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INTEGRATED ENVIRONMENTAL AND ECONOMIC ACCOUNTING: FRAMEWORK FOR A SNA SATELLITE SYSTEM

BY PETER BARTELMUS

United Nations Statistical Office

CARSTEN STAHMER

Federal Statistical Office, Germany

AND

JAN VAN TONGEREN

United Nations Statistical Office

National accounts have provided the most widely used indicators for the assessment of economic performance, trends of economic growth and of the economic counterpart of social welfare. However, two major drawbacks of national accounting have raised doubts about the usefulness of national accounts data for the measurement of long-term sustainable economic growth and socio-economic development. These drawbacks are the neglect of (a) scarcities of natural resources which threaten the sustained productivity of the economy and (b) the degradation of environmental quality from pollution and its effects on human health and welfare. In the present paper, the authors attempt to reflect environmental concerns in an accounting framework which maintains as far as possible SNA concepts and principles. To this end, the accounting framework is used to develop a "SNA Satellite System for Integrated Environmental and Economic Accounting" (SEEA). Environmental costs of economic activities, natural asset accounts and expenditures for environmental protection and enhancement, are presented in flow accounts and balance sheets in a consistent manner, i.e. maintaining the accounting identities of SNA. Such accounting permits the definition and compilation of modified indicators of income and expenditure, product, capital and value added, allowing for the depletion of natural resources, the degradation of environmental quality and social response to these effects. A desk study of a selected country is used to clarify the proposed approaches, to demonstrate their application in future country studies and to illustrate the quantitative effects of the use of modified concepts on the results of analysis.

1. INTRODUCTION

The discussion of environmentally sound and sustainable socio-economic development has received increased attention by the international community, stimulated in particular by the report of the World Commission on Environment and Development (1987). At its forty-second session, the General Assembly welcomed the Commission's report (resolution 42/187) and adopted an "Environmental Perspective to the Year 2000 and Beyond" which proclaimed "as the overall aspirational goal for the world community the achievement of sustainable development on the basis of prudent management of available global resources and environmental capacities" (resolution 42/186). Environmentally sound and

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sustainable development will also provide the basic theme for the planned United Nations Conference on Environment and Development in 1992.

The need for clarifying this new development concept and for developing methodologies for its assessment and implementation has been recurrently stressed in international conferences, seminars and workshops. Joint workshops, organized by UNEP and the World Bank, examined the feasibility of physical and monetary accounting in the areas of natural resources and the environment and developed alternative macro-indicators of ecologically adjusted and sustainable income and product (Ahmad, El Serafy and Lutz, 1989). A consensus emerged in the workshops that enough progress had been achieved to link environmental accounting to the standard System of National Accounts, the SNA (United Nations, 1968), and to include certain aspects of environmental accounting in the ongoing revision of SNA.

National accountants and environmentalists reviewed a first draft of the present paper in a UNEP/World Bank-sponsored expert meeting (Paris, November 21-22, 1988). The experts at the meeting endorsed the idea of developing a satellite system of environmental accounts and discussed a variety of methodological and procedural questions. These questions should be resolved before preparing an internationally recommended manual of environmental accounting. The experts also requested that the revised SNA should elaborate on the approaches to incorporating environmental concerns in national accounts.

The immediate objective of the present framework is to serve as the basis for the preparation of a "SNA Handbook on Integrated Environmental and Economic Accounting" to be issued within the United Nations series of national accounting handbooks. The framework should also facilitate the consideration of environmental accounting in the revised SNA, possibly as part of a more general treatment of the concept of satellite accounts and with appropriate cross-referencing to the Handbook. The draft methodologies have been tested in pilot country studies, and will be distributed widely for comments and contributions.

The framework discussed in this paper is the basic structure for a "Satellite System for Integrated Environmental and Economic Accounting" (SEEA). It is presented in tabular form with an illustrative set of data and is described in some detail in the text. In section 2 the main objectives of environmental accounting as well as the general structure of the SEEA are described. Section 3 contains a description of the supply side of goods and services, focusing on environmental protection services and the supply of natural growth products. The accounting for the costs of environmental depletion and degradation, resulting from production and consumption, is the main issue of section 4. In this section, the authors also explain how these costs affect value added and final demand. One basic indicator, the Environmentally Adjusted Net Domestic Product or "Eco Domestic Product" (EDP) is presented in this context. In section 5 the flow accounts of sections 3 and 4 are complemented by the presentation of stock assets of tangible wealth that include natural assets and changes therein. In section 6 the possible extensions of the flow accounts to obtain welfare-oriented macro-indicators are discussed. Finally, some comparative analyses of the conventional and environmentally modified concepts are presented in section 7.

2. General Features of a Satellite System for Integrated Environmental and Economic Accounting (SEEA)

(a) *Objectives of Integrated Environmental and Economic Accounting*

The focus of traditional systems of national accounts on market and some related non-market transactions (except for imputations for "directly competitive" non-market production of goods and services) has effectively excluded the accounting for changes in the quality of the natural environment and the depletion of natural resources. These effects have been considered to be particularly relevant for the assessment of long-term sustained growth and development and of increases in "social welfare." The overall objective of environmental accounting is thus to measure more accurately the structure, level and trends of socio-economic performance for purposes of environmentally sound and sustainable development planning and policies. The attainment of this objective would facilitate both the systematic compilation and analysis of environmental and related socio-economic data and the formulation of alternative standard macro-economic variables for the analysis of environmental-economic interrelationships.

The current revision of the SNA (United Nations, 1990) presents a unique opportunity to examine how the various concepts, definitions, classifications and tabulations of environmental and natural resource accounting can be linked to or incorporated in the SEEA. It may appear premature, however, to radically change a well-established system of economic accounts that serves many different short-, medium-, and long-term socio-economic analyses. Further elaboration of the standards of environmental and natural resource accounting in a *SNA satellite system* of environmental accounts has therefore been proposed (Bartelmus, 1987). A similar view was expressed by the experts working on the current revision of the SNA (Lutz and El Serafy, 1989).

Satellite systems of national accounts generally stress the need to expand the analytic capacity of national accounting for selected areas of social concern in a flexible manner, without overburdening or disrupting the "core" system (Lemaire, 1987; Teillet, 1988; Schäfer and Stahmer, 1990). Typically, satellite accounts allow for the:

—provision of additional information on particular social concerns of a functional or cross-sectoral nature,
—linkage of physical data sources and analysis to the monetary accounting system,
—extended coverage of costs and benefits of human activities, and
—further analysis of data by means of relevant indicators and aggregates.

Accordingly, the following specific objectives can be formulated for the planned SEEA:

(i) Segregation and Elaboration of All Environment-Related Flows and Stocks of Assets of Traditional Accounts

Satellite accounts, in the narrow sense of detailed accounting for expenditures and revenues in major areas of social concern, were pioneered by France (Institute National, 1986a). There is now an increased interest in segregating all flows and stocks of assets in national accounts related to environmental issues and, in

particular, in estimating the total expenditure for the protection or enhancement of the different fields of environment. One objective of this segregation is the identification of the increasing part of the Gross Domestic Product (GDP) which reflects the costs necessary to compensate the negative impacts of economic growth ("defensive expenditures") rather than increases in "true" (welfare-relevant) income (Hueting, Leipert, 1987; Leipert, 1989; and Olson, 1977).

(ii) Linkage of Physical Resource Accounting with Monetary Environmental Accounting and Balance Sheets

Physical resource accounts aim at covering comprehensively the total stock or reserves of natural resources and changes therein, even if these resources are not (yet) affected by the economic system.[1] The proposed accounting for these resources is considered the "hinge" by which comprehensive physical resource accounts could be linked to the monetary balance sheet and flow accounts. Another important method for analyzing the environmental-economic interrelationship in physical terms is the development of material/energy balances (Ayres, Kneese, 1969; Ayres, 1978; United Nations, 1976). This approach allows in particular the linkage of input-output tables with data on natural resource inputs, the description of the transformation of natural resources in the production process and the assessment of the generation of residuals of the economic activities (Isard, 1969; Leontief, 1973). Systems of environmental statistics such as those proposed by the United Nations (in preparation) should facilitate achieving compatibility between physical and monetary accounts by specifying those parameters that could be valued in monetary terms to obtain the figures required in environmental accounts. Non-monetary data in physical accounts are considered to be an integral part of the SEEA and will be fully elaborated in the Handbook on Integrated Environmental and Economic Accounting. However, the present framework will concentrate on the monetary stocks and flows of an environmental accounting system.

(iii) Assessment of Environmental Costs and Benefits

In contrast to the above-mentioned "narrow" satellite accounts, a broader framework for satellite accounting, covering additional "external" environmental costs and benefits, is proposed here. Taking the current state of knowledge and data availability into account, this framework focuses on expanding and complementing the SNA, with regard to two major issues, namely

—the use (depletion) of natural resources in production and final demand and
—the changes in environmental quality resulting from pollution and other impacts of production, consumption and natural events on one hand and environmental protection and enhancement on the other.

Possibilities of extending the framework for the analysis of environmental welfare effects, i.e. the "damage costs" of human health impairment, recreation and other aesthetic or ethical values, are also indicated.

[1]See e.g. the Norwegian approach to natural resource accounting (Alfsen, Bye and Lorentsen, 1987) or the more complex (including interactions in the biophysical environment) French "natural patrimony" accounts (Institute National, 1986).

(iv) Accounting for the Maintenance of Tangible Wealth

The recent discussion of the new paradigm of sustainable development stressed the need to fully account for the use of both man-made and "natural" capital in order to alert to possible non-sustainable growth and development scenarios. The proposed framework aims at extending the concept of capital to cover not only man-made capital, but also natural capital. Accordingly, SEEA will include additional costs for the depletion and degradation of these natural assets. It will also extend the concept of capital formation to capital accumulation which reflects additionally the deterioration of natural capital as a result of economic uses.

(v) Elaboration and Measurement of Indicators of Environmentally Adjusted Income and Product

The consideration of the depletion of natural resources and changes in environmental quality permits the calculation of modified macro-economic aggregates, notably the Environmentally Adjusted Net Domestic Product, short: Eco Domestic Product (EDP).

All these objectives can only be realized step by step. Initial emphasis in practical work should be on the improvement of physical environmental data and on linking them with national accounts as a prerequisite for the valuation of environmental effects.

(b) *Scope and Structure of the SEEA*

The proposed SEEA follows as far as possible the principles and rules established in the SNA (United Nations 1968, 1977, 1990). It is based on SNA's production boundary, follows its analysis of costs and outputs and incorporates the same accounting identities between supply and use of products and between value added and final demand. Information needed for environmental analysis is presented separately. In this manner, original (unadjusted) SNA data can be directly compared with environmentally adjusted statistics and indicators, facilitating the linkage with the central framework of the SNA. Such compliance and linkage with SNA aims at better integration of environmental variables into established economic analysis.

The very nature of a framework allows only the most important concepts and accounting procedures to be highlighted. Definitions, classifications, valuation principles, data sources and processing will be further elaborated on in the Handbook on Integrated Environmental and Economic Accounting. The Handbook will benefit from the experience gained in country studies and existing expertise at the national and international levels.

The present framework seeks to be flexible regarding alternative approaches to integrated environmental-economic accounting and analysis. The interrelationship between the environment and the economy is described as complete as possible. However, in line with the production boundary of SNA, phenomena that take place wholly within the environment, i.e. outside the economic system, are excluded. Such phenomena are probably better accounted for by the use of complementary biophysical resource accounts and systems of environment statis-

tics and monitoring. Also, welfare effects from environmental quality degradation that affect "human capital," i.e. human health and welfare, are not accounted for in the present framework. However, as shown below (see section 6), a "window" to the analysis of environmental damage related to human welfare has been opened, facilitating further extension or alteration of the framework for such analysis.

The main emphasis of the proposed scheme is on the implications of the environment for production, value added, final and intermediate demand and tangible wealth. Therefore, the framework does not present complete accounts for all institutional sectors. Transactions related to income distribution and those concerning intangible assets, including exploitation rights, and also financial assets are excluded. A complete analysis of the interrelationships between the economy and the environment will call for an extended system of all institutional accounts, which shows not only the flows of goods and services, but also of income and finance.

In Table 1 the general structure of the system which consists of three basic components is illustrated. In Tables 1.1 and 1.2 the supply and use of goods and services is shown. The asset accounts with opening and closing assets and the items linking them are shown in Table 1.3. Tables 1.2 and 1.3 are connected via the accounts of capital accumulation. The component tables are further elaborated on in Tables 2, 3 and 5 as explained in sections 3 to 5.

The supply Table 1.1 contains an additional row which shows the involuntary "imports" of residuals (wastes etc.) of foreign economic activities which were transported to the domestic economy (−1.6). The use/value added Table 1.2 is extended by row as well as by column. In the table, we show not only the traditional GDP and NDP, but also further corrections due to the use of natural assets (depletion of natural resources, degradation of natural assets by residuals, agricultural and recreational use etc.). This use is valued with the costs which would have been necessary to keep the natural capital intact (ecological valuation; see below section 4c for an alternative approach in the case of "exhaustible" resources). These costs are interpreted as the decrease in value of the natural assets comparable to the consumption of man-made fixed assets. The deterioration of the natural assets could be caused by current production activities (59.8), consumption activities (household consumption 17.1) or by (scraps of) produced assets (5.1). The restoration activities of the government diminish the impacts of the economic activities on the natural assets (−5.0). The use of natural assets could affect the domestic nature (loss of ecological functions of the produced biological assets −0.9, natural non-produced assets −73.0) or—as far as the generation of residuals is concerned—could lead to transportation to the rest of the world (exports: −4.7). The value of the deterioration of the domestic as well as foreign natural assets caused by domestic sources (59.8 + 22.2 = 82.0) is used for estimating the environmentally adjusted Net Domestic Product (NDP), called Eco Domestic Product (EDP) (185.1) (see section 4c below).

The asset accounts (Table 1.3) show the produced assets (including cultivated biological assets) and the non-produced assets which contain only natural assets (wild biota, land, subsoil assets, water and air). Market valuation is applied except for the depletion and degradation values of natural assets shown in the

use/value added table (Table 1.2). These volume changes are valued with the (hypothetical) costs for maintaining them on the same overall quantity and quality level during the reporting period. The question of how such values could be integrated into the asset balances containing mainly market values is discussed in section 5.

3. Supply of Goods and Services

The supply table (Table 2) includes two elements: gross output, resulting from domestic production, and imports. Gross output is cross-classified by industries and type of product (good or service). Imports are classified by the same type of product as domestic gross output, so that the two elements of supply can be added together to obtain total supply by product. Furthermore, the involuntary "imports" of residuals of foreign economic activities are shown. This item could contain e.g. the unaccepted dumping of foreign wastes in national territories.

In Table 2 we show a breakdown of domestic production activities by environmental protection activities and other industries. The fully elaborated system will display a further breakdown by industries according to the International Standard Industrial Classification of all Economic Activities (ISIC) (United Nations, 1990a).

A major modification of the SNA is the separate identification of *environmental protection services* from other production activities for all industries. The separation is to facilitate the assessment of the importance of environmental activities in gross output, employment, other production costs, and in capital consumption. Environmental protection services comprise in principle all activities to maintain and enhance the quality of the natural assets. This could be achieved by avoiding environmental impacts of the economic activities (e.g. by using integrated or end-of-pipe technologies) or by restoring the natural environment already degraded or depleted. Environmental protection activities can be produced for third parties (external use) as main or secondary production activities of the establishments (36.2) or they can be used internally. The internal provision of environmental protection services is considered to be an "ancillary" activity which is not shown as separate output of the respective establishments in Table 2. The cost value of ancillary services is identified separately, however, in Table 3 as the total of intermediate consumption (17.9), consumption of fixed capital (4.8), compensation of employees (8.7) and net indirect taxes (0.3). These costs are balanced by a negative operating surplus (−31.7). It is not proposed to "externalize" the internal environmental protection activities within the SEEA in order to maintain close linkage with the SNA. For more comprehensive analyses of environmental expenditures and operations, ancillary activities could be externalized in supplementary tables.

The supply of products is disaggregated in Table 2 according to the three categories of natural growth products, external environmental protection services and other products only. A further breakdown of these categories needs to be developed, as far as possible in terms of the Central Product Classification (CPC) (United Nations, in prep.).

TABLE 1

SYSTEM FOR INTEGRATED ENVIRONMENTAL AND ECONOMIC ACCOUNTING (SEEA)
(Summary presentation)

					Tangible assets (Table 1.3)				
					Produced				
					Except Natural	Natural (biota)	Non-Produced Natural Assets		
Opening Stocks (Market Valuation)					991.3	83.1	1744.4		
					+(plus)				
					Capital Accumulation				
					Produced Assets			Rest of the World	
Use/Value added (Table 1.2)	Total	Domestic Production (Industries)	Final Consumption		Except Natural	Natural (biota)	Non-Produced Natural Assets	Exports/ Imports	Flow of Residuals
			Households	Government					
Use of products	591.9	224.0	175.0	42.5	68.0	1.4	7.3	73.7	
Gross Domestic Product (GDP)		293.4							

Consumption of fixed capital		26.3			−23.0	−3.3			
Net Domestic Product (NDP)		267.1							
Use of natural assets (ecological valuation)	−1.6	59.8	17.1	−5.0	5.1	−0.9	−73.0		−4.7
Environmental adjustment of final demand		22.2	−17.1		−5.1				
Environmentally Adjusted Net Domestic Product (EDP)		185.1							
						+(plus)			
Supply/Origin (Table 1.1)									
Supply of products	591.9	517.4						74.5	
Origin of residuals	−1.6								−1.6

	+(plus)		
Adjustment of natural assets accumulation to market valuation		0.9	81.2
Other volume changes (market valuation)	−25.3		22.8
Revaluation due to market price changes	138.1	12.6	382.8
	=(equals)		
Closing Stocks (Market Valuation)	1149.1	93.8	2165.5

TABLE 2

SUPPLY/ORIGIN

	Total	Domestic Production (industries)			Imports	
			Other industries			
		External Environmental Protection Activities	Internal Environmental Protection Activities	Other Activities	Products	Residuals
(1) Supply of products (goods and services)	591.9	36.2		481.2	74.5	
(1.1) Natural growth products	40.7			38.2	2.5	
(1.2) External env. prot. services	36.2	36.2				
(1.3) Other products	515.0			443.0	72.0	
(2) Origin of residuals	−1.6					−1.6
∑ Total supply [(1)+(2)]	590.3	36.2		481.2	74.5	−1.6

Natural growth products of agriculture, forestry and fishing (40.7) refer to those growth-based outputs that are controlled by human activities and can thus be considered as part of planned economic production. Natural growth in these products is treated as primary production which increases the stocks or fixed assets by the amount of growth taking place during the accounting period. On the other hand, those primary natural growth-based products that are largely harvested from the non-controlled natural environment (without human interference in the growth process, such as hunting, gathering of wild fruits, deep-sea fishing or the exploitation of tropical forests) are considered as either "free" inputs or, in case of "scarcities," as environmental depletion costs (see below, section 4) of the agriculture, forestry and fishing sectors. For example, in the case of free supply of fish to the fishing industry, the sector's output would not consist of live fish, but rather of fish landed and sold in the market-place.

4. Use and Value Added

The use/value added table (Table 3) shows the use of products and (man-made as well as natural) assets as inputs of the domestic production activities or as components of final demand (final consumption, capital accumulation, exports). These data are supplemented with information on the value added of the different production activities. The use table is an instrument to distribute the total supply of goods and services from the supply table to its various destinations. However, the supply of environmental assets is not displayed in the supply table, but is shown as negative entries in the natural non-produced assets column of capital accumulation. In comparison to the traditional framework of the SNA, the use of natural assets is shown in additional rows and the capital accumulation of non-produced natural assets in an additional column.

(a) *Use of Goods and Services*

The first block of rows in Table 3 presents the use of products (goods and services) by intermediate consumption of economic activities and final demand, as supplied from Table 2 (591.9). This corresponds to the traditional use table in the SNA. The sum of the gross value added (293.4), the conventional Gross Domestic Product (GDP), is shown explicitly in Table 3. Subtracting the consumption of fixed capital obtains the Net Domestic Product (NDP) (267.1).

As indicated in section 3, the supply of natural growth products (40.7) stems from "controlled" production processes of agriculture, forestry and fishing only. These products are used as inputs into different economic activities (23.0), exported (5.0), consumed by private households (11.3), or may increase fixed capital or stocks (1.4). Stock increase results from the growth in products which are not used in the same period. Stock decrease is shown where naturally grown products of a former period are used for intermediate or final purposes. The increase of fixed capital on the other hand represents a growth in the remaining biomass that is not intended to be used up in intermediate or final consumption,

TABLE 3

USE VALUE ADDED

	Total	Domestic Production (industries)			
			Other Industries		
		External Environmental Protection Activities	Internal Environmental Protection Activities	Other Activities	Subtotal Domestic Production
(1) Use of products	591.9	15.9	17.9	190.2	224.0
(1.1) Natural growth products	40.7			23.0	23.0
(1.2) External envir. protection services	36.2			22.4	22.4
(1.3) Other products	515.0	15.9	17.9	144.8	178.6
Gross value added of industries [(9)-(1)]		20.3	−17.9	291.0	293.4
(2) Use of produced fixed assets (consumption of fixed capital)	0	1.3	4.8	20.2	26.3
Net value added of industries [(9)-(1)-(2)]		19.0	−22.7	270.8	267.1
(3) Use of natural assets (ecolog. valuation)	−1.6	6.3	4.6	48.9	59.8
(3.1) Quantitative depletion	0	0.3	0.4	16.8	17.5
(3.2) Degradation of land (except by residuals)	0	0.2		8.8	9.0
(3.3) Degradation by residuals	−1.6	5.8	4.2	23.3	33.3
$\sum$ Total use [(1)+(2)+(3)]	590.3	23.5	27.3	259.3	310.1
(4) Environmental adjustment of final demand		1.8	2.1	18.3	22.2
Env. adj. net value added (EDP) of industries [(9)−(1)−(2)−(3)−(4) or (5)+(6)+(7)+(8)]		10.9	−29.4	203.6	185.1
(5) Compensation of employees		13.0	8.7	72.0	93.7
(6) Indirect taxes minus subsidies		2.0	0.3	34.1	36.4
(7) Net operating surplus		4.0	−31.7	164.7	137.0
(8) Eco-margin [−(3)−(4)]		−8.1	−6.7	−67.2	−82.0
(9) Total gross inputs/total total final demand [(1)+(2)+(3)+(4)+(5)+(6)+(7)+(8)]		36.2		481.2	517.4

Final Demand							
Final Consumption		Net Capital Accumulation			Exports		
		Produced Assets					
Households	Government	Except Natural	Natural (biota)	Non-Produced Assets	Products	Residuals	Sub-total Final Demand
175.0	42.5	68.0	1.4	7.3	73.7		367.9
11.3			1.4		5.0		17.7
8.8	5.0						13.8
154.9	37.5	68.0		7.3	68.7		336.4
		−23.0	−3.3				−26.3
17.1	−5.0	5.1	−0.9	−73.0		−4.7	−61.4
0.7			−0.9	−17.3			−17.5
0.8				−9.8			−9.0
15.6	−5.0	5.1		−45.9		−4.7	−34.9
192.1	37.5	50.1	−2.8	−65.7	73.7	−4.7	280.2
−17.1		−5.1					−22.2
175.0	37.5	45.0	−2.8	−65.7	73.7	−4.7	258.0

such as the trunks and branches of fruit trees or the breeding stock of livestock.[2]

External environmental protection services (36.2) are used for avoiding potential or restoring actual decreases in environmental quality. It is assumed in the numerical example that the environmental protection services of the government which are not sold on the market (government consumption: 5.0) are restoration activities whereas the other environmental protection activities (31.2) are avoidance activities and are bought by industries (22.4) and households (8.8). Environmental protection activities of the government for avoiding environmental degradation caused by its own production are assumed to be part of the internal environmental protection activities. Government environmental protection services services sold in the market are assumed to be intermediate consumption of industries or household consumption.

The other products (515.0) are used for intermediate consumption (178.6), final consumption (192.4), capital accumulation (75.3) and exports (68.7).

(b) *Use of Natural Assets*

Integrated environmental-economic accounting in the present framework focuses on the inclusion of costs, resulting from the quantitative depletion of natural resources and from the qualitative degradation of environmental quality by economic activities.

Depletion activities (at a total of 18.2) are shown in Table 3 to consist of depletion of natural assets by industries (17.5) and by households (0.7). As detailed in Table 5, they comprise the exploitation of natural resources such as sub-soil assets (mineral deposits) by mining and quarrying (−8.9), aquifers (−4.7) and biological assets (e.g. timber from tropical forests or fish stocks of inland and marine waters) by agriculture, forestry and fishing (−0.9, −3.7). The assumption is that scarcities in the availability of renewable (forest, fish, wildlife etc.) and cyclical (water) resources have been observed. Depletion costs are only estimated in these cases as far as the economic use of natural assets leads to imbalances in nature, i.e. if the depletion of biota exceeds the natural growth or the use of water exceeds replenishment of aquifers. The recording of corresponding negative amounts of tangible wealth reduction is discussed below in section 4d.

The other category of economic use of natural assets represents the environmental quality degradation of the environmental media of air, water and land by production and consumption activities. The degradation of land could be caused by improper agricultural practice (soil erosion, water logging, salinization), by excessive use for recreational purposes or by polluting the soil with wastes or waste-water. The main reason for degrading the quality of air and water is their use as a sink for residuals (wastes, pollutants) of economic activities. It has to be stressed that only the immediate influence on the environmental media is taken into account. The indirect effects by transboundary transport in the air or by transition from one environmental medium to another are not recorded in

[2]This treatment of natural growth processes in agriculture, forestry and fishing differs from the 1968 SNA recommendations, but may be adopted in the revised SNA.

the SEEA. These complex dynamics within the natural environment could be shown in supplementary data systems which should be linked with the SEEA. Furthermore, it should be noted that impacts of natural or man-made disasters are assumed not (or in some cases only indirectly) to be caused by economic use of environmental assets and are therefore excluded from the use/value added Table 3 but are included as a category (4) of asset volume changes in Table 5.

The net value of *degradation* is assumed to be equal to potential abatement (restoration) costs, required either to achieve the level of environmental quality at the beginning of the accounting period or at least a level specified by "official" environmental standards (Hueting, 1980). It is assumed that such standards reflect a technological solution to abating environmental quality degradation that can "reasonably" be expected to be applied by the different polluters. Obviously, such valuation does not measure actual environmental "damage" from pollution. A possible treatment of such welfare effects is discussed in section 5.

The environmental degradation is caused by production activities (9.0 plus 33.3), by consumption activities of households (0.8 plus 15.6), by man-made assets (5.1) and by imported residuals (1.6). Man-made assets have an effect on the natural environment by their residuals (e.g. scrapped machinery). A part of the environmental degradation is restored by government activities (−5.0). The remaining degrading impacts affect the domestic natural assets (−9.8, −45.9) and—as far as residuals are "exported"—the natural environment of the rest of the world (−4.7).

In Table 4, the value of the economic use (depletion as well as degradation) of domestic and non-domestic (foreign) natural assets and the corresponding impacts on the asset values are shown in a simplified balance sheet.

TABLE 4

ECONOMIC USE AND IMPACTS ON NATURAL ASSETS

Use of Natural Assets (environmental costs)		Impacts on Natural Assets (decrease of asset values)	
Domestic use		**Domestic environment**	
Depletion		Depletion	
industries	17.5	prod. natural assets	0.9
households	0.7	non-prod. natural assets	17.3
	18.2		18.2
Degradation		Degradation	
industries	42.3	non-prod. natural assets	55.7
households	16.4		
government	−5.0		
prod. assets	5.1		
Imports		**Environment of the rest of the world**	
Degradation	1.6	Degradation	4.7
	60.4		60.4
	78.6		78.6

(c) *Environmental Adjustments of the Value Added*

Deducting the imputed costs of natural asset use (environmental costs) from net value added leads to a new value-added concept, termed here "environmentally adjusted net value added." The environmental costs represent the hypothetical costs for maintaining the natural assets at the same level during the reporting period. This concept reflects a "strong" or "narrow" sustainability concept which implies that future generations should receive a natural environment with a quantitative and qualitative level being at least comparable with the present situation (Bartelmus, in preparation; Blades, 1989; Daly, in preparation; Pearce, Markandya, Barbier, 1989 and 1990; and Pezzey, 1989). The international discussion of the last years has proved that it is not sufficient to sustain a constant level of total (man-made as well as natural) capital, denying substitution possibilities between these capital categories ("broad" or "weak" sustainability concept). The uncertainty of long-term impacts of economic activities on the natural environment and the increasing knowledge about irreversible damages of natural balances (climate change, ozone layer depletion etc.) has led to a more cautious risk-conscious attitude towards overburdening the natural environment. From this point of view, it seems necessary to maintain the natural assets treating them as complementary to man-made capital. The strong sustainability concept thus applies not only to the case of environmental quality degradation, but also to the maintenance of "stocks" of natural resources. In the case of subsoil assets, this approach seem to be questionable because the strong sustainability concept would lead to non-use of the resources, possibly causing severe world-wide economic problems. Instead, the objective could be to maintain a long-term optimal depletion rate, considering that new finds could only retard the shrinkage of the stocks. It has been proposed that the sustainability concept should be weaker in this case, and it would be sufficient to balance a decrease of the subsoil assets with an increase of other types of assets (with preference for permanent or renewable natural assets) to sustain the same income level in the future (El Serafy, 1989; Daly, in preparation).

The maintenance cost approach used for valuing the economic use of natural assets corresponds to the methods of national accounting for estimating the use of man-made fixed assets. The user costs of these assets are estimated with the costs necessary to keep the man-made fixed capital intact, i.e. to maintain the level of the assets at the same level during the reporting period. These costs which are called "consumption of fixed capital" or "depreciation" are also used to compile the net capital formation of the man-made assets in the accounting period.

As far as the natural assets have the character of *fixed assets*, treating the maintenance costs of natural assets in the same way as the depreciation of man-made assets seems plausible. However, distinguishing between assets that bear characteristics of fixed assets and those that are more in the nature of an *inventory* or *stock* (in this case, decrease of assets in the national accounts is booked as intermediate consumption and not as depreciation) is problematic because natural assets may exhibit simultaneously economic and environmental functions (Hueting, 1980). For instance, a timber tract represents a stock resource, but has also an important role in cleaning the air and regulating water balances.

Furthermore, it serves as habitat of animals and as recreational area. From an ecological point of view, the environmental media, i.e. land, water and air as well as the ecosystems can be considered as fixed assets. The maintenance costs of these assets should therefore be treated as depreciation. Further discussion seems to be necessary in the case of subsoil assets. They mainly have the character of inventory stocks of nature. Their depletion could therefore be treated as intermediate consumption.[3] For sake of simplicity of the present framework, the value of the depletion of these assets is not shown separately from the other environmental costs, but is also treated as decrease of a fixed asset.

Whatever the treatment of the environmental costs, as depreciation of natural assets or as intermediate consumption, their deduction from gross output affects the calculation of net value added. The gross value added of the industries remains unchanged in the SEEA. The environmental adjustments of the net value added (−82.0) comprise the imputed environmental costs connected with domestic production (−59.8), household consumption activities (−17.1) and the use of man-made assets (−5.1). These adjustments are called eco-margin which is introduced explicitly in order to permit the identification of all components of value added (including operating surplus) according to the conventional SNA concepts.

Impacts of household activities and of man-made *assets* on environmental quality are taken into account for correcting the net value added despite the fact that the respective environmental costs are not directly associated with production activities. Regarding households, their polluting activities could be viewed as non-market production of goods and services which produces "jointly" residuals like wastes and pollutants. In this case, the net value added of the households' production would be diminished by the imputed environmental costs of the households. This is achieved by shifting these imputed values (17.1) from final consumption to the totals of domestic production. A similar correction is made with regard to the environmental impacts of man-made assets, comprising additional imputed costs of the asset owners (5.1). These costs refer e.g. to pollution caused by controlled landfill and to the residues of unrecycled man-made assets. It is theoretically possible to transfer these costs to the different industries. In this case, their net value added would directly be affected. This procedure has not been applied in the SEEA in order to show separately the environmental costs caused by current production and man-made capital use. The shift of the environmental costs of households and man-made assets to the columns of domestic production is shown in Table 3 in the row "environmental adjustments of final demand." Net value added is thus corrected only for the totals of environmental protection activities (1.8 and 2.1) and of other activities (18.3).

In Table 3 we also record the components of value added, consisting of the compensation of employees, indirect taxes net of subsidies, net operating surplus and environmental costs equal to item (8) "eco-margin." Use of SEEA thus permits the analysis of these components of value added for the environmental

[3]See El Serafy (1989). However, the total depreciation approach is advocated by Harrison (1989) and Repetto (1989).

protection activities of the different economic sectors. Indirect taxes and subsidies, charged or granted as part of environmental protection policies, will be identified separately in the SEEA, reflecting the application of polluter- and user-pays-principles at the micro-economic level. Macro-policy makers on the other hand, might be concerned with the assessment of employment devoted to "defensive" environmental protection activities (total "environmental" renumeration of employees of 21.7 as compared to a total of other wages and salaries of 72.0).

The net operating surplus of the different production activities has not been environmentally adjusted in Table 3. The additional environmental costs are balanced by introducing the eco-margin. The idea is to facilitate the unequivocal linkage of the production accounts of the SEEA with the income accounts of the conventional SNA. Another possible presentation of the operating surplus could show an environmentally adjusted net operating surplus, but extend the table at the same time for identifying explicitly the non-adjusted gross and net operating surplus:

Environmentally adjusted net operating surplus	55.0
= Gross operating surplus	163.3
− Consumption of fixed capital	26.3
− Eco-margin	82.0

The total of the environmentally adjusted net value added is called Environmentally Adjusted Net Domestic Product or, short, Eco Domestic Product (EDP). EDP could be derived from GDP as follows:

Gross Domestic product (GDP)	293.4
− Consumption of fixed capital	26.3
= Net Domestic Product (NDP)	267.1
− (Imputed) environmental costs	82.0
= Eco Domestic Product (EDP)	185.1

(d) *Final Demand*

Final demand consists of final consumption, net capital accumulation and exports. Import and export flows are only slightly modified for environmental accounting. However, significant alterations are proposed for both final consumption and net capital accumulation to allow corrections of net value added while heeding the principle of accounting identities (see below, section 4e).

Imports and exports include flows of wastes which are not marketed, but transported to/from a foreign country or to the open sea. They represent either a degradation of the foreign natural media by exporting domestic residuals or of domestic media by importing residuals. They are estimated as negative values—costs for avoiding or restoring environmental quality degradation (exports: −4.7, imports: −1.6). The imports of residuals reduce the total value of imports and of the domestic natural assets (negative item in the column of net accumulation

of natural assets). The exports of residuals lead to an increase of the imputed environmental costs of the exporting industry which implies a reduced environmentally adjusted net value added of the exporting economic units and a reduction of the total value of the exports. Transboundary flows of residuals of the economic activities which are not transported by man but by environmental media (e.g. water, air), are recorded as degradation of the environmental media which directly receive the residuals. Their final destination is not taken into account.

The conventional final consumption of households (175.0) remains unchanged in the SEEA. The additional (imputed) environmental costs (17.1) which would have been necessary to avoid or which need to be incurred in order to restore a degradation of environmental quality by household activities (recreational use of land 0.8, pollution 15.6), or which represent the costs of depleting natural resources (firewood consumption 0.7) are shifted to domestic production.

The fully elaborated SEEA will comprise a further breakdown of the final consumption of households by environmentally oriented functions for identifying e.g. the environmental protection expenditures of the households and the expenditures required to compensate for the damages caused by environmental deterioration (health expenditures etc.).

Final *consumption of government* (42.5) is corrected by the environmental protection expenditures (−5.0) which are non-marketed and which are undertaken to avoid or restore a decrease of environmental quality caused by other economic units. These expenditures have the characteristics of an investment in environmental quality. Its value is shifted from the government final consumption to the capital accumulation of natural assets and diminishes the degradation of the natural assets which would have occurred if no restoration activities had taken place. The environmental protection activities of the government for own purposes (internal activities) and the additional (imputed) environmental costs of the government production activities are already recorded in the columns of domestic production. It is therefore not necessary to extend the concept of final consumption of government in the SEEA by taking into account imputed environmental costs.

The section on the *net accumulation of tangible wealth* in Table 3 differs considerably from the traditional incorporation of capital formation in a use table. The presentation of this part of final demand in Table 3 is limited to an asset classification by only three types of asset: produced biological (natural) assets, other produced assets, non-produced natural assets. A further breakdown of the capital accumulation is given in Table 5 which shows complete asset balances for the different types of assets. The following comments refer especially to the disaggregated version in Table 5. The capital accumulation concept of Table 3 corresponds to the (traditional) capital formation (item 2 of Table 5) and to the ecological valuation of volume changes of natural assets due to economic use (item 3.1 of Table 5). The valuation problem (market versus ecological valuation) and the other items of Table 5 are discussed in section 5.

In the SEEA, the asset boundary has been extended for including all natural assets which are actually or potentially used by economic activities or which could be affected by the residuals of economic production and consumption

TABLE 5

ASSET BALANCES OF NET TANGIBLE ASSETS

Monetary units

	Total	Produced Assets		Non-produced Natural Assets					
		Produced Assets (except biological)	Produced Biological Assets	Non-produced Biological Assets	Land (landscape, ecosystems)		Sub-soil Assets	Water	Air
					Cultivated etc.	Uncultivated			
(1) Opening stocks (market values)	2818.8	991.3	83.1	65.4	1366.7	50.4	261.9		
(2) Net capital formation (use of products, market values)	50.4	45.0	−1.9		4.6		2.7		
(2.1) Gross capital formation	76.7	68.0	1.4		4.6		2.7		
(2.2) Consumption of fixed capital	−26.3	−23.0	−3.3						
(3) Volume change of natural assets due to economic use (market values)	36.0			−2.1	23.3	−5.0	19.8	0.0	0.0
(3.1) Ecological valuation									
(3.1.1) *Quantitative depletion*	−18.2		−0.9	−3.7			−8.9	−4.7	
(3.1.2) *Degradation of land (except by residuals)*	−9.8			−7.7	−2.1				
(3.1.3) *Degradation by residuals*	−45.9				−9.5	−3.1		−12.9	−20.4

(3.2) Adjustment due to market valuation									
(3.2.1) *Quantitative depletion*	8.1		0.9	1.6			0.9	4.7	
(3.2.2) *Land use (except by residuals)*	35.2				33.1	2.1			
(3.2.3) *Degradation by residuals*	38.8				4.0	1.5		12.9	20.4
(3.3) Other volume changes (change of land use, new finds, new estimates etc.)	27.8				3.4	−3.4	27.8		
(4) Volume change by natural or multiple causes (market values)	−30.3	−25.3		1.3	−4.3	−2.0			
(5) Revaluation due to market price changes	533.5	138.1	12.6	11.1	331.0	11.8	28.9		
(6) Closing stocks (market values) [(1)+(2)+(3)+(4)+(5)]	3408.4	1149.1	93.8	75.7	1721.3	55.2	313.3		

processes. The extended asset concept comprises the following types of assets:

Produced assets
- Man-made assets (non-biological such as machinery and equipment, stocks of non-biological products)
- Natural assets produced by agriculture, forestry and fishing (fixed assets and inventory stocks)

Non-produced natural wild assets
- Wild biological assets
- Land (cultivated and uncultivated)
- Subsoil assets (developed and undeveloped proven reserves)
- Water (stored and unstored)
- Air

This classification distinguishes in particular between assets which are (economically) produced or not and which are man-made or natural. These two criteria are not identical because the (economically) produced biota are both produced and natural. In this case, the produced biota should only be subsumed under natural assets as far as they are living. A further breakdown is possible according to the degree of human influence on the natural environment (e.g. cultivated-uncultivated land, developed-undeveloped subsoil assets).

In Table 3, the net capital accumulation of *produced assets* is recorded mainly according to the conventional concepts of the SNA (gross capital formation: 68.0 and 1.4, consumption of fixed capital: −23.0 and −3.3). Only two minor deviations should be mentioned: The residuals of the produced assets which are loaded on the natural environment (e.g. scraps, pollution of controlled landfill) are valued with their avoidance costs (5.1) and shown in addition to the net capital formation. In a second step, these imputed costs are shifted to the industries of the responsible activities or, alternatively, to the industries as a whole [via the environmental adjustment row (4)]. In the case of produced biological assets, it might be necessary to estimate additional depletion costs (−0.9) if the economic activities of agriculture, forestry and fishing disturb the natural balances, e.g. if the amount of cut wood exceeds the natural growth and destroys the ecosystems of cultivated forests. In this case, the sustainability principle should be applied, and avoidance or restoration costs could be calculated.

The imputed depletion costs of *wild biota* (in Table 5: −3.7) are estimated only if depletion by economic activities (e.g. hunting, ocean fishing) and natural growth are not balanced. Depletion costs are thus estimated if depletion exceeds natural growth. The discussion of valuation of net depletion in this case has not been conclusive. One possible approach could be to value net depletion as the gross value added generated by the depleting activity. This would show value added foregone if the net depletion had been avoided. Another approach could be to assess the costs for compensating projects to restore the natural balances.

Net capital accumulation of *land* refers to the impacts of economic land use. The costs of developing land are treated in the conventional SNA as capital formation which normally leads—from an economic point of view—to an improvement of land quality and to increasing market values (in Table 5: 4.6).

From an ecological point of view, increasing economic use of land could cause a qualitative degradation of the land and the terrestrial ecosystems. The main reasons are restructuring (further economic development of cultivated land, cultivation of uncultivated land), intensive agricultural use (soil erosion etc.), recreational use (disturbing ecosystems) and use as a sink for residuals (such as pesticides and the pollution of controlled and uncontrolled landfill). In Table 5 degradation by residuals (−9.5 and −3.1) and by other economic activities (−7.7 and −2.1) are distinguished.

The degradation of land is valued as the cost to avoid (or at least mitigate) the negative impacts of economic activities or to restore the degraded areas, with a view to maintaining the terrestrial ecosystems in their present state. This valuation concept might differ widely from the market valuation. Changes in economic land use will often increase the market value of land, but at the same time could imply a decrease of the ecological quality of land.

Subsoil assets comprise the proven reserves of fossil and mineral assets. Proven reserves normally have to meet three criteria: high probability of existence (95 percent), exploitability with existing techniques and positive net return, i.e. the market price exceeds exploitation costs (Martinez *et al.*, 1987). Subsoil assets can be undeveloped or developed (established mines and other exploration facilities). The costs for developing subsoil assets (e.g. by exploration activities) have to be treated according to the conventional SNA as capital formation (Table 5: 2.7). The valuation of the depletion of subsoil assets has to reflect the future scarcity of the assets. Exploitation is mainly an economic and not an ecological problem because the immediate impacts on natural balances are usually low, with the notable exception of surface mining. The indirect impacts of subsoil depletion (e.g. losses of crude oil during transportation, pollution connected with energy consumption) are registered independently from the valuation of assets as environmental degradation from polluting economic activities.

Various methods have been proposed to value subsoil asset depletion (see Ward, 1982). Several authors suggest the use of the net operating surplus of the exploiting industry or a part of it. The proposal of El Serafy (1989) seems to be an approach tailored to the concept of sustainability. The idea is to estimate the depletion costs as the amount of money which should be invested to achieve a long-term constant flow of income, even after complete exploitation of the resources. This rule implies a substitution of the use of subsoil assets by other types of income generating activities and corresponds to a broad sustainability concept. The decrease of subsoil assets could be balanced, e.g. by increasing renewable (biological) assets or by the development of solar and wind energy sources instead of coal or crude oil. The value of subsoil depletion amounts to 8.9, in Table 5.

The economic use of *water* could lead to increasing scarcity (depletion) or to decreasing quality (degradation by residuals). Increasing scarcity of water will be observed if the economic abstraction exceeds the average natural inflow of water during the accounting period. In this case, net depletion could be valued as the value added, or part of it, generated by additional water use of the abstracting industries (−4.7). This value could represent the avoidance costs as in the case of wild biota. Further discussion is necessary to develop a generally

accepted valuation method for water depletion. The degradation of water by residuals is valued as its avoidance (or restoration) costs (−12.9).

As described above (section 4b), the value of the degradation of *air* is its avoidance costs (−20.4).

In section 5 below, we describe a comprehensive system of balance sheets of tangible assets, including changes in volume not accounted for by capital accumulation in the use/value added table (e.g. effects of natural and other disasters).

(e) *Accounting Identities*

The national accounting identities between the totals of environmentally adjusted value added (plus imports) and final demand are maintained in the use/value added Table 3 by treating capital accumulation of natural assets as part of final demand. In Table 6 we show the transition from the conventional aggregates, according to the SNA, to the environmentally adjusted aggregates of the SEEA by using the numerical example (cf. Tables 2 and 3).

TABLE 6

ACCOUNTING IDENTITIES

Primary Inputs (value added, imports)		Final Demand (domestic, exports)	
Gross value added (Gross domestic product)	293.4	Domestic final demand (SNA concept)	294.2
− Use of produced assets (consumption of fixed capital)	26.3	− Consumption of fixed capital	26.3
− Use of natural assets for current production	59.8	− Government restoration costs	5.0
Environmental adjustment of final demand	22.2	+ Net capital accumulation of natural assets (−78.9+5.0)	−73.9
Environmentally adjusted net value added (Environmentally adjusted Net Domestic Product)	185.1	Environmentally adjusted domestic final demand	189.0
+ Import of products	74.5	+ Export of products	73.7
+ Import of residuals	−1.6	+ Export of residuals	−4.7
Environmentally adjusted primary inputs	258.0	Environmentally adjusted final demand	258.0

As already explained, the gross value added (293.4) is corrected by the consumption of fixed produced capital (26.3) and by the user costs of natural assets (current production 59.8, households 17.1, residuals of man-made assets 5.1). This obtains the environmentally adjusted net value added (185.1). The concept of imports is extended to additionally include imports of residuals (74.5 and −1.6). The total of the environmentally adjusted primary inputs (value added plus imports) is 258.0.

Domestic final demand (294.2) is corrected by the consumption of fixed produced assets (26.3) to achieve a net concept. The environmental restoration costs of the government (5.0) are treated as an increase of the value of natural assets and therefore reflected in the capital accumulation of natural assets. The value of depletion and degradation of natural assets by economic activities would have been −78.9 without government restoration activities. Taking these activities into account, the net capital accumulation amounts to −73.9 (−73.0 plus −0.9). The environmentally adjusted figures of total final demand (258.0) comprise the adjusted domestic final demand (189.0) and the export of products (73.7) and residuals (−4.7). This total is equal to the total of primary inputs.

5. Asset Balances of Tangible Wealth

As illustrated in Table 1, the section of the use/value added table on tangible wealth accumulation can also be viewed as an integral part of the asset balances. This is indicated in Table 1 by plus (+) and equal (=) signs, inserted between the four elements of the asset balances. This illustration shows an accounting identity between the closing stocks and the sum of opening stocks, net capital accumulation, adjustment of natural assets accumulation to market valuation, other volume changes and revaluation due to market price changes. This identity holds for man-made assets (produced, not natural):

$$1{,}149.1 = 991.3 + (68.0 - 23.0 + 5.1 - 5.1) + (-25.3 + 138.1),$$

for the (economically) produced natural assets:

$$93.8 = 83.1 + (1.4 - 3.3 - 0.9) + (0.9 + 12.6),$$

and for those non-produced natural assets which are used or affected by economic activities:

$$2{,}165.5 = 1{,}744.4 + (7.3 - 73.0) + (81.2 + 22.8 + 382.8).$$

The asset balance sheets are further elaborated on in Table 5. The asset classification has already been described in Section 4d. The volume and price changes of the assets during the reporting period are further disaggregated in Table 5, consisting of:

(2) Net capital formation (use of products);
(3) Volume change of natural assets due to economic use;
  (3.1) Ecological valuation,
  (3.2) Adjustment due to market valuation,
  (3.3) Other volume changes (market valuation),
(4) Volume change by natural or multiple causes;
(5) Revaluation due to market price changes.

The volume changes (2) and (3.1) reflect the net capital accumulation described in the use/value added table (Table 3 and Table 1.2), the adjustment due to market valuation (3.2) corresponds to the "adjustment of natural assets accumulation to market valuation" in Table 1.3. The other volume changes due to economic use (3.3) and the volume change by natural or multiple causes (4)

are summarized under "other volume changes" in Table 1.3. The revaluation due to market price changes is presented in both tables under the same name.

The design of the asset balance sheets aims at introducing environmental aspects in the national stock accounts without disrupting the concepts of the conventional SNA balance sheets. As recommended in the International Guidelines on Balance-Sheet and Reconciliation Accounts (United Nations, 1977) and in chapter XI of the preliminary draft of the revised SNA (United Nations, 1990), the *opening* and *closing stocks* are valued at market prices or have values derived from market prices. Direct market valuation could be applied if the assets are marketed (some produced fixed assets like cars, inventory stocks of products, land). Indirect market valuation uses the net value concept (replacement costs minus cumulated depreciation) or tries—in the case of depletable natural assets like wild biota, subsoil assets or water—to estimate the assets by the discounted value of future net returns (future market prices minus all exploitation costs including a normal rent of capital).[4] It should be stressed that the SEEA does not aim at a complete market valuation of the non-produced natural assets. The market valuation should be limited to natural assets which are regularly depleted for market purposes (e.g. ocean fish, tropical wood and subsoil assets) or to assets which are directly marketed (uncultivated land in exceptional cases). The opening and closing stocks of the other non-produced natural assets have a market value of zero. In these cases, their volume changes are valued only if they are affected by economic activities.

Market valuation has also been applied in general for the *volume* and *price changes* during the accounting period. Net capital formation of produced assets [item (2) in Table 5] reflects the volume changes described in the conventional SNA framework. Some of the other volume changes of assets caused by economic, natural, non-economic and multiple (combination of these causes) activities and events [items (3) and (4) in Table 5] which had been part of the reconciliation accounts in the 1968 version of the SNA, will be integrated into the accumulation accounts which explain the changes in the balance sheets of the revised SNA at market values. Opening and closing stocks of these assets are also measured at market values. The transition to the level of the market values at the end of the accounting period (closing assets) is shown as item (5) in Table 5 (revaluation due to market price changes).

The connection between the SEEA and the conventional assets balance sheets is introduced by a breakdown of the volume change of natural assets due to economic use (item (3) of Table 5). As far as the economic use affects the natural balances and leads to a decrease of the value of the natural assets from an ecological point of view, the avoidance or restoration costs are estimated for maintaining the same qualitative and quantitative level of natural capital during the accounting period. These values are introduced in the extended use/value added table of the SEEA (see Table 3). This ecologically oriented valuation does not necessarily correspond to the market values due to the respective economic use. Therefore, an adjustment item is introduced which allows the transition to the market valuation of the asset balance sheets [item (3.2) of Table 5]. Volume

[4]The normal rent of capital refers to the produced assets which have been used for the exploitation of natural assets (e.g. trawlers for fishing and drilling instruments).

changes due to economic activities which do not directly deplete or degrade the natural assets (changes in land use, discoveries, etc.) are separately recorded and have market values [item (3.3) of Table 5]. In the SEEA, the analysis of the volume changes of the natural assets is focused on the economic uses. Therefore, no ecologically orientated valuation of the volume changes of natural assets due to natural or multiple causes (like wars and disasters) is applied, but market values of the volume changes are given.

It is not possible to describe the volume changes of the different types of assets in this overview article in detail. More detail on the extended asset balance sheets will be given in the SNA Handbook on Environmental Accounting. The following limited observations are thus only to facilitate a better understanding of the general scope and coverage of environmental assets in the SEEA.

The consumption of fixed capital (fixed produced assets) comprises only insurable risks of premature losses. Further losses by war or natural disasters are recorded under item (4) (−25.3).

The asset balances of the *biological assets* are relatively complicated because of the different concepts for describing the volume changes of produced and non-produced biota at market values. The natural growth of produced biota is treated as economic production (and gross capital formation) whereas the natural growth of non-produced biota is, as far as market values are associated to them, part of "(4) Volume change by natural or multiple causes" of Table 5. The depletion (due to economic use) of the produced biota is shown as decrease of stocks or consumption of fixed capital [item (2) of Table 5], whereas the depletion of non-produced biota is indicated under item (3). This different treatment implies that the net growth (natural growth minus depletion) of produced biota at market values is shown as net capital formation under item (2) ($-1.9 = 1.4 - 3.3$), while the net growth of non-produced biota equals the difference of the values under item (4) and item (3) ($-0.8 = 1.3 - 2.1$).

The ecological value of depleting produced biota (−0.9) reflects the ecological consequences of depleting cultivated biota beyond the economic use of these assets. If, for example, the wood of timber tracts is cut, the natural balance of forests could be disturbed as far as depletion exceeds natural growth. The necessary "ecological" costs could be estimated by the costs of compensating projects or by the additional value added generated by the net depletion (gross depletion minus natural growth). Further considerations are necessary to avoid double-counting if the depletion of produced biota exceeds their natural growth. In this case, the ecological valuation has to take into account that the (negative) net growth has already been valued at market values as (negative) capital formation.

The depletion of wild biota (−3.7) could be valued in ecological terms in a similar way. The natural balances could only be maintained if depletion and natural growth are balanced. That is, if the net depletion is positive avoidance or restoration costing refers to a reduction of the production (hunting, harvesting etc.) and a decrease of the corresponding value added, and the loss of ecological functions of the resource.

The valuation of the quality changes of *land* caused by economic activities might produce completely opposite results, depending on the economic or

environmental point of view. Restructuring and development of land are normally connected with increasing market values, whereas their ecological effects could decrease the land values under environmental aspects. The development costs (4.6) are shown as capital formation. They reflect, together with the market value of the volume changes due to economic use (23.3, −5.0), the market value of all quantitative and qualitative volume changes of land caused by the different economic activities. The quantitative aspects of land use (changes in land use) are described under item (3.3) of Table 5 (3.5, −3.4). The qualitative component is shown under ecological aspects first (−7.7, −9.5, −2.1, −3.1) and adjusted to market valuation in a second step (33.1, 4.0, 2.1, 1.5). The qualitative changes do not only comprise the results of restructuring and development, but also excessive economic use, e.g. for agricultural purposes (often connected with soil erosion) and for recreation. Furthermore, the degradation by residuals is taken into account.

The ecological valuation of land degradation raises difficult estimation problems. In principle, the adequate avoidance or restoration costs to maintain the same level of land quality has to be estimated. Avoidance costs could comprise the decrease of value added in case of reducing excessive land use. Restoration costs could be the costs of compensation projects.

The opening and closing stocks of *subsoil assets* (proven reserves: developed and undeveloped) are valued with the discounted value of future net returns (i.e. revenues minus exploitation costs: 261.9, 313.3). New discoveries and changes in the economic conditions of exploitation which lead to new estimates of the proven reserves, are shown under item (3.3) of Table 5 (27.8). The exploitation costs do not contain the exploration costs (2.7) because they have already been included under item (2) of Table 5. The extraction (depletion) of these assets is estimated at "ecological" values (−8.9) and in a second step adjusted to market values (−8.9+0.9=−8.0). These market values reflect the net prices of the depleted assets (current market price minus exploitation costs). The ecological valuation could comprise the costs for maintaining the level of natural capital (compensating projects to develop renewable or permanent assets) or of the total capital (man-made and natural).

The stock of *water* has normally no market values. Exceptions are stored water for drinking or irrigation purposes. The depletion of water is valued from an ecological point of view only if the average water stock is affected. This net depletion is valued with its avoidance costs [costs of reducing water use, e.g. by reducing agricultural production (−4.7)]. The avoidance cost approach can also be applied for valuing water degradation by residuals (−12.9).

The *air*, as a natural asset, has no market value. Therefore, the value of opening and closing stock is zero. For balancing the value of degradation by residuals (−20.4), a corresponding positive item has been introduced as an adjustment to market valuation.

6. Welfare-Oriented Measures of the Economic Use of the Environment

The concept of sustainability used in this paper is cost-oriented rather than welfare-oriented.[5] It reflects cost estimates which would be necessary to avoid,

restore or replace decreases of environmental quantities and qualities during the reference period. Such an approach would normally suggest a greater effort at protecting the environment, as compared to estimating an economically optimal level of pollution. Optimality would require a balance of marginal costs of protection activities and of the (discounted) flows of marginal future environmental damages avoided. Because of underestimation, uncertainty and undervaluation (high discounting) of future damage, the optimality criterion will almost certainly present an amount of environmental deterioration which might be optimal from a micro-economic point of view, but not from a social point of view. In view of the uncertainties related to individual (marginal) evaluation and of prevailing societal and international concerns over long-term threats to critical life-support systems, the cautious concept of sustainability implicit in the cost values of the present framework, i.e. the maintenance (non-decrease) of environmental quality, appears to be a realistic approach. Under this aspect, the present cost approach also reflects (social) welfare aspects in its valuation of environmental degradation. Theoretical considerations, recently presented by Pearce, Markandya, Barbier (1990, especially p. 9), seem to support this approach.

Measurement and valuation problems of estimating the consequential damage (welfare losses) caused by environmental degradation are formidable. It is also difficult to associate unequivocally particular pollutants with health and welfare effects (for example, health damage caused by air pollution). One approach proposed to assess damage costs is to measure actual expenditures required for the elimination of the damage (Uno, 1989). Such expenditures could be shown separately in the SEEA as possible deductions under welfare aspects (Leipert, 1989). Another approach is to directly estimate health and welfare losses, including the impairment of recreational functions or aesthetic and ethical aspects of the environment. Some of these losses have been estimated by using the willingness-to-pay approach as an approximation of individual ("revealed") preferences or by other methods of contingent valuation (see OECD, 1989). Once comprehensive estimates of the value of damages become available, research projects could be undertaken to associate them with the polluting sectors. In this case, separate accounts should be established, which would allow a comparison of the actual and hypothetical avoidance cost on one hand and of the actual and imputed damage costs on the other. These comparisons would facilitate macroeconomic cost-benefit analyses, as proposed for example by Peskin (1989). Such additional accounts would permit further modifications of the components of final demand for the derivation of welfare-oriented measures (Bartelmus, 1987). In the SNA Handbook on Integrated Environmental and Economic Accounting, an approach will be discussed which could be derived from the cost-oriented measures of the SEEA by extending not only the asset boundary, but also the production boundary. This implies the introduction of the concept of environmental services "produced" by nature (see Peskin, 1989; Schäfer and Stahmer, 1989; and Stahmer, 1990).

[5]The question of welfare-oriented measures in national accounts is discussed in Drechsler (1976) and United Nations (1977a). The limits of accounting approaches to assets, the sustainability of economic growth, and possibilities of modeling the "feasability" of development programs are discussed in Bertelmus (in preparation).

7. Application of the Framework: A Desk Study of Country X

The environmentally modified concepts developed in the framework should stimulate alternative economic analyses and policies, based on an integrated assessment of environment-economy relationships. One aspect of such analysis is to focus on income available for spending on final consumption and new investments. Due to the consideration of environmental costs of production, environmentally adjusted income would generally be lower than income derived in traditional accounting. This *welfare* aspect of environmental accounting has received most of the attention in environmental studies of income and expenditure.

On the other hand, production cost and tangible asset and resource requirements of production reflect a *productivity* aspect of economic performance and environmental-economic analysis. Environmental accounting may result in values of value added generated and tangible assets used in each sector, that are different from the values of income and capital in traditional accounting. The reasons are the inclusion of cost due to environmental uses and of non-produced natural assets in broader concepts of cost and capital, respectively. Changed relations between value added and economic assets used in production might well lead to considerable re-assessment of the rentability and productivity of economic sectors from an environmental (accounting) point of view.

(a) *Economic and Environmental Features of Country X*

This analysis is done on the basis of an illustrative database, developed for the clarification of the above-described environmental accounting concepts and procedures. Only part of this database is reflected in Tables 1 to 5 above. The data describe the economic and environmental features of a realistic, but fictitious country "X" and are thus to a large extent fictive. There is however a basic core of data which was taken from the national accounts of an existing country. These core data include GDP by activity and expenditure categories, compensation of employees, indirect taxes (net of subsidies), operating surplus, output, intermediate consumption, capital formation and the consumption of fixed capital.

All other national accounts data, included in the framework, are elaborated on the basis of assumptions about the type of country, the circumstances under which traditional GDP is being generated in production, the effects of production on the environment, and environmental protection and response carried out by government, enterprises and individuals. These assumptions permit the breakdown of aggregate economic data which are part of conventional national accounts, but which could not be compiled from original data sets. Further assumptions about the environmental conditions of the country were made to obtain environmental data for calculating the environmentally adjusted concepts of income and expenditure.

The economic and environmental features of the fictive country X, as reflected in the data and assumptions, are described in the following. The country is a developing country with oil resources, agricultural production, exploitation of timber resources, and fishing activities in rivers, lakes and ocean.

(i) Tangible Wealth

Fixed assets consist of buildings, machinery and equipment, roads and other public structures, and also of livestock for breeding, draught and dairy, trees in orchards and grapevines in vineyards. As regards land, the assumption is that it is used mainly in agriculture for the cultivation of crops and rearing of livestock, in other services for dwellings and office buildings, and that it is owned as infrastructure by government (roads, dams and other structures).

(ii) Environmental Protection

Environmental protection activities are carried out in the country by all sectors. They are concentrated, however, in three sectors which are selling protection services: (a) "other services" which provide private waste disposal services, environmental consulting and recycling; (b) government, which provides sanitation services, and (c) trade and transport, which transports wastes to dumping areas and treatment and recycling plants. The environmental protection (sanitation) services offered by the government are sold to a very limited extent, the rest is assumed to be used by the government itself. The value of the cleaning activity is assumed to be equal to the cost (5.0). Households also purchase environmental protection services. These purchases (8.8) are presented as expenditure in the column of "household final consumption" in Table 3.

(iii) Mining Exploitation

The value of the mineral deposits of the country consists in particular of the value of oil reserves (opening stock in Table 5: 261.9). New deposits of oil were found as a result of exploration activities. This is presented in Table 5 as "Other volume change" (27.8), exceeding the amount of depletion (−8.9+0.9).

(iv) Natural Growth

The country has an important agricultural sector, a fishing industry which operates in rivers, lakes and the ocean, and timber tracts where wood is cut and replanted in a controlled exploitation activity. There are also minor wood collection activities in rural areas which are not controlled by any permits.

(v) Natural Disasters

During the period of accounting, the country suffered from a major earthquake which destroyed some of its infrastructure, particularly affecting roads owned by the government, machinery and equipment in the manufacturing sector, and dwellings and other buildings that are recorded as capital of the other service sector. The total value of destruction is included in Table 5 ("Volume change by natural or multiple causes:" −25.3).

(vi) Pollution

Pollution effects as a result of economic activities in the country are recorded in Table 3 in the row corresponding to qualitative degradation of land, water and air by residuals. In the case of air and water pollution, it is assumed that not only the domestic air and water were affected, but also those of neighboring

countries (−4.7). Private households also cause pollution, which is assumed to consist of the effects of accumulated and illegally discharged wastes. The cost of this pollution (15.6) is reflected in the intersection of qualitative degradation by residuals and the household consumption.

(vii) Conversion of Tropical Forest to Commercial Use

Tropical rain forests are being converted to a limited extent to land for agriculture, urbanization and industrial development. This is recorded as change of land use in Table 5 (±3.4).

(b) *Comparative Analysis of the Economic Conditions of Country X, based on National and Environmental Accounts*

In Tables 7 and 8 we compare aggregates and indicators from traditional accounting with corresponding ones in environmental accounting. NDP is the main concept of national accounting and EDP is used as the environmental accounting alternative.

TABLE 7

ANALYTICAL MEASURES IN TRADITIONAL AND ENVIRONMENTAL ACCOUNTING: RESOURCES AND USES

Macro-aggregates	Based on: NDP (1)	EDP (2)	Percentage Difference (2)−(1)/NDP
Income/expenditure	267.1	185.1	−31
Final consumption	217.5	212.5	−2
% of final domestic uses	81	112	
Capital formation (accumulation) net	50.4	−23.5	−28
% of final domestic uses	19	−12	
Exports	73.7	69.0	−2
Minus: imports	74.5	72.9	−1

(i) Income and Expenditure

The income and expenditure analysis is done on the basis of the national accounts identity between income on one hand and domestic expenditure (final consumption, investment) plus exports minus imports on the other. The income and expenditure aggregates, based on Tables 2 and 3, are presented in Table 7.

In the case of traditional national accounting (column 1 of Table 7) the income concept is NDP, and the expenditure concepts are final consumption, net capital formation and exports minus imports. In the case of environmental acccounting (column 2), NDP is replaced by EDP, consumption by environmentally adjusted consumption and net capital formation by net capital accumulation. Environmentally adjusted consumption is derived from final consumption by deducting the improvement in the environment which is assumed to be equal to the government's net (accounting for clean-up of its own pollution) expenditure for environmental protection (5.0). Environmentally adjusted capital accumulation (−23.5) is arrived at by deducting from net capital formation (50.4) total environmental uses for all (produced and non-produced) asset categories (73.9).

The two sets of aggregate data present a very different picture of the economic situation of the country. Income is reduced drastically between NDP and EDP from 267.1 to 185.1, which represents a 31 percent reduction. Most of this reduction is caused by the modifications of the concept of capital formation to obtain a new concept of capital accumulation. Net capital formation changes from being positive (50.4) to a negative net capital accumulation of −23.5, which constitutes a reduction of income of 28 percent. The remaining 3 percent of the total reduction of GDP are explained by the difference between final consumption and environmentally adjusted consumption (−2 percent) and the decrease of exports minus imports (−1 percent) (see column 3, Table 7).

According to conventional national accounting, the country's domestic expenditure presents a healthy picture of capital formation of 19 percent of total expenditure. Environmental accounting indicates, however, that capital accumulation has been negative. The main factor explaining this result is the inclusion of non-produced assets into the asset boundary: the depletion of natural assets reduces the capital formation by a value of 18.2; a further reduction (−55.7, see Table 3) results from the degradation of land, water and air.

(ii) Income, Output and Capital

Production-related changes in environmental accounting, as compared to traditional national accounting, are elaborated on in the three sections of Table 8. In Table 8 we use figures for specific industries which are not shown in Tables 2 and 3 above, but which represent disaggregated (by economic sectors) figures of these tables. Section (i) of the table shows that there is a reduction in value added for the economy as a whole with EDP amounting to 69 percent of NDP. The impact differs from sector to sector, however. The largest reductions are in mining (52 percent) and agriculture (49 percent). In manufacturing, the reduction is 22 percent. Trade and transport also show a reduction of 14 percent due to the environmental cost of traffic pollution. All other sectors have lower reductions.

These differences are also reflected in the ratios of value added over output under NDP and EDP calculations in section (i) of Table 8. For the economy as a whole, the ratio falls from 52 percent to 36 percent. The largest drop is in agriculture from 77 percent to 39 percent, followed by mining (44 percent to 21 percent), trade and transport (61 percent to 52 percent), and manufacturing (34 percent to 27 percent). Other sectors show much lower reductions. Consequently, there are changes in the order of sector contributions to EDP as compared to NDP. Trade and transport is the largest contributor to both EDP and NDP. Manufacturing is the second largest and other services the third largest contributor to NDP. For EDP, however, this order is inverted. The weight of agriculture and mining in the economy is decreased whereas construction and government services increase in importance.

The other element of production cost, the use of economic wealth, is also affected by differences in coverage between traditional national accounting and environmental accounting. As shown in section (ii) of Table 8, produced assets, which are the capital element in national accounting, for the economy as a whole amount to only 38 percent of the total value of capital used, if non-produced assets are taken into account. For individual sectors the differences in coverage

TABLE 8

ANALYTICAL MEASURES IN TRADITIONAL AND ENVIRONMENTAL ACCOUNTING: INCOME, OUTPUT AND CAPITAL
(in percents)

Analytical Measures	Industries									
	Total	Agriculture	Mining	Manufacturing	Electr., Gas Water	Construction	Trade and Transp.	Other Services	Government Services	Environ-mental Adjustm.
(i)										
EDP as percentage of NDP	69	51	48	78	97	90	86	91	96	
Value added as percentage of output, based on:										
NDP	52	77	44	34	36	45	61	62	61	
EDP	36	39	21	27	34	41	52	57	59	
Value added as percentage of:										
NDP	100	12.1	12.6	16.7	0.8	7.1	26.2	14.5	9.9	
EDP	100	8.9	8.8	18.7	1.1	9.2	32.5	19.1	13.7	−12
(ii)										
Opening balance sheet: Ratio of produced assets/all assets, inclusive of non-produced assets	38	43	13	91	92	95	97	34	29	

Percentage changes between opening and closing balance sheets:									
Net capital formation and volume change due to econ. use (ecol. valuation)									
Produced assets	4	2	0	11	2	3	4	10	3
All assets, incl. non-prod. assets	1	−4	−2	10	2	3	4	3	1
Other volume changes in assets, net									
Produced assets	−2	0	0	−16	0	0	0	−5	−1
All assets, incl. non-prod. assets	0	0	8	−14	0	0	0	−2	−1
Revaluation and environ. value discrepancies									
Produced assets	14	15	13	13	15	13	12	15	15
All assets, incl. non-prod. assets	20	20	13	14	16	13	13	23	24
Total changes, net									
Produced assets	16	17	13	8	17	15	16	20	17
All assets, incl. non-prod. assets	21	17	19	10	18	16	16	24	24
(iii)									
Value added—capital ratios, based on:									
NDP	25	20	73	46	35	21	44	49	6
EDP	7	4	5	32	31	18	36	15	2

of economic wealth used in production is even more pronounced: particularly in the mining sector, produced assets are only 13 percent of the total value of assets used by economic activities.

Changes in coverage of assets also affect the change over time of economic wealth between opening and closing balance sheets. In section (ii) of Table 8, the total changes in assets are broken down into net capital accumulation (including ecologically valued volume change of natural assets due to economic use), other volume changes and valuation discrepancies due to market price changes and adjustments of ecological assets to market valuation.

The percentage change attributed to net capital accumulation is higher for produced assets (4 percent) than for all assets (1 percent). For other volume changes, however, this relationship is inverted. In the case of the traditional capital concept, other volume changes—due to earthquake damages—cause a reduction of produced assets (−2 percent), while economic wealth based on the broader concept roughly remains unchanged (0 percent). This inversion is mainly the result of the inclusion of new finds of subsoil assets (27.8, see Table 5) in the latter concept.

Discrepancies in valuation amount to 14 percent for produced assets, reflecting the average annual inflation in the country which was assumed to be 15 percent. In contrast to this, the value of all assets is increased by 20 percent. This is mainly due to the inclusion of the asset of cultivated land with its high price increases (331.0 on an opening stock of 1,366.7, see Table 5).

For the individual sectors a basic pattern can be described: total volume changes, defined as the sum of net capital accumulation and other volume changes, are approximately the same between the traditional capital concept and the broader economic wealth concept. There is a marked difference in the case of agriculture: In this sector, the volume of economic wealth increases by 2 percent (net capital accumulation of 2 percent plus other volume changes of 0 percent) when the narrower concept of produced assets is used, while it decreases by 4 percent (net capital accumulation of −4 percent plus volume changes of 0 percent) when volume changes in all assets are taken into account. The latter reduction is the result of the negative effects of land erosion, depletion and pollution (including acid deposition) on natural resources held by agriculture, forestry and fishing.

The combined changes in value added and economic wealth used in economic activities have considerable effects on the productivity or rentability of capital. The different effects on NDP- and EDP-based value added/capital ratios are presented in the last part (iii) of the table. For the economy as a whole, the ratio between value added and capital based on national accounting (NDP) is 25 percent; this is reduced to 7 percent if based on environmental accounting (EDP). For specific sectors, the differences are even larger. In mining, the value added/capital ratio based on NDP is 73 percent while for EDP it is only 5 percent. For agriculture, the ratio is reduced from 20 percent to 4 percent and for other services from 49 percent to 15 percent. These are significant changes in productivity or rentability indicators which might prompt a reassessment of investment policies as far as capital allocation to economic sectors is concerned. To the extent that environmental costs are also included in (internal) business

accounts, new EDP-based measures might also affect micro-economic investment decisions.

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