consistent consumption. In order to take into account levels of consumption that are unsustainable (thus leading to an overestimation of wealth), the unsustainable part is subtracted, as represented by adjusted net savings. This measure of total wealth, then, becomes independent of our estimate of the subcomponents of wealth.

The most difficult component of national wealth to measure is the return to individuals and societies from the use of natural capital and produced capital. In this calculation the value assigned to human resources is a residual value based on the return to a country's population estimated by multiplying agricultural GDP (which includes the value added of the forestry and fisheries sectors in the aggregate national accounts data) by 45 percent to reflect the return to labor, and then adding all non-agricultural GDP and subtracting the economic rents from subsoil assets and the depreciation value of produced assets. Since the value of resource stocks has been explicitly accounted for under natural capital, it is important to subtract the rents on current production of these stocks from current income (non-agricultural GNP), to avoid double counting. This amount is then discounted over the average number of productive years of the population, calculated by taking the life expectancy of the national population at year 1 (or 65, whichever is lower) and subtracting the mean

Box3.1 The wealth accountants toolkit

Measuring the total wealth of a country necessarily involves some heroic assumptions. The first choice a wealth accountant confronts is the discount rate: a rate of 4 percent per annum is used throughout the measurements. Total wealth is the sum of each of the following components.

* *Minerals and fossil fuels* are valued by taking the present value of a constant stream of resource-specific rents (or, to be more precise, economic profits, the gross profit on extraction less depreciation of produced assets and return on capital) over the life of proved reserves.

* *Timber* is valued as the present value of an infinite stream of constant resource rents where the rate of harvest is less than annual natural growth (the mean annual increment). Where timber harvest is not sustainable, because harvest exceeds growth, a reserve life is calculated and the timber resource is treated in the same manner as a mineral.

* *Nontimber benefits* of forests are valued by assuming that 10 percent of forested area will yield an infinite stream of benefits in the form of nontimber products, hunting, recreation and tourism. Per hectare values of nontimber benefits vary from $112 to $145 in developing and developed countries.

* *Cropland* is valued as an infinite stream of land rents, where land productivity is projected by region up to the year 2025 and held constant thereafter. Individual rental rates for rice, wheat, and maize are multiplied by, production values at world prices to arrive at per-hectare unit rents for cereal lands; other arable land is valued at 80 percent of this rate.

* *Pasture land* is treated similarly to cropland-rental rates are derived from the value of beef, mutton, milk, and wool production at world prices.

* *Protected areas* valued at their opportunity cost in terms ofthe per-hectare value of pasture land.

* *Produced assets* are calculated using a perpetual inventory model, with investment data and an assumed life table for assets being the major inputs. Urban land is valued as a fixed proportion of produced assets.

* *Human resources* are measured residually. The wealth value of returns to both labor and capital is measured as the present value of the following: nonagricultural GNP, p*lus* agricultural wages, minus rents on miner on minerals and fossil fuels, and *minus* depreciation of produced assets. Agricultural wages include proprietors' income and exclude resource rent; agriculture includes hunting, fishing, and logging. The present value is taken over the mean productive years of the population-the lesser of 65 years or life expectancy at age one, *minus* the mean age of the population. Subtracting produced assets derived from the perpetual inventory model, and urban land from this present value yields the value of human resources at current exchange rates. This is then revalued using the purchasing power parity rate to obtain the final value of human resources.

* *Not included:* Fish are excluded from the analysis, partly for data reasons and partly because poor management has driven rents to zero in so many of the world's marine fisheries. Inland fisheries could be valued but data limitations prevent this at present. Water is also not included;most water use is already included in the value of agricultural

and industrial output. Domestic water use could be valued in the future but was not included here.

Source: World Bank (1997): expanding the measure of wealth – indicators of environmentally sustainable development.

(average) age of the population. This calculation estimates the returns to human resources, produced assets, and urban land with the given population or age distribution and the current labor force that implicitly reflects current levels of under- and unemployment.

These annual values are converted to a stock using a 4 percent social discount rate. From this stock value we subtract the value of produced assets and urban land to arrive at the present value of human resources.

Using this new total wealth calculation method, the World Bank has estimated that, on average, the produced assets component of a nation's balance sheet accounts for 20% or less of a nation's actual wealth while human resources (capital) and natural resources (capital) account for the greatest percentage of national wealth. This method stresses the importance of human resources or capital and that investment in human resources is critical to economic development.

3.2.1.2 Characteristics and policy significance of national wealth

This new method to measure the national wealth is of the following characteristics:

A. The national wealth should be divided into three aspects: natural capital (representing basis of existence and development), produced capital (representing ability which could be changed into requirements of market) and intangible capital (human resources, representing the skills and creation potential of productivity development). These three elements could cover the essential meaning of sustainable development in a comprehensive and rational way.

B. Comparing with per capital GNP, this measurement method could estimate the true wealth and sustainable development ability of a country. It expands the concept of wealth from traditional category with characteristics of currency, investment and trade.

The definition is of great significance to the policy option of implementing sustainable development:

A. Effective management on natural resources and environment, increased investment of production assets, increased investment on human resources closely integrated with other investment, constitution of various systems and social structures, and promotion of social capital would be embodied in the changes of national wealth and become symbol and achievement of sustainable development.

B. Only if making investments of produced assets and human resources by using of rents obtained by exploitation of natural resources instead of consumption, can the non-negative growth of national wealth be guaranteed in the total amount through counteracting of different parts of wealth and sustainable development be achieved through substitute guarantee of different assets.

3.2.2 Genuine Saving

In 1995, an indicator called "genuine saving" was introduced in report of Monitoring Environmental Progress. This indicator is the true rate of saving of a nation after accounting for the depreciation of produced assets, the depletion of natural resources, investments in human capital, and the value of global damages from carbon emissions. And the trend of gross capital stock or flow of a country or region can be measured by this indicator.

3.2.2.1 Theory of genuine saving

The starting point in the calculation of genuine saving is just standard national accounting. GNP minus public and private consumption will gain the Gross saving. Next the depreciation of produced assets is deducted, we will get net saving, finally, genuine saving is obtained by subtracting the value of resource depletion and pollution damages from net saving.

The following table states the calculation process of Eco-Domestic Product, Genuine Investment and genuine saving and the related macro-economy indicators.

From table 3.1, we can conclude that genuine saving pays more attention to the investment of development than EDP and has more strong relativity with policy. Some policies on resource and pollutant discharge are relevant with Genuine Saving directly.

Table 3.1 Eco-Domestic Product, Genuine Investment and genuine saving

Eco-Domestic Product	Genuine Investment	Genuine Saving
GDP – depreciation of fixed capital =**NDP** – nature resource depletion – pollution damage = **EDP**	fixed assets investment + stock change + education investment = **Gross Investment** - depreciation of fixed capital = **net investment** - nature resource depletion - pollution damage = Genuine Investment	**GDP** – consumption of products and services =**Saving** + education investment **= Gross Saving** – depreciation of fixed capital = **Net Saving** – nature resource depletion – pollution damage = Genuine Saving

Source: PRCEE (2001), research report on city environmental sustainable development indicator system in China

3.2.2.2 Calculation of genuine saving

Table 3.2 shows the calculation process of genuine saving. The key problem is how to estimate the nature resource depletion and pollution damage. There are two problems: one is that what kind of resource and environmental factor are included in the calculation? The second is how to calculate the marginal cost of resource and pollutant. The WB recommends that the resource and environmental indicators should reflect the situation of country or region. According to the latter question, the WB suggests using various methods to solve it .

Table 3.2 Calculation process of genuine saving

GDP	(1)
Gross consumption	(2)
Export goods and services	(3)
Gross Domestic investment	(4)=(1)-(2)-(3)
Education investment	(5)
generalized Gross Domestic investment	(6)=(4)+(5)
foreign borrowing	(7)
foreign borrowing	(8)=(7)
Gross saving	(9)=(6)-(8)
depreciation of fixed capital	(10)
Net saving	(11)=(9)-(10)
nature resource depletion	(12)
maximum of pollution damage	(13)
Genuine saving 1	(15)=(11)-(12)-(13)
minimum of pollution damage	(16)
Genuine saving 2	(17)=(11)-(12)-(16)

Source: PRCEE (2001), research report on city environmental sustainable development indicator system in China.

In order to make the genuine saving more easy to calculate, WB simplify the resource and environmental accounts (see table 3.3).

Table 3.3 indicator of resource and environmental account

Resource account			Environmental account (only CO_2)	
Item	Indicator	Approaches	Indicator	Marginal cost
Energy	Coal, oil, nature gas	Net price, market	CO_2	\$20/ton (Fankhauser 1995)
mineral	bauxite, copper, gold, iron ore, lead, phosphate rock, nickel, silver, tin	Rent, Net price, market		
Forest	coniferous forest, deciduous forest, and etc.	opportunity cost, WTP		

3.2.2.3 Comparison of genuine saving

Table 3.4 is the genuine saving of some countries in 2000.

From the table, we can see that the education expenses account for 1.9% of GDP in China, which is lower than that of world average level (5%) and low income countries (3.4%). The genuine saving of China is relatively high because of China's rapid economic development. In terms of Saudi Arabia, an oil exporting nation where energy consumption accounts for 43.6% of GDP,. t only a small part of national savings were transformed into human investment (5.8%), resulting in a negative genuine savings rate.

3.2.2.4 Policy implication of genuine saving

The policy implications of measuring genuine saving are quite direct: Negative rates of genuine saving must lead, eventually, to declining well-being. For the decision-maker, from relation between sustainable development and genuine saving, they can find out more feasible point to increase the sustainability of country or region.

Genuine saving can dynamic indicate the sustainable development capability. If a country increases its income just by exploitation of nature resource capital (such as sale of crude oil, coal and timber and other materials) and take these incomes into consumption instead of investment, the characteristic of "negative saving" of this country will be shown, which also indicates that its sustainable ability is being weakened and the development opportunity of future generations is threatened. On the other hand, a country can increase net wealth through positive saving. Genuine saving can be regarded as an effective tool to measure dynamic growth and decline of wealth.

Table 3.4: genuine saving and its proportion in GDP (%)

	Gross saving	depreciation of fixed capital	Net saving	educational expenses	Energy consumption	Mineral consumption	Forest consumption	CO2 damage	Genuine saving
world	22.3	11.7	10.5	5	1.2	0.1	0.1	0.4	13.6
low income country	17.0	8.0	9.1	3.4	4.2	0.6	1.8	1.2	4.8
medium income country	26.2	9.2	17.0	3.5	3.8	0.5	0.2	1.1	15.0
high income country	21.4	12.4	9.0	5.3	0.5	0	0	0.3	13.5
China	42.7	6.2	36.5	1.9	0	0.5	0.6	2.4	34.9
USA	16.0	10.7	5.3	5.8	0.7	0	0	0.4	9.9
Chile	24.5	6.8	17.7	3.2	0.1	6.4	0	0.4	14.1
Saudi Arabia	34.6	10.0	24.6	5.8	43.6	0	0	1.0	-14.2
Japan	30.5	15.8	14.6	5.8	0	0	0	0.1	20.3

Source: WB (2000), world development report

3.3 NAMEA

NAMEA (national accounting matrix including environmental accounts) is an environmental accounting framework developed by Statistics Netherlands. Since most of industries in Netherlands are based on natural resources, the Government of Netherlands actively sets up and improves NAMEA system in order to assess sustainable development level. The NAMEA was established in 1991, however, the first NAMEA account was completed in 1993 by the Statistic Bureau of Netherlands.

NAMEA consists of a conventional national accounting matrix extended with environmental accounts in physical units. It accounts for the relationship between activities of production and consumption and the natural environment and forms a comprehensive accounting framework covering details at different levels.

3.3.1 Theoretical framework of NAMEA

The theoretical framework of NAMEA is the Social Accounting Matrix (SAM). There are 12 accounts in total. Account No.1 – Account No.10 are the general accounts of national economic accounting. The economic accounting account in NAMEA is different from the standard SNA account. Its characteristic is to divide the production and consumption expenditure into two items: general and environmental protection, which facilitates calculation of environmental protection expenditure and consumption. In addition, NAMEA divides outputs and consumptions of environmental protection activities from that of other economic activities.

Accounting Matrix of National Economy is expanded. Two accounts related to environment are produced: environmental substances accounts and environmental themes accounts. These accounts are expressed in physical units but not in monetary units. The emphasis of two environmental accounts lies in the consistency of material input of natural resources and output of residues.

Environmental substances accounts include information on materials exchange of the economy and the natural environment. The sources and circulation of ten pollutants (CO_2, N_2O, CH_4, CFCs, NOx, SO_2, NH_3, P, N, wastes） are measured.. The detailed information on sources and quantity of pollutants is shown in table 3.5.

Pollutant sources mainly include production, consumption, household and inflow from other countries (see table 3.5). The pollutants amounts from production, consumption and household constitute the total pollutants discharge amount of one country. These data are of importance for determining the allocation of sector-specific pollutant discharge reduction amounts. For example, greenhouse gas emission data in NAMEA included emission amount produced from transportation activities of the country.

Environmental themes account is introduced by De Haan (1994) to assess impacts of environmental deterioration, which is of important reference for formulation of related environmental policies.

Table 3.5 main pollutants source (1997)

	CO_2	N_2O	CH_4	CFCs and halons	NO_x	SO_2	NH_3	P	N	Waste
	11a	11b	11c	11d	11e	11f	11g	11h	11i	11j
	mln kg			*1 000 kg*	*mln kg*					
EMISSION BY CONSUMERS	36 790	3.53	21.17	45	109.42	2.05	6.77	8.64	115.44	5 120
Own transport	15 640	3.32	3.99	-	87.61	1.52	-	-	25.50	70
Other purposes	21 150	0.21	17.18	45	21.81	0.53	6.77	8.64	89.94	5 050
EMISSION BY PRODUCERS	163 270	69.32	618.58	803	591.09	234.08	180.89	84.49	903.37	10 050
Agriculture and forestry	9 230	26.32	448.95	5	32.51	1.75	176.50	53.01	612.79	860
Fishing	3 760	0.88	0.13	-	77.31	63.11	-	-	19.81	110
Crude petroleum and natural gas production	250	0.02	0.08	-	1.00	0.35	0.15	-	0.50	90
Other mining and quarrying	1 820	0.01	157.57	-	3.20	0.17	-	-	1.17	100
Manufacture of food products, beverages and tobacco	4 520	0.07	0.34	20	6.99	0.48	0.23	2.54	15.46	460
Manufacture of textile and leather products	420	0.01	0.05	-	0.58	0.01	0.01	0.03	1.95	50
Manufacture of paper and paper products	1 930	0.01	0.08	-	2.18	0.08	0.10	0.82	4.33	360
Publishing and printing	310	0.02	0.04	-	1.07	0.03	-	-	0.41	90
Manufacture of petroleum products	11 200	0.07	0.60	-	15.53	52.14	0.02	0.01	5.99	70
Manufacture of chemical products	22 470	35.06	3.11	231	27.65	12.22	2.77	7.51	19.37	1 980
Manufacture of rubber and plastic products	250	0.01	0.04	-	0.41	0.01	-	0.02	0.27	90
Manufacture of basic metals	8 870	0.01	0.09	-	9.35	10.09	0.07	0.17	3.98	110
Manufacture of fabricated metal products	530	0.03	0.04	-	1.42	0.04	-	0.02	1.33	80
Manufacture of machinery n.e.c.	380	0.02	0.04	-	1.03	0.03	-	0.07	0.90	80
Manufacture of electrical equipment	1 140	0.01	0.11	-	1.79	0.35	0.01	0.02	1.10	90
Manufacture of transport equipment	170	0.01	0.07	1	0.44	0.02	-	-	0.86	70
Recycling industries	370	-	-	78	0.15	-	-	-	0.00	740
Manufacture of wood and wood products	80	0.01	0.01	-	0.34	0.01	-	-	1.13	40
Manufacture of construction materials	3 150	0.02	0.29	-	11.93	3.85	0.50	0.05	5.84	180
Other manufacturing	300	0.02	0.03	-	0.61	0.04	-	-	1.34	120
Electricity supply	44 400	0.35	1.23	-	44.33	12.46	-	0.03	21.81	50
Gas and water supply	50	-	1.95	-	0.15	0.02	-	-	0.03	30
Construction	1 910	0.40	0.25	225	21.38	1.44	-	2.95	8.83	1 330
Trade and repair of motor vehicles	660	0.04	0.02	-	1.85	0.06	-	-	0.99	100
Wholesale trade	1 890	0.30	0.13	6	12.30	0.33	-	0.04	4.22	170
Retail trade, repair (excl. motor vehicles), hotels and restaurants	2 280	0.04	0.02	11	2.73	0.06	-	0.01	1.51	140
Land transport	7 560	1.83	0.44	-	87.62	2.31	-	-	27.62	90
Water transport	6 440	1.51	0.24	-	129.32	57.95	-	-	35.46	610
Air transport	10 290	0.06	0.11	-	38.63	0.85	-	-	9.82	20
Supporting transport activities	390	0.05	0.03	1	3.84	0.27	-	-	1.45	50
Financial, business services and								-		
communication	4 030	0.58	0.50	-	20.46	0.67	0.53	-	8.56	510
Public administration and social security	2 710	0.32	0.12	-	21.88	11.39	-	-	6.22	180
Education	870	0.04	0.12	-	1.37	0.01	-	-	0.44	70
Health and social work activities	1 730	0.43	0.22	-	2.03	0.39	-	-	0.62	130
Sewage and refuse disposal services	5 590	0.72	1.40	225	4.87	1.05	0.02	17.21	76.26	740
Other services	1 320	0.07	0.11	-	2.82	0.04	-	-	1.00	60
OTHER DOMESTIC ORIGIN										
Waste dumping sites	960	-	464.06	33	0.31	0.02	-			
Transport differences								6.62	15.66	
Emission by residents	201 020	72.85	1103.81	881	700.82	236.15	187.66	99.75	1034.47	15 170
FROM THE REST OF THE WORLD										
Non-residents in the Netherlands					41.01	12.00	-	-	11.25	.
Transfer by surface water or air					59.80	70.40	22.10	15.00	313.41	
OTHER CHANGES OF NATURAL RESOURCES										
Total = NAMEA colomn total 11	201 020	72.85	1103.81	881	801.63	318.54	209.76	114.75	1359.12	15 170

Source: Netherlands Statistics.

The NAMEA contains two environmental themes that address global environmental problems: the greenhouse effect and ozone layer depletion. The greenhouse-effect theme relates to the danger of climate change caused by a concentration of greenhouse gases in the atmosphere. The greenhouse gases include carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4). The ozone-layer-depletion theme relates to the potential negative effects of a higher exposure to UV-B radiation caused by chlorofluorocarbons (CFCs) and halons. These substances are sometimes also regarded as greenhouse gases, but the evidence is mixed. The following data expresses the relative contribution of each greenhouse gas in CO_2-equivalents. The conversion factors for N_2O and CH_4 respectively are 309.315 and 20.996. CFCs and halons are expressed in CFC11-equivalents. The resulting aggregated theme-indicators for the greenhouse effect and ozone layer depletion reflect the contribution of Dutch residents to these global environmental problems.

The themes 'acidification', 'eutrophication' and 'waste' relate to internal environmental problems that are caused by the accumulation of pollution on Dutch territory. The acidification theme relates to the damage caused by the deposition of nitrogen oxides (NOx), sulphur oxides (SO_2) and ammonia (NH_3) in soil and surface water. The eutrophication theme relates to the problem of accumulating nitrogen (N) and phosphorus (P) in soils and subsequently in groundwater and surface water. The accumulation of waste is a serious environmental problem as well. This theme is restricted to waste consisting of products that have lost their economic use. This kind of waste can be measured in kilograms. Acidification is expressed in acid-equivalents by applying the conversion factors 0.217, 0.313 and 0.588 to NOx, SO2 and NH3, respectively. Nutrient-equivalents, which are assumed to equal 10 kg P or 1 kg N, are taken as the common unit to calculate the eutrophication indicator.

The theme 'change in natural resources' points to the interdependence of economic activities and the depletion of natural resources. Natural gas and crude oil are the related indicators of this theme.

3.3.2 Main characteristics of NAMEA

NAMEA is mainly of the following characteristics:

(1) The accounts include "imported" wastes from abroad and "export" wastes from Netherlands;

(2) They emphasize pollutants discharge and wastes;

(3) These are reported in objects accounts;

(4) The accounts cover major global environmental issues.

Viewed from the function of NAMEA, the Government of Netherlands hopes to achieve the following goals through implementation of NAMEA:

(1) As an analysis tool for formulation of environmental policies. For example, the matrix shows that stockbreeding is the main source of greenhouse gas; the administrative department in charge should therefore reduce its scale of production and reduce impacts to climate change;

(2) To make people aware of the importance of environmental themes through the establishment of accounts;

(3) Since the matrix is reported in physical units in objects accounts and does not touch upon the issue of monetary assessment of environmental resources, this makes economists and statistics easier to accept;

(4) Some indices on the relationship between the environmental and the economic derived are derived from NAMEA, such as the energy utilization efficiency and sustainable development levels. For example, ecological production rate (GDP/pollutants amounts from production activities) is used to show environmental efficiency, from which the relation between economic growth and environmental pressure could be shown clearly.

In 2004, NAMEA was expanded into the NAMWA (National accounting Matrix including Water Accounting) including accounting for water resources and more information on pollutants and water resources, using NAMEA as the foundation. It connects the water resources utilization and water pollution data with the general economic accounting system.

3.4 SERIEE

The European System for the Collection of Economic Information on the Environment (SERIEE) (European Commission, 2002), developed in 1994, focuses on what the SEEA labels as defensive expenditures. The SERIEE comprises two satellite accounts; the Environmental Protection Expenditure Account (EPEA) and the Resource Use and Management Account. The EPEA, the more developed of the two, describes within a framework consistent with the European system of integrated economic accounts (ESA);

- The expenditures and resources a nation commits to environmental protection
- The ways of financing this expenditure as well as the financial burden related to environmental protection
- The production of environmental protection services

Thus, the SERIEE is generally closely tied to a country's national income accounting framework (SNA), but is limited only to the defensive spending aspects covered by the SEEA. Further, SERIEE is limited to observing the impacts of this defensive expenditure on the physical nature of degradation rather than estimating the monetary benefits of such expenditures, again in line with the SEEA. Thus, this approach is generally viewed as compliant with that which is recommended by the SEEA.

3.5 Indices of sustainability

The indices of sustainability are the base of quantitative analysis of sustainable development. Some experts have set up many index systems and models to measure the level of sustainable development.

Table3.6 Indices of sustainability: concepts and methods

	Ecological footprint (EF)	***Environmental sustainability index (ESI)***	***Sustainable development index (SDI)***	***Index of sustainable economic welfare (ISEW/GPI)***
Definition	Biologically productive areas, required for natural resource use and waste absorption, using current technology	Unweighted average of indicators related to environmental sustainability	Arithmetic mean of indicators for significant aspects of sustainable development	Final consumption corrected for positive and negative welfare effects (household and community services, external effects on society and the environment, defensive expenditures, income distribution)
Indicators	Six main categories of ecologically productive areas	20 indicators, which combine 68 variables	14 indicator (2 for each problem area), combining 58 variables	'More than 20 welfare effects ignored by GDP'
Weighting	Area equivalents of world average bio-productivity for natural resource use and waste absorption	Equal weighting of standardized indicator scores	Equal weighting of all (standardized) variables	Monetary valuation mix of positive and negative welfare effects; adjustment for income inequality
Sustaina-bility concept	*Ecological sustainability*: inverse of the carrying capacity of a country's natural systems	*Potential for environmental sustainability*: high lasting environmental performance resulting from policies and programmes	*Overall (development) sustainability:* high index values in political, social, demographic, economic and environmental areas	*Economic sustainability: non-declining welfare ('real' sustainable consumption)*

Sources: EF: Wackernagel et al. (2000)
ESI: Global Leaders of Tomorrow (2002)
SDI: Novácek and Mederly (2002, Ch. 4)
GPI: Cobb, Halstead and Rowe (1995).

The collection of physical environmental data forms the basis of all relevant environmental accounting systems and indicators - being a precondition for an accurate monetary valuation. Determining the 'total cost' of environmental degradation, in particular requires a large amount of physical data, coupled with the application of a monetary valuation technique. In fact the approach taken by each accounting system is one of the primary differentiating factors. This is the topic of the following section.

4 Environmental accounting and valuation experiences

Internationally, countries are still trying to develop and harmonize their environmental accounting systems and the development of these approaches has largely depended on country specific needs and priorities. Below, we provide an update of international efforts in implementing the environmental accounting. We then provide a description of a number of examples where countries have made an attempt at implementing one or more monetary valuation methodologies.

4.1 Korea

Korean environmental accounting system adopted the SEEA framework. The environmental factors for adjustment on the traditional NDP include the environmental protection expenditure, environmental resources values, resource depletion and environmental degradation. The major four kinds of accounts are as following:

i environmental protection expenditure and valuation of environment

ii asset account of renewable resource

iii asset account of non-productive resource

iv environmental degradation

The indicator "Environmentally adjusted Domestic Product"(EDP) can be calculated after adjustment of NDP and it will be used to measure the level of sustainable development.

The maintenance cost method is adopted to estimate the environmental degradation which includes the air pollution, water pollution, soil pollution, consumption of surface water and solid waste. The related air pollutants involve CO, NOx, SO2 and TSP which were divided to motive and fixed pollutant. The related water pollutant is BOD. And because it is difficult to gain the monetary value of soil depletion, the valuation of soil is calculated by the waste treatment cost in landfill.

4.2 Canada

Because of the importance of natural capital to Canada, Statistics Canada was amongst the early adopters and pioneers of EA beginning in the 1980s and has made a significant contribution to the art of EA. Statistics Canada has developed satellite environmental asset (natural resource) accounts, physical flow accounts (material and energy flow accounts), and environmental and resource management expenditure accounts.

The Canadian System of Environmental and Resource Accounts (CSERA) is Canada's version of SEEA. Canada has been producing natural capital stock accounts for timber and subsoil assets since the early 1990s. Statistics Canada's CSERA were developed during the same period as the SEEA was undergoing its own development. The accounts compiled for the country are generally consistent with the SEEA 2003 though they were not based directly on it. With the completion of SEEA 2003, Statistics Canada is making greater efforts to apply SEEA's recommendations in the on-going development of Canada's environmental accounts.

Natural Capital Asset Stock Accounts: Statistics Canada has produced non-produced natural capital asset accounts that are integrated with produced assets in their balance sheets. The primary focus has been on asset accounts for subsoil assets, timber, and land with data generally available from 1976-2001. Other accounts that are prepared irregularly are: water extraction and use accounts (latest year 1996) and land cover and use. Canada's Natural Resource Stock Accounts measure quantities of natural resource stocks (subsoil and timber) and the annual changes in these stocks due to natural and human processes. These accounts are recorded using both physical and monetary units (e.g. economic rent calculations) using methodologies similar to those proposed in the SEEA 2003 guidelines.

Material and Energy Flow Accounts: These accounts measure in physical terms only, the flows of materials and energy in the form of natural resources (energy and water) and wastes (greenhouse gas emissions) between the economy and the environment for over 100 industries plus household and government activities. This information has been useful for analysis of climate change and strategies for meeting Canada's Kyoto Protocol target, both at the national and provincial level.

Environmental Expenditure Accounts: Statistics Canada has been compiling environmental expenditure accounts since the mid-1990 and are current to 2002. These accounts identify current and capital expenditures by business, government and households for the purpose of protecting the environment. They measure the financial burden associated with environmental protection and the contribution of environmental protection to economic activity from a demand-side perspective. Statistics Canada's EPE accounts show that five industries (mining, pulp and paper, primary metals, petroleum refining, and energy utilities) account for 80% of all expenditures (Lange 2003: p. 44).

We should observe that Statistics Canada does not calculate environmentally-adjusted macroeconomic aggregates such as a green GDP or eaNDP, even on an experimental basis because of some reasons. Nor does Statistics Canada or other government agencies use the CSERA to express opinions on sustainability through the creation of sustainability indicators or indices such as the GPI/ISEW or other sustainability indices. Instead, Statistics Canada simply reports stocks, flows, monetary values (economic rents) of various natural capital assets, material and energy flow information, and environmental expenditures which it leaves to the discretion of policy makers and other interest groups to come to their own conclusions about sustainability of Canada's natural capital patrimony. For example, in 2001 the Pembina Institute, an environmental think-tank based in Alberta, developed a GPI (sustainable well-being account) for the province of Alberta examining the sustainability of both human, social, natural and produced capital assets. Information from CSERA's timber, subsoil assets (oil, gas, coal) and agricultural land accounts, as well as environmental expenditure data, was used to develop natural capital accounts for Alberta along and derive sustainability indicators of Alberta's natural capital as well as other capital assets (Anielski et.al. 2001), expressed in both monetary and non-monetary terms. This is one example of the potential utility of SEEA-type accounts for measuring and reporting on sustainability of both human, social, natural and produced capital.

4.3 USA

In order to reflect the environmental impact of economy activities, Bureau of Economic Analysis (BEA) of USA began to develop pollution abatement and control expenditure in 1972 which just includes the environmental protection expenditure of government, enterprises and household. In 1994, BEA established Integrated Economic and Environmental Satellite Accounts (IEESA) aimed to seek the relationship between economic activities and nature resource. IEESA included the market price of resources and the impacts of production and consumption process except the pollution abatement and control expenditure.

There are two main aspects in IEESA. At first aspect, environmental resources are treated as a productive capital and one part of national wealth, which will calculate its contribution in the production process. At the other aspect, IEESA also provide some detailed data of expenditure and capital which will help us to cognize the relationship between economic activity and nature resource. (Zhang yaoren, 1999)

The net price method was adopted to estimate the nature resources which including oil, nature gas, timber, coal and fishery. However, the maintenance cost method was used to calculate the environmental degradation which including air, water and soil degradation. At the air pollution aspect, pollution sources include TSP, Sox, NOx, VOC, CO and Pb which were divided to motive and fixed pollutant. At the soil aspect, USA evaluated the soil which has recreational function depletion by the maintenance cost and repair expenditure based on the pollution control expenditure for unexploited soil.

The government did not operate official environmental accounting for several years because of the objection of Congress. But there also existed some good experiences, for example, EPA have set up database on pollution control and pollution sources which could satisfy the require of SNA or other policy analysis, at the other hand, the accounts of nature and environmental resource are more detailed.

4.4 Mexico

Mexico was one of the first developing countries to implement significant components of the SEEA at an attempt to link the country's SNA with data pertaining to the environment, particularly forest resources, oil, soil erosion, soil pollution, land use changes, water resources, and air and water pollution. The diverse environmental themes are tracked by physical accounts for environmental and economic assets – both stocks and flows (e.g. barrels of petroleum, cubic meters of timber and hectares of forest). In addition, monetary accounts have also been set up. The result is a macro-economic indicator labeled 'Net Ecological Domestic Product (NEDP)', defined as a measure of sustainable economic growth, calculated as GDP less consumption of fixed capital, natural resource depletion and environmental degradation. In one study (OECD, 1996), which covered the period 1985-1992 the cost of resource depletion was estimated at 3.9 percent of GDP and the cost of environmental degradation was estimated at 8.6 percent of GDP, for an estimated total cost of 12.5 percent.

Table 4.1 provides a list of references provided to the London Group regarding the Mexican experience.

Table 4.1 SEEAM: Summary of documents

Publication	Coverage	Period of Generation	Printing Date
Integrated Environmental and Economic Accounting. A Case Study for Mexico	1985	November 1989-December1991	Dec-1991
System of Economic and Ecological Accounts, Mexico (Spanish), publication 1985-1990, inside the CD "Historical Statistics of Mexico"	1985-1990	January 1992-January1994	Feb-1994
System of Economic and Ecological Accounts, Mexico (Spanish), publication 1985-1992	1985-1992	March 1994-March1996	Apr-1996
System of Economic and Ecological Accounts, Mexico (Spanish), publication 1988-1996	1988-1996	May 1996-February 1998	Jan-1999
System of Economic and Ecological Accounts, Mexico (Spanish), publication 1993-1997	1993-1997	January 1998-February 1999	August-1999
System of Economic and Ecological Accounts, Mexico (Spanish), publication 1993-1998	1993-1998	January 1999-March 2000	Jun-2000
System of Economic and Ecological Accounts, Mexico (Spanish), publication 1993-1999	1993-1999	January 2000-Dec 2000	Dec-2000
System of Economic and Ecological Accounts, Mexico (Spanish), publication 1995-2000	1995-2000	January 2001-Feb 2002	Mar-2002
System of Economic and Ecological Accounts, Mexico (Spanish), publication 1996-2001	1996-2001	April 2002-March 2003	May-2003
System of Economic and Ecological Accounts, Mexico (Spanish), publication 1997-2002	1997-2002	May 2003-March 2004	June-2004

4.5 Norway

The Norwegian Economic and Environmental Accounts Project (NOREEA) was first established in 1997 as a cooperative project between the Division for National Accounts and the Division for Environment Statistics at Statistics Norway. The corresponding emissions data are distributed by industry, so as to enable a comparison of economic activity and environmental impacts. Funding for this project has come from Eurostat, Statistics Norway and the Norwegian Ministry of the Environment. There are three major areas that are included in the larger NOREEA system. One area of development focuses on connecting the environmental statistics to the economic statistics (NAMEA). A second area involves separating out environment related information already included in the economic statistics. The final area includes the valuation of important natural resources (Hass, Sørensen and Erlandsen, 2002).

As a result of this project, an emissions data set was created and a time series analysis was conducted, comparing trends in emissions with trends in value added, disaggregated by sector. The most recent results are summarized here (Statistics Norway, 2005);

- The transportation industry accounted for 28 percent of greenhouse gas emissions in 2003. This industry was the largest contributor to greenhouse gas emissions. Calculations show that ocean transport alone contributed 17 percent of total greenhouse gas emissions, in other words, more than the emissions from all inland transportation industries.
- The mining and extraction industry had a relatively even reduction in greenhouse gas intensity between 1990 and 1997-98. After that it appears that the trend has changed. The change from oil production to more natural gas production has contributed to greater emissions of both greenhouse gas emissions and acidification precursors without having an increase in value added due to this structural change.
- In the manufacturing industry, due to higher electricity prices in 2003, resulted in more light fuel oil use displacing some electrical power consumption in a number of land-based industries. Due primarily to this increased use of light fuel oil, emissions of both greenhouse gases and acidification precursors increased from 2002 to 2003.
- Household waste continued to increase. For households it is most relevant to use consumption as an indicator for economic development. In addition to air emissions data, there are also statistics for solid waste from households. The statistics show that households' waste production continued to increase more than consumption, in spite of the politically established environmental goals to the contrary.
- Households’ greenhouse gas emissions also increased for the first time over the 1990-level. This is primarily because of the increased use of heating oil but there was also an increased use of gasoline in privately owned cars. Emissions of acidification precursors and ozone precursors continued to go down, which

is explained primarily by the fact that catalytic converters are now installed in most of the automobile fleet.

4.6 Philippines

There are two different environmental accounting systems in Philippines, one is ENRAP and the other is SEEA. Philippines has begun to develop ENRAP with prof. Peskin since 1990. The original objective of this program was to research the depletion of forest resource and extended to fishery, mineral and other nature resource. Moreover, National Statistical Coordination Board (NSCB) of Philippines developed Philippine SEEA (PSEEA) in 1995 under the suggestion of UN. Despite some same points are existed in these two system, but there still have some difference between them due to the different theory.

4.6.1 PSEEA

PSEEA adopted the main structure of SEEA. NSCB have developed the forest, fishery and mineral resource account and the net price method is used to calculate the nature resource depletion. The asset accounts include the beginning stock, change of stock (such as exploitation and use), closing stocks. PSEEA will establish monetary value asset account based on these physical accounts.

On the valuation of environment degradation, PSEEA adopted maintenance cost method to estimate it. The minimum operational cost of equipment which including the annualized capital cost, maintenance cost and operating cost will be used.

Because PSEEA just estimate the nature resources service which has the market price, the other environmental services which have no market price will not be included in system. (Liao zhaoning)

4.6.2 ENRAP

The USAID funded ENRAP(Environmental & Natural Resources Accounting Project), implemented in the Philippines, aims at more fully capturing all relevant environmental costs and integrating these costs into the national accounts and the subsequent economic aggregates. For purposes of this report, ENRAP can be viewed as an alternative approach to the SEEA. To this end, the ENRAP encourages the use of imputation approaches that draw on many of the methodologies. In fact, this approach has been labelled as the first full-fledged attempt at incorporating pollution costs into the accounting system (Hecht 2005).

The ENRAP accounts measure, in particular, the damages caused by pollution, including health costs, forgone income as a result of morbidity and mortality, decreased fishery output because of water pollution, reduced reservoir capacity as a result of soil erosion, and reduced rice paddies as a result of sedimentation. Further, the services provided by the environment, valued based on what it would cost to prevent the pollution, are then added to the macroeconomic indicators in the accounts. In other words, the damages caused by the use of those services –pollution damages – are deducted to arrive at an estimate for green GDP (Hecht, 2005).

A version of the ENRAP approach has been recommended by the National Academy of Sciences panel for implementation in the USA (Nordhaus and Kokkelenberg, 1999). In particular, it is recommended that a series of accounts be constructed in order to account for a broad range of non-marketed goods and services, particularly those that are provided by the environment. The report explicitly addresses only air pollution, pointing to similarities with other important pollution categories. However, it is admitted that the valuation of both clean air and subsequent pollution is controversial and would prove very difficult[9]. Thus, it is recommended that more research on valuation be conducted. The academy recommends that the accounts be used particularly for calculating resource depletion and degradation, but not Green GDP. An estimation of Green GDP is, however, calculated in the case of the Philippines (below).

The only complete application of the ENRAP approach that we are aware of has been conducted in the Philippines (ENRAP 1996) and the results have subsequently been compared with those of the implementation of the SEEA. As already noted above, the ENRAP's accounts measure the damages caused by pollution, including health costs, forgone income as a result of morbidity and mortality, decreased fishery output because of water pollution, reduced reservoir capacity as a result of soil erosion, and reduced rice paddies as a result of sedimentation. Further, the services provided by the environment, valued based on what it would cost to prevent the pollution, were then added to the macroeconomic indicators in the accounts; the damages caused by the use of those services – pollution damages, that is – were deducted to estimate green GDP (Hecht, 2005).

4.7 Mediterranean Environmental technical assistance program

The program particularly addresses the following cost categories of environmental degradation:

- loss of healthy life and well-being of the population (e.g.: premature death, pain and suffering from illness, absence of a clean environment, discomfort).

[9] However, the USA is at the forefront of environmental valuation research and practice, and has applied environmental valuation to air and water pollution in a number of other contexts, e.g. for the cost benefit analysis of the Clean Air Act and for resource damage assessments used in courts (e.g. the Exxon Valdez oil spill)

- economic losses (e.g. reduced soil productivity and reduced value of other natural resources, lower international tourism).
- loss of environmental opportunities (e.g. reduced recreational value for lakes, rivers, beaches and forests).

This program has estimated environmental cost of Algeria, Egypt, Lebanon, Morocco, Syria, and Tunis. The following table (Table 4.2)shows the results.

Table 4.2 Result of environmental cost in countries (1999)

Countries	Domestic environmental cost (millions, US$)	Percent of national GDP,%	Global environmental cost (millions, US$)	Percent of national GDP, %
Algeria	1693	3.6	568	1.2
Egypt	4280	4.8	560	0.6
Lebanon	565	3.4	90	0.5
Morocco	1230	3.7	300	0.9
Syria	624	3.5	228	1.2
Tunis	440	2.1	124	0.6

Source: Proceedings of UNCEEA & London Group Meetings, 2004

To arrive at a monetary valuation of the cost of environmental degradation, various methodologies were applied:

Soil degradation: The soil degradation includes soil erosion, soil salinization and desertification, which will reduce the agricultural product. The value of soil degradation will be estimated by the decrease of production.

Air pollution: The primary costs are due to acute respiratory illness in children and adult females, adult female morbidity, and respiratory child mortality. The cost of negative impacts on health is estimated by applying a combination of valuation techniques. For morbidity the cost-of-illness (COI) approach has been used. This approach estimates treatment costs and the cost of lost work days or time provided by care givers. In addition, DALYs (Disability Adjusted Life Years) lost to morbidity have been valued in relation to GDP per capita to account for the cost of pain and suffering of illness which is not included in the COI (cost of illness) approach. The cost of adult mortality from air pollution is estimated based on WTP for mortality risk reduction.

Indoor air pollution: It is similar to air pollution.

Water pollution: the deficiency of drinking water and low water quality will increase the children and adult morbidity. We can change it into DALYs and estimate water pollution damage cost.

Coastal zone degradation: the damage will be valued by the decrease of tour income.

5 Summary and conclusions

5.1 Existed problems in environmental accounting

To date, no integrated environmental and economic accounting approach enjoys the internationally approval which is coveted by the SNA. This is largely due to significant international disagreement as to both the methods of valuing the environment, as well as the subsequent use of this valuation. However, the SEEA 2003 has been endorsed by the UN Statistical Commission and will soon be published by 5 major multilateral organizations and has emerged as the primary approach being adapted around the world, largely in the form of 'pilot cases'. Nonetheless, no single country has implemented all components of the SEEA, though many have adopted various aspects of the SEEA that address country-specific public policy, sustainability accounting and reporting needs.

The following two tables describe the differences in the environmental accounting systems and the current situation of some countries which are implementing these systems. From the results of tables, we can conclude that it is very difficult to establish a common global environmental accounting system. Because we must estimate the value of environment asset and nature resources in the process of adjustment of GDP, the following obstacles are inevitable when we attempt to establish an environmental accounting system.

i. How to convert physical quantities (stocks and flows) of environment and resources into economic values? The valuation of national capital accounts should be based on market price system. But due to issues of public property rights of environment and natural resources and different methods for price-fixing and monetization of environment and natural resources, monetizing changes in physical natural capital is problematic. In addition, the cost for changing physical stock of environment and natural resources into economic value has yet to be solved.

ii. The issue of economic assessment on environmental value, especially the economic assessment issue on human health damage caused by environmental pollution. The Survey Evaluation Approach in common internationally use is to monetize damage on human health caused by environmental pollution through surveys on the public payment willing to reduce risk of health. Even though the Willing To Pay (WTP) method is an evaluation approach for environmental economy which is relatively recognized in the international academia, it cannot be simply converted or copied for different groups in different regions under different economic and natural conditions are of different willing to pay.

Table 5.1 Contrast of Environmental accounting system

System	SEEA2003	ENRAP	SERIEE	NAMEA
Established by	1.First version of the SEEA was published in 1993 2. Operational manual was published in 2000 3.SEEA2003 was published in 2003	1.It is presented by economist Mr.Peskin 2.It is implemented in the Philippines	It is published by statistic bureau of EU in 1994.	1.It is presented by Statistics Netherlands 2. At the beginning, Netherlands established air emissions account in 1991.
Main Content	1. non-productive assets substance accounts 2.Environmental protection and resource management expenditure accounts 3.Integrated Environmental and Economic Accounts 4.depletion and degradation costs of environment 5.Define eaGDP indicator	1. It regards the environment as production sector and this sector can produce non-market environmental service value. 2. It takes the environmental pollution damage as the negative output of production sector. 3. Define "net environmental benefit" indicator	1.Environmental protection expenditure accounts 2.Nature resource use and management accounts 3.Collection of elementary material	1.Emission accounts 2.National environmental themes 3.global environmental themes
Scope	1. It is recommended that market price method, net present value method can be used to estimate the valuation of resource depletion. 2. It is recommended that damage cost approach, maintenance cost approach can be used to estimate the valuation of environment degradation.	1. The environmental pollution cost will be estimated. 2. The environmental service valuation will be estimated.	Only environmental protection expenditure is calculated and the pollution damage is not including in SERIEE.	The environmental account of environment is presented only in physical terms and is not in monetary terms
Remark	The countries which adopted SEEA will make some adjustment to the environmental themes in SEEA according to the actual condition.	1. It includes the non- market service provide by nature environment such as tourism. 2. It estimates the health damage of pollution.	This system focus on the environmental protection expenditure account, so it is more detailed than that of SEEA.	The environmental accounts in the NAMEA are denominated in physical units and focus on the consistent presentation of material input of natural resources and output of residuals for the national economy.

Source: research report on the theory and establishment model of green national accounting system in Taiwan

Table 5.2 Contrast of environmental accounting in different countries

Countries	Adopted system	Resource depletion	Environment degradation			Solid waste	Note
			Sewage	Air	Soil		
Korea	SEEA	Related resources include forest, fishery, mineral and etc.	Related Pollutants includes BOD	Pollutants are divided to fixed and motive and include CO, SO2 and etc.		The general household waste is included.	1. The net price method is adopted to estimate forest and mineral value. 2. The average market price is adopted to estimate the soil value. 3. The maintenance cost method is adopted to estimate environment degradation value.
Japan	SEEA	Related resources include mineral (coal, zinc), forest and etc.	Related pollutants include COD and BOD	Related pollutants include SO2 and NO2.	The soil damage cost by economy activities is estimated in system.		1. The average unit cost is adopted to estimate the soil and forest value. 2. The maintenance cost method is adopted to estimate environment degradation value.
USA	SEEA	Related resources include oil, nature gas, timber, coal, water and fishery.	Related pollutants include P, N and BOD.	Pollutants are divided to fixed and motive and include CO, SO2, VOC and etc.	The soil degradation is estimated by maintained cost of soil function.	The general waste is included.	1. The net price method is adopted to estimate nature resource value. 2. The maintenance cost method is adopted to estimate environment degradation value.
Netherlands	NAMEA	Related resources include natural gas and crude oil	Related pollutants include wastewater.	Related pollutants include CO_2, N_2O,CH_4,CFCs, NOx,SO_2,NH_3, P, N	Related pollutants include NOx, SO2, NH3 which cause acidification of soil	The discharge amount is recorded.	The related data is only in physical terms.
Germany	SEEA	The physical accounts water and energy resource are established, which include coal, mineral, oil,	Related pollutants include wastewater amount discharged from industries and household. But the value of water is not estimated.	Related pollutants include CO_2, N_2O, CH_4, CO, SO_2, NH_3 and dust, especially attach importance to international CO_2		The discharge amount is recorded.	1. The environmental protection expenditure of government and industry, environmental tax revenue are recorded. 2. The comparison of multinational CO_2 discharge is

Countries	Adopted system	Resource depletion	Environment degradation			Solid waste	Note
			Sewage	Air	Soil		
		timber and etc.		discharge amount.			emphasis.
Philippines	SEEA	Related resources include forest, fishery, and mineral.					1. The net price method is adopted to estimate resource depletion. 2. The maintenance cost method is adopted to estimate environment degradation value.
	ENRAP	Related resources include forest, fishery, and mineral.	Related pollutants include N, P and BOD.	Related pollutants include PM_{10}, CO, VOC, NOx and etc.	The soil damage cost by agriculture activities is estimated in system.	The environmental service provided to waste is estimated	1. The net present value method is adopted to estimate resource depletion. 2. The damage cost method is adopted to estimate environment degradation value.
Canada	CSESR	Related resources include forest, soil which is recorded in physical and monetary term.	Only the wastewater discharge amount is recorded.	Related pollutants include GHG.			The environmental protection expenditure of government, industry, and household are recorded.
Mexico	SEEA	The water, air, soil and forest are treated as environmental assets.	Related water includes use of underground water and water pollution.	Related pollutants include CO2, NO, CO and suspend substance.		Only physical quantity is recorded.	1. The net price method is adopted to estimate mineral and forest value. 2. The Damage Cost Avoided method is adopted to estimate environment degradation value.

Source: research report on the theory and establishment model of green national accounting system in Taiwan

iii. The issue of evaluation on pollution damage. Though many researches on pollution damage have been conducted, it is still very difficult to make exact valuation on environmental capacity since uncertainty of dose-respond function resulted in various research results and there is not any comprehensive research on pollution damage yet.

5.2 Enlightenment for establishment of green national accounting system in China

On this note, the Chinese Green GDP project has just started and it is too early to provide specific recommendations as to which level of ambition or type of accounting framework would be best suited to the Chinese context. However, below we list a few initial observations from the review of international experiences and actual conditions of China:

i. It is clear from the international experiences that the implementation of the accounting approaches is complex and demanding. That is why so few countries have well developed accounting systems in place even after more than 20 years of research. Given these international experiences, it is important for China not be overly ambitious in its approach to green GDP accounting.

ii. The national environmental accounting system in China should be established on the basis of standards of SEEA. We should also pay attention to comparability and scientific rigour of the national environmental accounting system. Currently, scholars of China mainly focus on accounting scope and methodology of Green GDP. However, Green GDP should not only provide service for Chinese strategy of sustainable development but also connect with international efforts for macro economic decision-making at the national and global levels. Consideration should be given to adopting SEEA for China since SEEA does help reflect on the relationship between environment and economy in a comprehensive and systemic way with expanding analysis capability of national accounting without necessarily altering the original SNA structure. Other countries are taking this approach It is therefore recommended that a national environmental accounting system be established in China on the basis of SEEA in order to facilitate comparative research.

iii. A green or environmental accounting system should be based on a scientifically rigorous approach to measurement. On the basis of current national economic accounting system, the first step in establishing “satellite” accounts on environmental resources is establishing a physical quantity accounting system of environmental resources (measuring stocks and flows). The second step is to monetize or value the physical units of environmental resources using various valuation methods. These monetized accounts would exist as “satellite” accounts in an expanded SNA. Systematic monitoring on key resources and environment should be conducted; physical accounts and "satellite" natural capital accounts should be revised; and the models related to economy and environment should be set up and assessed.

iv. Choice of priority fields of accounting. In the short term, it is hard to achieve comprehensive economic accounting system that fully incorporates the environment. It is practical to choose some regions and conduct accounting on specific environmental subjects. Based on environmental data and information currently being collected, we could consider to accounting for sulfur dioxide, soot, waste water, COD and industrial solid wastes into an emerging environmental accounting framework.

v. Development and specific choice of evaluation approaches in value assessment. Different evaluation approaches will require support of different data and information sources and will result in different accounting results. In the light of the actual environmental data sets that currently exist in China, we should select accounting methods that conform to these data sets and to of national and regional environmental conditions in China.

vi. Improvement of statistical index system and materials should be accelerated in China. Viewed from other countries, one of problems hindering establishment of national environmental accounting system is the lack of statistical indices and data. Indices owned and finalized by some countries is 20%-30% of that prescribed in SEEA. Incomplete data would directly result in poor quality of accounts. Due to historical reasons, the current statistical index system of China is still incomplete, basic data and information is not enough, there are still great data gaps as well as challenges of timeliness, completeness and openness of statistical data between China and the international world, which requires us to strengthen fundamental statistic work, improve quality of statistic personnel, and improve the statistic indicators system. We should give priority to the design of a set of environmental indices which could accurately reflect national environmental information. On the basis, information on natural resources and environment should be gradually compiled in the accounts of national economy..

vii. In addition to the development of a national environmental accounting system, the research on other sustainable index systems should also be conducted. Green GDP is one example whereby traditional GDP is adjusted for the environment and natural capital depreciation.. Even though Green GDP methodology has improved greatly, the Green GDP still has its shortcomings both methodologically and politically. Green GDP is the first step in accounting for the full impacts of economic development on human society as well as on the environment. Economic growth is only one part of the development of human society and measures like the GDP cannot represent the progress or overall welfare of the whole human society. Therefore, social factors must also be considered in measuring sustainable development and overall societal well-being.

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