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Edited by Hussein Abaza
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Preface

This collection of papers has been put together to provide interested readers with a range of views and approaches on environmental accounting in a relatively short, easy-to-read document. The importance that this topic has assumed in the last few years means that public interest is substantial.

The set of papers were presented at the Workshop on Environmental and Natural Resource Accounting, jointly sponsored by the United Nations Environment Programme (UNEP), United Nations Economic Commission for Europe (UNECE) and the United Nations Statistical Division (UNSD), held in the Slovak Republic from 21-23 March 1994, and the Workshop on Natural Resource Accounting for the members of the Organization of Islamic Countries (OIC) jointly sponsored by UNEP and the Statistical, Economic and Social Research, and the Training Center for Islamic Countries (SESRTIC), held in Ankara, Turkey from 12-14 June 1995.

The main purpose of the joint UNEP/ECE/UNSD workshop was to provide recommendations on the theoretical and methodological advances and modalities of introducing environmental and resource accounting (ERA) in countries in transition to market economies. It also addressed the use of those methodologies for policy-making and planning for sustainable economic growth and development in those countries.

The objective of the UNEP/SESRTCIC workshop was to address the implementation of the revised system of national accounts (SNA) together with the development of environmental satellite accounts. The workshop was also expected to provide recommendations on the theoretical and methodological advances and modalities of introducing environmental and resource accounting in the Organization of Islamic Countries. It also addressed the use of these methodologies for policy-making and planning for sustainable economic growth and development in these countries.

In the first chapter, Cesare Costantino sets out a basic outline of physical environmental accounting in the context of System of Integrated Environmental and Economic Accounting (SEEA), with emphasis on the physical data requirements of SEEA itself, in order to determine the issues which underlies the proposed accounting framework. In Peter Bartelmus's paper on *Environmental Accounting: An Operational Perspective*, Bartelmus provides a more concise guide through the intricacies of integrated environmental and economic accounting. A step-by-step discussion of how to implement the SEEA has been applied as far as possible, providing further elaboration and concrete materials from country studies in text boxes and tables. In Chapter III, paper on *Integrated Environmental and Economic Accounting* by Carsten Stahmer, possible steps for extending the System of National Accounts towards environmental accounting are described. In addition, different valuation concepts and their consequences for deriving different types of eco (green) domestic products are presented, and implementation problems have been addressed briefly.

In Chapter IV, Claire Grobecker presents a paper on *Natural Patrimony Accounts and Environmental Statistics*: the French Approach. Mark de Haan and Steven J. Keuning, in their paper on *A National Accounting Matrix Including Environmental Accounts: Concepts and First Results*, argue that the consequences of economic actions on ecosystems and vice versa do not only relate to production processes, but also to other parts of the SNA. The concept module presented in the paper distinguishes both environmental matter accounts (including "free" gifts of nature, as well as various types of "free" disposals) and environmental assets accounts (i.e. ecosystems). Finally, Hans Viggo Saebo, in his paper on *Natural Resource Accounting - The Norwegian Approach*, gives an overview of the Norwegian natural resource accounting system: principles structure, use and experiences, using the original concepts.

Acknowledgement

Acknowledgement is made to the staff of the Environment and Economics Unit (EEU), UNEP for their contribution and input towards the preparation and finalization of the publication. Particular mention is made to Bernie Schanzenbacher, JPO, EEU, in this respect.

Contents

Chapter I

PHYSICAL ENVIRONMENTAL ACCOUNTING IN THE CONTEXT OF SEEA AND RELATED ISSUES

Cesare Costantino[6]

Introduction

A number of approaches have been developed and experience gained in the field of environmental accounting in physical terms. Materials/Energy Balances (MEB), Natural Resource Accounting (NRA) and Natural Patrimony Accounts (NPA) are examples of systems developed in this field (see, for instance, United Nations 1976 Alfsen-Torstein-Lorentsen 1987 and INSEE 1986). The scope of these accounts is either on environment-related economic aspects or on strictly ecological phenomena, depending on the focus of the specific account.

Environment-related monetary accounting, on the other hand, may be confined within the conventional system of national accounts (United Nations 1992), thus based on an economic perspective which does not extend to cover sustainability concerns.

In response to a demand for the integration of economic and environmental policies, such as that expressed at the United Nations Conference on Environment and Development (United Nations, 1993a), the System of Integrated Environmental and Economic Accounting (SEEA) Handbook provides a framework for integrated environmental and economic accounting (United Nations, 1993b), which includes both monetary and physical accounts.

The approach followed by SEEA is intended to reflect a synthesis of the ecological and economic points of view. Nevertheless, the extent to which it is envisaged that physical accounts will be presented within this accounting framework is limited, as compared with the monetary accounts part, mainly due to the fundamental choice not to elaborate and describe within SEEA, the flows and transformations which occur exclusively within the natural sphere. Indeed, it may be argued that the field of environmental accounts in physical terms that are relevant for integrated environmental and economic accounting seems broader than the (explicit) physical part of SEEA.

The following paragraphs set out a basic outline of physical environmental accounting in the context of SEEA, with emphasis on the physical data requirements of SEEA itself, in order to determine the issues which underlies the proposed accounting framework. Some consideration is also devoted to the international research work currently being carried out by the Conference of European Statisticians (CES) Task Force on Physical Environmental Accounting, in as much as it relates to SEEA. Reference is made to P. Bartelmus' and C. Stahmer's papers, which were scheduled for presentation to this Workshop prior to the present paper. A knowledge of the general background, structure and contents of the SEEA Handbook is assumed.

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6 Economist, in charge of environmental accounting at the Italian National Statistical Institute

1. Some basic concepts of particular interest set forward in the SEEA Handbook

As already indicated, this paper will not give a complete overview of the main concepts introduced by the SEEA Handbook. This section aims simply to emphasize selected statements in the SEEA, which are deemed particularly relevant together with the concepts specifically considered elsewhere in this paper. The numbers in parentheses indicate the paragraphs where the statements/concepts can be found in the SEEA Handbook.

a) On general issues:

- Using the United Nations System of National Accounts (SNA) as a starting point for SEEA does not necessarily lead to a purely economic view of environmental concerns. Rather, it permits the introduction of ecological elements into economic thinking and decision-making through the employment of a common framework (68);
- the input-output framework is the most suitable economic one for analyzing environmental-economic, relations because it can be easily extended to include flows of natural resources from the natural environment as input of economic activities, and flows of residuals of production and consumption activities as unwanted output delivered back to the natural environment (79);
- a complete integration of existing environmental and economic data systems cannot be fully realized at present, mainly because it is impossible to get a significant description of the dynamics of natural processes, beyond the possible assessments of the state of the natural environment at a certain point in time (64 and 65);
- the concept of sustainability need not necessarily be applied to each and every use of the natural environment, but could focus on the maintaining of vital natural resources only (56);
- since the different functions of natural assets do not have a market value, their description in physical terms is needed as a first step in their assessment (40);

b) on the scope of SEEA accounts:

- flows and transformations within the natural environment are not described in SEEA. The dynamics of environmental transformations dealt with in ecological models are not further elaborated (202 and 203);
- use of the information contained in Materials/Energy Balances and Natural Resource Accounts is limited, in SEEA, to recording physical flow from natural assets to the economy (use of natural assets) and flows back to the natural environment (residuals flows). A comprehensive picture of the transformation processes within the economy is not provided (200);

- SEEA focuses on the description of environmental-economic relations at the national level. The breakdown of data by region could be presented in supplementary tables. This might be preferable, especially in the case of indicators of air and water quality and land use (75);

- imputed environmental costs are associated with the economic activities that are the immediate causes of environmental stress (300);

- imputed environmental costs are associated with the environmental media that are the immediate recipients of the residuals generated by economic activities (316);

- imputed environmental costs are shown for three types of uses of the natural environment: 1) quantitative use of natural assets; 2) spatial and qualitative use of land, landscape, ecosystems (except as a sink of residuals); 3) use of the natural environment for assimilating the residuals of economic activities (disposal function of natural assets) (304 and 274);

c) **on priorities:**

- the association of environmental costs with the economic activities causing environmental deterioration is given high priority ("costs caused" concept) (256);

- "costs caused" are assessed by applying a "maintenance cost" valuation concept. This concept reflects the requirements for achieving a country's economic development under the constraints of maintaining the natural environment quantitatively and qualitatively intact (257);

- Version I to Versions IV of SEEA constitute the core of SEEA; they cover, besides the basic SEEA matrix, environment-related disaggregation of the SNA, linked physical and monetary accounting and imputed environmental costs (85);

- the "environmentally adjusted domestic product" (EDP), calculated taking into account imputed environmental costs at maintenance values ("EDP at maintenance costs", Version IV.2 of SEEA), and thus reflecting the "costs caused" concept, is particularly significant in elaborating of strategies of sustainable development (277);

3. Environmental accounting in physical terms within SEEA: a basic outline

This section gives an essential picture of SEEA physical accounting, without aiming at completeness. For the sake of simplicity, reference is made mainly to the core of SEEA, excluding the envisaged extensions of the accounting framework. Physical aggregates that have their monetary counterparts in traditional systems of economic accounts are not considered, rather, the focus is on physical data relating to phenomena of environmental-economic relevance which are not dealt with in the conventional SNA. On the basis of the high priority given to the "costs caused" concept, that part of SEEA physical accounting is highlighted which has the imputed environmental "costs caused" as monetary counterpart (see table 4.5).

2.1 The general framework

A comprehensive description of the natural environment is not provided by SEEA, since the focus is on the interrelationships between economy and environment. Much room is given to physical data on the flows of natural resources from the natural environment to the economy and their transformation within the economy, and on the flows of the residuals of economic activities to the natural environment. The design of the physical accounting framework is dominated by the main aim of providing links with the monetary flows and assets of SEEA, with the final objective of determining sustainability indicators in monetary terms.

As Table 3.3 of SEEA (relating to Version III) shows, information in physical terms is to be provided, in particular, on the origin and destination (supply and use) of flows which may give rise to economic impacts on the natural environment; this latter is treated as a set of natural assets within the non-financial assets account.

Linkage with monetary accounts is ensured in particular by using the same general concepts, basic definitions and classifications of the SNA (see the column and raw classifications of Table 3.3, apart from the rows "Use of non-produced natural assets" and "Treatment of residuals"). In addition, the relevant general concepts, basic definitions and classifications introduced in monetary accounting for calculating EDP are used. With a view to the requirements for calculating the main categories of imputed environmental costs (corresponding to environmental impacts by the economic activities in terms of depletion and degradation), in providing physical data on the use of non-produced natural assets reference is made, then, to the depletion of natural assets (row 3 in Table 3.3), separately for domestic and foreign origin, to the spatial and qualitative use of land, landscape, ecosystems (except as a sink of residuals) (row 4) and to the use of the natural environment for assimilating the residuals of economic activities (row 5). Physical data relating to the treatment of residuals are also taken into account (row 6).

2.2. Three sets of flow accounts

Rows 2; 3/4 and 5/6 in Table 3.3 represent, respectively, the "Product flow accounts", "Raw material flow accounts" and "Residual flow accounts". Columns 4 to 6 represent the asset accounts.

The "Product flow accounts" row is intended to show the supply and use of products. A distinction between natural growth products (produced biota) and other products is considered of interest for environmental-economic analysis. Furthermore, if an appropriate classification of the relevant products were used, the description in physical terms of product flows could be

Table 3.3 SEEA matrix with linked physical and monetary accounting (version III): summary

		1 Domestic production of industries	2 Final consumption		3 Non-financial assets (uses and stocks of assets)			4 Ex-ports	5 Total uses	
					3.1.1 Produced assets of industries		3.2 Non-produced natural			
			2.1 Individual	2.2 Collective	3.1.1.1 Man-made	3.1.1.2 Natural			Domestic origin	Foreign origin
		1	2	3	4	5	6	7	8	9
1	Opening stocks (1)		B (+)		B (+) A	B (+) A	B** (+) A			
2	Use of products of industries (2.1)	B (+) A	B (+) A	A	B (+) A	B (+) A	A	B (+) A	B (+) A	B (+) A
	Use of non-produced natural assets (3.1)									
3	Depletion of non-produced natural assets (3.1.1)	B (+)	B (+)				B (-)	B (+)		B (+)
4	Use of land etc. (3.1.2)						B** (+,-)			
5	Discharge of residuals (3.1.3)	B (-)	B (-)		B (-)	B (-)	B (+)	B (+)		B (+)
6	Treatment of residuals (3.2)	B (+,-)	B (-)		B (+,-)	B (-)		B (+)		B (+)
7	Use of produced fixed assets (3.3.1)	A (+)			A (-)	A (-)				
8	Net value added/NDP (4.2.2)	B* (+) A	B* (+)							
9	Gross output of industries (5.1)	B (+) A								
	Other volume changes (6)									
10	Due to economic decisions (6.1.2; physical data only)		B (+,-)				B** A (+,-)			
11	Due to natural and multiple causes (6.2)		B (+,-)		B A (+,-)	B A (+,-)	B** A (+,-)			
12	Revaluation due to market price changes (7)				A (+,-)	A (+,-)	A (+,-)			
13	Closing stocks (8)		B (+)		B (+) A	B (+) A	B** (+) A			

Note: A-matrices denote monetary data (market values); B-matrices physical data.

Table 4.5. SEEA matrix: environmental costs at maintenance values (version IV.2) - general concepts

		1.1 Domestic production of industries		2 Final consumption		3 Non-financial assets (uses and stocks of assets)									4 Ex-ports	5 Total uses
						3.1.1 Produced assets of industries		3.2 Non-produced natural assets								
												3.2.5 Land (including ecosystems)				
												3.2.5.1 Soil	3.2.5.2 Areas			
		Agri-culture, forestry, fishing ISIC 0	Other industries ISIC 1-9	2.1 Individual con-sumption	2.2 Collective con-sumption	3.1.1.1 Man-made	3.1.1.2 Natural (living) biota)	3.2.1 Wild biota (living)	3.2.2 Subsoil assets	3.2.3 Water	3.2.4 Air		Cul-tivated	Uncul-tivated		
		1	2	3		5	6	7	8	9	10	11	12	13	14	15
1	Opening stocks (1)			B		B A	B A	B A	B A	B A	B	B	B** A	B** A		
2	Use of products of industries (2.1) Domestic production (2.1.1)	B A	B A	B A	A	B A	B A		A				A		B A	B A
3	Imports (2.1.2)	B A	B A	B A		B A									B A	B A
	Use of non-produced natural assets (3.1) Depletion of natural assets (3.1.1)															
4	Domestic origin (3.1.1.1)	B (+) C (+)	B (+) C (+)	B C (+ (+)			C (+,-)	B (-) C (-)	B (-) C (-)	B (-) C (-)		B (-)		B (+)	B (+)	
5	Foreign origin (3.1.1.2)	B (+) C (+)	B (+) C (+)													B (+) C (+)
6	Use of land, landscape etc. (3.1.2)	C (+)	C (+)	C (+)									B** (+,-) C (-)	B** (+,-) C (-)		
7	Discharge of residuals (3.1.3)															
8	Domestic origin (3.1.3.1)	B (-) C (+)	B (-) C (+)	B (-) C (+)		B (-) C (+)	B (-) C (+)			B (+) C (-)	B (+) C (-)	B (+) C (-)			B (+) C (-)	
9	Foreign origin (3.1.3.2)									B (+) C (-)	B (+) C (-)	B (+) C (-)				B (+) C (-)
10	Restoration of natural assets (3.1.4)	C (-)	C (-)	C (-)	C (-)					B C (+,-(+)		C (+)	B** (+,-) C (+)	B** (+,-) C (+)		
11	Shift in environmental costs (3.1.5)	C (+)	C (+)	C (-)		C (-)	C (-)									
	Treatment of residuals (3.2)															
12	Domestic origin (3.2.1)	B (+,-)	B (-)	B (-)		B (+,-)	B (-)								B (+)	
13	Foreign origin (3.2.2)	B (+)				B (+)										B (+)
14	Use of produced fixed assets (3.3.1)	A (+)	A (+)			A (-)	A (-)									
15	Eco value added/EDP (4)	C	C													
16	Adjustment due to market valuation (4.1)	C (+,-)	C (+,-)	C (+)	C (+)		C (+,-)	C (+,-	C (+,-	C (+,-	C (+,-	C (+,-)	C (+,-)	C (+,-)	C (+)	C (+,-)
17	Eco value added/EDP at market values (4.2)	C	C													
18	Eco-margin (4.2.1)	C (-)	C (-)													
19	Net value added/NDP (4.2.2)	B* A	B* A	B*												
20	Gross output of industries (5.1)	A	A													
21	Other accumulation of non-produced assets due to economic decisions (6.1.2)							B A (+,-)	B A (+,-)	B A (+,-)	B (+,-)	B (+,-)	B** A (+,-)	B** A (+,-)		
22	Other volume changes due to natural, multiple causes (6.2)			B (-)		B A (-)	B A (-)	B A (+,-)	B A (+,-)	B A (+,-)	B (+,-)	B (+,-)	B** A (+,-)	B** A (+,-)		
23	Revaluation due to market price changes (7)					A (+,-)	A (+,-)	A (+,-	A (+,-	A (+,-						
24	Closing stocks (8)			B		B A	B A	B A	B A	B A	B	B	B** A	B** A		

Note: A-matrices denote monetary data (market values); B-matrices physical data; and C-matrices imputed environmental costs..

The "Raw material flow accounts" show the origin and destination of non-produced natural raw materials used as inputs from the natural environment to the economy. A basic breakdown of the non-produced natural assets involved should single-out wild biota (living), subsoil resources, water, air and land (including ecosystems). With reference to land, a distinction should be made between soil, cultivated and uncultivated areas.

As regards the destination side of the "Raw material flow accounts", the quantitative use of each of the first three basic categories of non-produced natural assets mentioned above should be described under depletion of domestic natural assets, and the same applies to soil (for erosion). The depletion of foreign natural assets (wild biota) would also have to be shown.

As far as cultivated and uncultivated areas are concerned, the movements between the two types of areas would have to be shown in row 4 of Table 3.3, thus providing starting information for assessing environmental degradation due to the spatial and qualitative use of land (including landscape and associated ecosystems and except as a sink of residuals).

In the "Residual flow accounts", since water, air and soil are supposed to be affected by discharge of residuals (row 5 of Table 3.3.), the relevant flows have to be described, showing those natural assets as recipient units. This description of physical flows should be made by type of residual (solid wastes, liquid wastes, cooling water, other waste water, solid particles, inorganic and organic gases) and with a breakdown of the sources originating the flows (domestic production of industries, separately for: recycling, waste treatment and disposal, protection of ambient water, ground water and soil, protection of ambient air and climate, other individual industries; final consumption; discharge of produced assets of industries). To complete the "Residual flow accounts", the flows originating from the afore-mentioned sources would have to be shown, by type of residual, under treatment of residuals (row 6 of Table 3.3.), in so far as the said flows are interested by treatment. In this context, the sectors of domestic production of industries mentioned above as sources of residuals, except "other individual industries", are also interested as recipient units in the destination side of the "Residual flow accounts" and the same applies to man-made produced assets of industries (column 4 of Table 3.3.), in the latter case, accumulation of materials in waste disposal facilities is taken into account.

2.3. Asset accounts

Produced as well as non-produced assets are taken into consideration in the asset accounts in physical terms of SEEA. The description in physical terms of the use of non-produced natural assets and of the treatment of residuals, besides being given within the flow accounts referred to above, is also reflected in the non-financial assets accounts. In these accounts completeness is not necessarily the aim and the calculation of opening and closing stocks is only required in so far as it is needed for the compilation of imputed environmental costs. Data on qualitative characteristics, not only on quantities, are needed in certain cases.

In the non-financial assets accounts the same classifications are used as the corresponding ones adopted for the flow accounts, particularly as far as the natural assets involved are concerned and the different uses of the natural environment (depletion of natural assets, use of land, landscape and discharge of residuals). These classifications are also the same as those used in the monetary accounts that are linked to the physical accounts in question. Where the concept of capital accumulation is adopted, as an extension of conventional capital formation (for example, in version IV.2 of SEEA), the physical aggregates on the use of the natural environment entered in the physical asset accounts can be directly linked to the corresponding imputed environmental costs, which are shown as a kind of consumption of fixed capital in the monetary asset accounts.

2.4. Need and issues for further research

SEEA is proposed in an interim version for the moment, for further research is needed. There is indeed scope for additional efforts to achieve improvements in the accounting framework and enrichments to the specific guidelines provided. This applies particularly to the physical accounting part of SEEA.

In this context, classification issues seem to be prime candidates for further research and both flow and asset accounts in physical terms could be involved in this process. The need for further development of the relevant classifications should be considered, in particular as far as products, raw materials and residuals are concerned.

A number of possible improvements may depend on foreseeable developments in basic environmental statistics and indicators. In addition, further advances may be based on achievements in specific fields of physical environmental accounting which now are not included in SEEA as explicit modules of the accounting framework. The suggested topics could include:

a) defining at a more operational level the occurrence of the environmental problems relevant to maintaining vital natural resources. Important aspects would include improving the classification of emissions for instance, in the case of nutrients, focus could be given to the discharge of NOx into air, NH3 into air and N into water. Significant developments in this field could be introduced as building blocks in SEEA, perhaps without having to make them explicit within the accounting framework itself;

b) developing indicators of the qualitative characteristics of non-produced natural assets as determined by the accumulation of residuals. Clearly, consideration should be given to the fact that the degree of deterioration depends also on the present state of the natural environment, that is on a number of annual processes of accumulation. Important inputs in this area are to be expected from outside SEEA;

c) highlighting, to the extent possible, the dynamic aspects of environmental problems due to economic activities (in particular, how these problems are transmitted from one environmental media to another). In this context, a major issue concerns the actual time-lag between the discharge of residuals and the ultimate loading of the natural assets.

Long-term research in this area should be planned to develop a better understanding (with the aim of quantification) of the economic impacts of residuals on the natural environment. Initially, development in this field could be derived from experience gained with existing consistent frameworks, such as MEB, NRA and NPA.

3. The work undertaken by the Conference of European Statisticians (CES) Task Force on Physical Environmental Accounting

In the framework of activities by international organizations to develop official environmental accounting, the Economic Commission for Europe is involved in methodological work. In this context, the CES is mainly concerned with environmental accounting in physical terms (Conference of European Statisticians, 1991).

A European Economic Commission pilot study on a conceptual framework for physical environmental accounting began in 1992 under a specifically established task force. The objective was to develop statistical research into conceptual questions of patrimony or resource accounting for primary use in statistical offices. The project aimed to determine the need for an feasibility of physical environmental accounting for structuring the field of environment statistics (ECE Task Force on Environmental Accounting, 1992).

Two specific subjects were identified for research, changes in land cover and land use and nutrients in the environment and two pilot groups were set up within the Task Force, one for each theme (Grobecker - Weber 1993; Costantino 1993b). Clearly, the subjects chosen are of great relevance to SEEA. They are, however, complex and detailed work on them could be difficult within the SEEA basic framework.

It is hoped that the two pilot groups will be able to specify: the actor accounts needed; the stocks and flows subject to accounting; their corresponding accounting units, including the necessary classifications; the movements between different environmental media of the environment; changes in relevant environmental conditions and their effects. Particular attention should be paid to the possibility of deriving aggregate environmental indicators.

The basic method agreed by both pilot groups is to focus on the human activities responsible for certain environmental effects, the effects themselves and the relevant material flows that explain how the activities produce such effects. Thus they consider that human activities, material flows and environmental effects are the main building blocks for developing environmental accounts in physical terms. The primary aim of this accounting scheme would be to describe environmental developments in terms of key ecological indicators, or variables, both within and between the said building blocks. The possibility of linking the resulting accounts with economic accounts should be preserved and the fullest possible compatibility with relevant international standard classifications, such as International Standard Industrial Classification (ISIC) for the accounting of human activities, should be ensured. Once fully developed, physical accounts are expected to meet the full range of requirements which statistical offices usually specify with regard to accounting techniques of data organization (e. g.

consistency checks of the statistics involved, identification of data gaps and use of data in modelling). Furthermore, the whole system of accounts should be specified and arranged, furthermore, in such a way that meaningful correlations can be investigated by the users. The accounting framework to be developed by each pilot group is based on a provisional broad scheme according to which a distinction is made between "core accounts" and "supplementary accounts" (UNECE 1993). The accounts will be tested by the pilot groups through an attempt to compile data for the respective core accounts.

The core accounts for the pilot study on land use and land cover should cover statistics on cover, use and related activities. The corresponding supplementary accounts should be devoted to describing sealing of soil, partitioning of surfaces, naturalness/artificiality of land cover, biodiversity in rural areas and the impact of tourism.

The core accounts of the pilot study on nutrients should cover emissions and the activities generating them and the supplementary accounts should cover extractions, imports, exports, use, production and, if possible, environmental quality indicators that can be linked to the accounts.

The work of the Task Force should be finalized by the end of 1994 and a report is required for submission to the plenary session of the Conference of European Statisticians in 1995.

This report is intended to include, besides findings and provisions relating to strict accounting issues, a consideration of the need for new or amended (CES) classifications in the field of environmental information and recommendations to the CES on whether to launch a developmental project on physical environmental accounting. In this context, due consideration will be given to the relationship of the project to other activities on environmental-economic accounting at international level (e.g. SEEA).

4. Final remarks

A general remark on SEEA relates to its fundamental choice of relying as far as possible on information derived from existing markets, with the aim of including all the available data in a comprehensive framework. In this way, the quantitative dimension of environmental-economic issues is stressed and the statistical approach to the integration of economy and environment may become less complex (Costantino 1991).

Taking markets into account means reasoning in monetary terms. Physical environmental accounting, on the other hand, is an essential part of SEEA. In order that the linkage between physical and monetary environmental accounting be ensured, it is very important that the basic concepts and classifications of the established systems of economic accounts are used as guidelines. This does not mean, however, that the role of physical accounting in SEEA is to be confined to providing a first step towards the assessment of the relevant monetary aggregates. Since there is no certainty that the question of global indicators of sustainability can be answered through monetary accounting (Weber J. L. 1993) - and beyond this point - physical accounts may also in fact provide very useful even partial indicators for in decision-making for sustainability (Costantino 1993a). It might be stressed, on the other hand, that even the economic dimension should not to be confined to the relevant monetary aspects. While providing monetary data is a of measuring this dimension, the scarcity of environmental functions expressed in physical terms can also be regarded as an economic issue independent of the actual possibility of monetary assessment, if the needs of future generations are to be taken into account.

A practical remark on physical environmental accounting in SEEA, as it stands now, relates to how far the SEEA provisions are operational (Costantino 1993c). In this context, a number of issues were raised in section 2.4. It is possible that future work on SEEA will not be able to cover all the issues without excessively burdening the accounting framework. In this regard, proper coordination of the various projects being carried out at the international level may be helpful.

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Chapter II

ENVIRONMENTAL ACCOUNTING: AN OPERATIONAL PERSEPCTIVE

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INTRODUCTION

National accounts have provided the most widely used indicators for the assessment of economic performance, trends of economic growth and the economic counterpart of social welfare. However, the new emphasis on sustainable development, in particular by the Earth Summit, the United Nations Conference on Environment and Development in Rio de Janeiro (3-14 June 1992), draws attention to the need for a broader assessment of growth and welfare by modified national accounts.

Two major drawbacks of conventional accounts have been stressed in this context. In their assessment of cost and capital, national accounts have neglected (1) the new scarcities of natural resources which threaten the sustained productivity of the economy and (2) the degradation of environmental quality, mainly from pollution, and consequential effects on human health and welfare. In addition, some expenditures for maintaining environmental quality are accounted as increases in national income and product, despite the fact that such outlays could be considered as a maintenance cost to society, rather than social progress.

Joint workshops, organized by the United Nations Environment Programme (UNEP) and the World Bank, set out to examine the feasibility of physical and monetary accounting in the areas of natural resources and the environment and to develop alternative macroindicators of environmentally-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 develop the links between environmental accounting and the United Nations System of National Accounts (SNA).

Parallel to this revision, the Statistical Division of the United Nations (UNSTAT) has developed methodologies for a System of integrated Environmental and Economic Accounting (SEEA) issued as an SNA handbook on *Integrated Environmental and Economic Accounting* (United Nations, 1993). Various components of the SEEA were tested in case studies in Mexico, Papua New Guinea and Thailand. It was found in those studies that environmental accounting is not only feasible but can provide, even in tentative form, a valuable information base for integrated development planning and policy. The main objectives of the SEEA are presented in box 1.

In the absence of an international consensus on how to incorporate environmental assets and the costs and benefits of their use in national accounts, the Statistical Commission of the United Nations requested UNSTAT to develop an SNA *satellite* system for integrated accounting rather than to modify the core system of the SNA itself. This approach was confirmed by the United Nations Conference on Environment and Development (UNCED) in its Agenda 21. On the other hand, as part of the revision of the SNA, selected elements of environmental accounting are already elaborated in the SNA (United Nations, 1992). They include the classification of non-produced tangible (natural) assets, the incorporation of asset accounts and a separate chapter on satellite accounts which deals, among others, with the links between the SNA and integrated economic-environmental accounting. Such linkage is a prerequisite for a meaningful comparison of conventional economic and environmentally adjusted indicators.

Reflecting the controversiality of some of the methodological proposals, in particular those on the monetary valuation of non-marketed environmental "externalities", the handbook has been issued as an *interim* version. It addresses numerous technical questions of valuation, accounting procedures and classification, and also discusses alternative solutions. In practice and at this stage of development, it might thus not be easy to choose among different approaches and methodologies (see e.g. Lutz, 1993).

The objective of this paper is, therefore, to provide a more concise guide through the intricacies of integrated environmental and economic accounting. A step-by-step discussion of how to implement the SEEA will be applied as far as possible, providing further elaboration and concrete materials from country studies in text boxes and tables. Cross-references to the Handbook facilitate its consultation for further details and explanations.

I. ADAPTATION OF NATIONAL ACCOUNTS FOR ENVIRONMENTAL ANALYSIS

Sections I and II demonstrate how the SEEA is derived from the overall national accounts framework, the recently revised 1993 SNA (United Nations, 1992). Close links between the two systems are maintained, facilitating the direct comparison of conventional and environmentally-adjusted indicators. This is achieved by the incorporation of produced and non-produced (natural) asset accounts in the 1993 SNA which are further elaborated and expanded in the SEEA. The implementation of the 1993 SNA would thus already produce a first-step (limited) version of the SEEA. It is for this reason that the adaptation of and transition from the SNA—to obtain a broader system of integrated accounting—is discussed in some detail.

Figure 1 shows how the data systems for produced and non-produced (natural, non-financial) assets can be integrated into one table of supply and use and asset accounts. Such integration is essential for integrated environmental-economic analysis as it permits to extend and link conventional accounts and accounting identities, incorporating environmental assets and changes therein. Box 2 lists those identities in terms of the "blocks" of figure 1.

A. Supply and use accounts

Figure 1 introduces two classifications for the further breakdown of its supply and use blocks. The first classification is by industry, based on the International Standard Industrial Classification (ISIC) (United Nations, 1990), and is applied vertically to the blocks of output, intermediate consumption and value added. The second classification is by products, based on the Central Product Classification (CPC) (United Nations, 1991b), and is applied horizontally to the blocks of supply (output and imports) and use (intermediate consumption, final consumption,

Box 1: Objectives of integrated environmental and economic accounting

(a) Segregation and elaboration of all environment-related flows and stocks of traditional accounts:

The segregation of all flows and stocks of assets, related to environmental issues, permits the estimation of the total expenditure for the protection or enhancement of different fields of the environment. A further objective of this segregation is to identify that part of the gross domestic product which reflects the costs necessary to compensate for the negative impacts of economic growth, i.e. the so-called "defensive expenditures";

(b) Linkage of physical resource accounts with monetary environmental accounts and balance sheets:

Physical resource accounts cover the total stock or reserves of natural resources and changes therein, even if those resources are not (...t) affected by the economic system. Natural resource accounts provide thus the physical counterpart of the monetary stock and flow ...ounts of the SEEA;

(c) Assessment of environmental costs and benefits:

The SEEA expands and complements the SNA with regard to costing

- 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;

(d) Accounting for the maintenance of tangible wealth:

The SEEA extends the concept of capital to cover not only human-made but also natural capital. Capital formation is correspondingly changed into a broader concept of capital accumulation allowing for the use/consumption and discovery of environmental assets;

(e) Elaboration and measurement of indicators of environmentally-adjusted product and income:

The consideration of the costs of depletion of natural resources and changes in environmental quality permits the calculation of modified macroeconomic aggregates, notably an Environmentally-adjusted net Domestic Product (EDP).

Source: Bartelmus (1992).

Box 2: SNA accounting identities

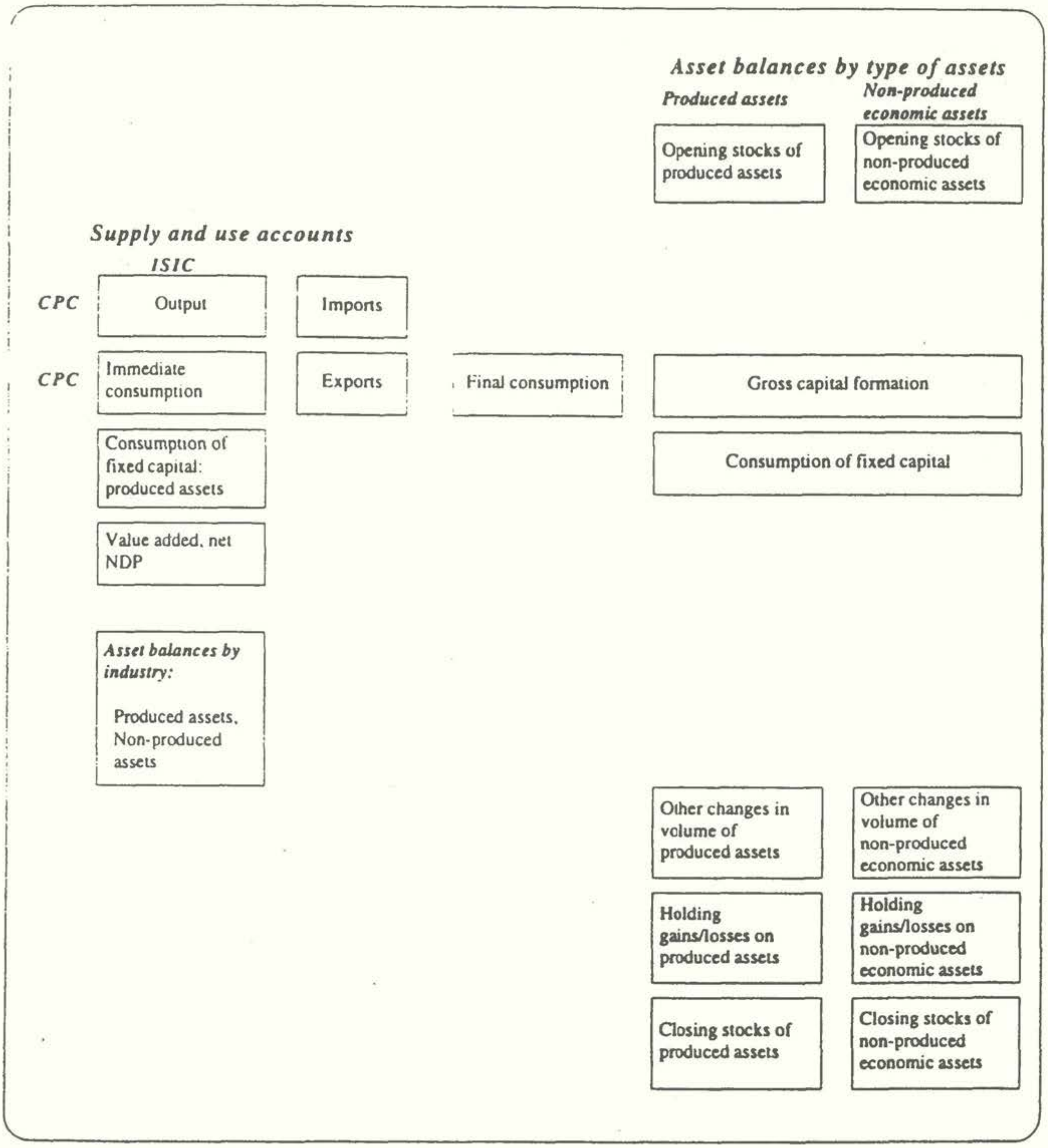
The supply and use accounts in figure 1 reflect three basic national accounts identities:

- the supply-use identity:
  - output + imports = intermediate consumption + exports + final consumption + gross capital formation;
- the value-added identity:
  - value added = output - intermediate consumption - consumption of fixed capital; and
- the domestic-product identity, which only holds for the economy as a whole:
  - net domestic product (NDP) = final consumption + gross capital formation + (exports - imports).

The incorporation of the asset balances in figure 1 adds another set of identities which explain the difference between opening and closing stocks of assets by flows during the accounting period. For produced and non-produced assets, the balances are defined as:

- closing stocks = opening stocks + gross capital formation - consumption of fixed capital + other changes in volume of assets + holding gains/losses on assets.

Figure 1. 1993 SNA, supply and use with asset balances for economic assets by type and industry



Explanations:

ISIC = International Standard Industrial Classification of All Economic Activities (United Nations, 1990).

CPC = Provisional Central Product Classification (United Nations, 1991b).

capital formation and exports). As a result of applying the two classifications at the same time, the blocks of output and intermediate consumption become so-called "make-and-use matrices" with cross-classifications of output and intermediate consumption by industry and product. The blocks of imports, exports and final consumption are vectors with a single breakdown by products. The block of value added is a set of vectors consisting of compensation of employees, net indirect taxes and operating surplus.

Gross capital formation and consumption of fixed capital are the only supply-and-use blocks which intersect with the blocks of the asset accounts. As a consequence, gross capital formation is cross-classified by the type of products that are distinguished in the rows of the supply and use section of the table and by type of assets that are distinguished in the asset accounts or balances (see below, section I.B). Within the latter, a distinction is made between produced and non-produced assets and corresponding capital formation.

The above-mentioned identities apply also to the different categories of the CPC and ISIC. The supply-use identity holds for each product category that is distinguished in the supply and use rows of the table and the value-added identity holds for each industrial sector. The identity between supply and use of products is complicated, however, by the use of different valuations in supply and use. The supply blocks of output and imports are valued in basic prices—excluding trade and transport margins and taxes on products less subsidies—and uses are in purchasers' values which include the tax, trade and transport margins. To maintain the identity in value terms between supply and use, an additional column vector of those margins could be introduced for each product.

B. Asset accounts/balances

The two columns of the asset balances for produced assets and non-produced assets in figure 1 are further detailed in terms of transactions in the SNA. Box 3 lists those transactions for the different blocks of figure 1.

Gross fixed capital formation, changes in inventories and consumption of fixed capital generally refer to additions to and reductions in the value of produced assets such as buildings, roads, machinery, stocks of commodities etc. However, gross fixed capital formation may also include additions to non-produced assets such as improvement of land, cost of transferring land and other non-produced assets between owners, and reforestation. The value of capital formation is added to the value of non-produced assets, but separately "depreciated" as other changes in volume (see box 3).

The account for other volume changes in produced and non-produced assets is one of the most relevant accounts of the SNA for environmental analysis, reflecting environmental impacts on natural and other assets. Economic appearance of non-produced assets (K3) covers the additions to non-produced assets that are used or made available for production activities, including additions to proven mineral reserves, virgin forests that are added to the economic reserves used in lumbering, and land that is cleared for use in agriculture or the development of human settlements. Further additions to non-produced assets are natural growth of non-cultivated natural resources (K5) which refers to the growth of natural biota that are not produced assets. Economic disappearance of non-produced assets (K6) covers all aspects of depletion of mineral assets, forests and other natural resources, as well as the degradation of non-produced assets. Economic appearance of produced assets (K4) mainly refers to additions to the stock of produced assets in the form of works of art, historical monuments and the like which heretofore had not been recognized as economic assets.

The categories discussed so far refer to changes in assets that are a consequence of economic decisions which may or may not affect the environment. The remaining categories in box 3 are either caused by economic decisions but have no environmental impacts (K8, K12), or reflect catastrophic losses (K7) which may have environmental impacts but are not directly caused by economic decisions.

Produced assets (in figure 1) may include natural assets such as livestock for breeding, orchards, plantation, timber tracts and inventories of agricultural crops standing on the land or stored after harvesting. Growth of cultivated assets is treated as gross fixed capital formation and growth of agricultural crops is treated as changes in inventories. Non-produced assets in the SNA refer only to *economic assets*, i.e. assets over which ownership rights are enforced and which provide economic benefits to their owners. Their products are generally valued in the market, either directly or indirectly (see section III.A.1, below). The SNA classification of the tangible non-produced assets is shown in box 4, together with a cross-reference to the—more detailed—SEEA classification (CNFA, in parentheses). The SEEA categories of non-produced natural resources are similar to those of the SNA but include in principle all non-produced natural assets and not only "economic" ones. An important category of non-produced assets in SEEA is air which is not included at all in the SNA as it does not (yet) represent an economic asset.

An alternative breakdown of the asset balances by industry is suggested in figure 1 as a separate block. Asset balances by industries that distinguish between produced and non-produced assets should be particularly useful in tracing the effects of industrial activities on different natural resources.

C. Identification of environmental<R>elements in the SNA

The SNA already contains information that is related to environmental concerns. Part of this information is explicitly identified in various categories of its classifications, notably those of the asset accounts as shown above. Further information can be obtained by disaggregation of SNA transactions and classifications without modifying the basic accounting structure. This approach has been applied in various satellite accounts (in a narrow sense) that aim at providing greater details of transactions in particular areas such as health, education and indeed environment (see e.g. INSEE, 1986). *Integrated Environmental and Economic Accounting* discusses such environment-related disaggregation of the SNA in a separate version (Ch. II), referring to environmental protection expenditures and non-financial asset accounts. Figure 2 illustrates this disaggregation in terms of the building blocks of figure 1 by highlighting the environmental components of those blocks.

Box 3

Box 3: SNA asset accounts categories*

Opening stocks	
Capital formation	
P.51	Gross fixed capital formation
P.52,53	Changes in inventories (acquisition less disposal of valuables)
K.2	Acquisition less disposal of non-produced (non-financial) assets
K.1	Consumption of fixed capital (-)
Other changes in volume of assets	
K.3	Economic appearance of non-produced assets
K.4	Economic appearance of produced assets
K.5	Natural growth of non-cultivated biological resources
K.6	Economic disappearance of non-produced assets
K.7	Catastrophic losses
K.8	Uncompensated seizures
K.9	Other volume changes in non-financial assets n.e.c.
K.12	Changes in classification and structure
Revaluation	
K.11	Nominal holding gains/losses
Closing stocks	

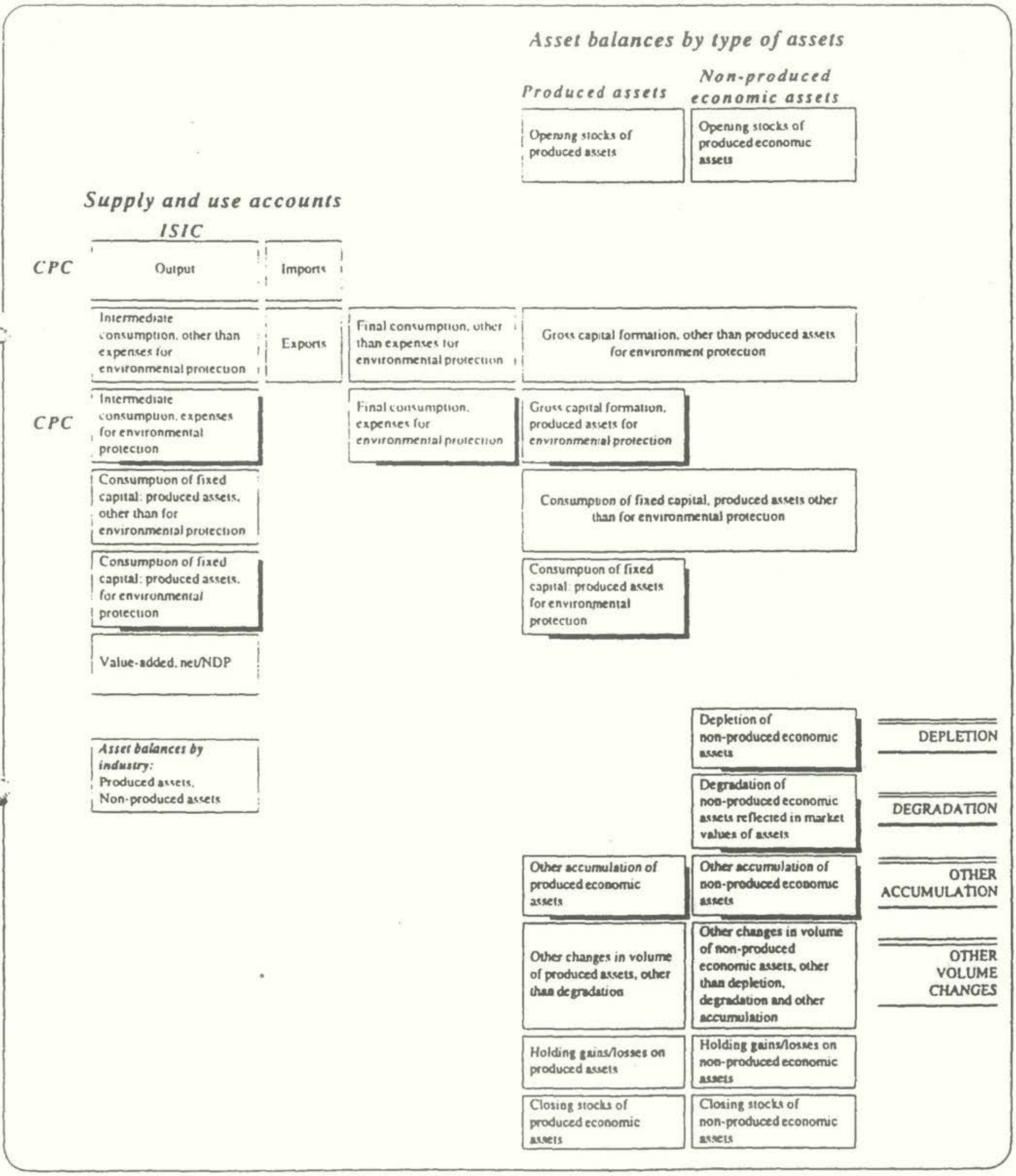
* Codes refer to SNA transaction and balancing items (United Nations, 1992).

Box 4: Classification of tangible non-produced assets in SNA and SEEA (in parentheses)

AN2	Non-produced assets (2)
AN21	Tangible non-produced assets (2.1 non-produced natural assets)
AN211	Land (2.1.3 land with ecosystems and soil)
AN2111	Land underlying buildings and structures (2.1.3.2.1)
AN2112	Land under cultivation (2.1.3.2.2 agricultural land)
AN2113	Recreational land and associated surface water (2.1.3.2.4, part of 2.1.3.3)
AN2119	Other land and associated surface water (2.1.3.2.5, part of 2.1.3.3)
AN212	Subsoil assets (2.1.2)
AN2121	Coal, oil and natural gas reserves (2.1.2.1 fossil/subsoil assets)
AN2122	Metallic mineral reserves (2.1.2.2 metal and other ores)
AN2123	Non-metallic mineral reserves (2.1.2.3)
AN213	Non-cultivated biological resources (2.1.1 wild biota)
AN214	Water resources (2.1.4 water)
n.a.	(2.1.5 air)

Sources: United Nations (1992 and 1993, Annex IV).

Figure 2. 1993 SNA, supply and use with asset balances for economic assets and separate identification of environmental elements



Explanations: see figure 1.

1. Environmental protection expenditures

Environmental protection services are identified within intermediate consumption of industries, final consumption by government and households, and investment (capital formation). Depreciation of assets used in environmental protection is also recorded separately from consumption of fixed capital of other assets.

Separation of environmental protection expenses requires, on one hand, the identification of establishments which produce environmental goods (waste/pollution treatment facilities, filters or cleaning materials) and protection services and, on the other hand, of similar expenses for environmental protection that are not identified as separate establishments in the SNA. The latter may range from simple cleaning activities to maintenance of environmental protection equipment. In-house construction of environmental protection facilities is not included in such "ancillary" activities since own-account construction is always dealt with as a separate establishment in the SNA.

The headings of a draft Classification of Environmental Protection Activities (CEPA), proposed in the *Integrated Environmental and Economic Accounting,* is reproduced in box 5. CEPA includes only those categories that are an immediate response to environmental degradation *caused* by production units, the government and households. It does not cover activities related to health protection and cure that are in response to effects *borne* (usually by other than those who caused them) and that are sometimes referred to as part of a broader concept of "defensive expenditures" (Leipert, 1989). Details of the accounting procedures for the "externalization", i.e. creation of a new "environmental protection industry" within the SEEA framework are discussed as a separate version of the SEEA in the *Integrated Accounting* (Ch.V).

The separate identification of environmental protection expenses provides a comprehensive picture of the efforts that have been undertaken by the different sectors and institutions of the economy to protect the environment. Input-output analyses could assess the direct and indirect value-added contributions to GDP in connection with environmental protection expenses, including employment created by such expenses. Also, such accounting could indicate how capital-output ratios are affected by investment in environmental protection equipment.

2. Environmental accounting elements in other volume changes of assets

Figure 2 groups the data recorded under other changes in volume in the SNA into categories of depletion and degradation, and other accumulation and volume changes. Depletion and degradation which apply to non-produced assets are accounted as production *costs* in the SEEA—contrary to the SNA where those items are part of other volume changes, outside the production accounts.

Depletion of non-produced economic assets refers to the depletion of natural resources. Degradation of those assets (part of K6 in SNA, see box 3) includes quality changes (including restoration of quality) and degradation of land and other non-produced natural assets due to economic uses or due to the discharge of residuals. Other accumulation elements are additions to the volume of *economic non-produced* assets that are caused by economic decisions, such as new finds of subsoil resources, or transfers of land and natural assets to economic use (part of K3 in the SNA). The remaining flows of other volume changes are those that are not caused by economic decisions but have political, natural or other non-economic causes that affect, however, the economic system. They include seizures of assets by governments (K8), and destruction by natural and man-made disasters (K7).

II. MODIFICATION OF THE SNA: TOWARDS A SYSTEM OF INTEGRATED ENVIRONMENTAL AND<R>ECONOMIC ACCOUNTING (SEEA)

Section I described the first-step version of the SEEA, as derived from the SNA, by introducing further environmental detail without changing SNA concepts and accounting procedures. For more comprehensive environmental-economic analysis, modifications in the SNA are required which are discussed as further "versions" of the SEEA in *Integrated Environmental and Economic Accounting*. The following describes two basic modifications whose implementation appears to be more practical than other SEEA versions. They are (1) the second-step version of the SEEA which simply shifts elements of other volume changes as environmental costs to the production/income accounts and (2) a third-step version which attempts to cover non-economic "environmental" assets by replacing SNA's market valuation by a maintenance-cost valuation. The different valuation methods, estimation procedures and consistency problems encountered in both market- and maintenance-cost valuation are discussed in section III. As a consequence of those valuations, alternative "green" indicators of value added, NDP and capital formation can be calculated. Figure 3 illustrates those modifications by highlighting elements shifted within or added to the SNA.

A. Environmental costs and capital accumulation at market values

The shift of the depletion, degradation and accumulation elements of other volume changes in the SNA to the production and capital formation accounts in SEEA is shown in figure 3 as a relocation of figure 2 blocks. This re-arrangement does not require additional data beyond those required for figure 2. The depletion and degradation blocks are presented together with the consumption of fixed capital as additional negative entries that reduce the value of non-produced assets. At the same time, positive counterpart cost items are imputed to those industries and final consumers that cause the depletion and degradation. The items constituting other accumulation of non-produced economic assets are shown together with gross fixed capital formation.

In general, it will be possible to identify separately the cost of degradation, as reflected in market price changes of economic assets, only in severe cases of degradation that can be traced unequivocally to their causes (production/consumption activity). Examples are industrial accidents such as oil spills that contaminate urban or agricultural land property, or environmentally unsound production (cultivation) and waste disposal resulting in land degradation (erosion and contamination). In those cases, conventionally measured value added should be adjusted to a more realistic value that measures more accurately the contribution of the—degrading—sector to net domestic product. An example of such analysis are cost estimates of land degradation in Costa Rica (Solórzano *et al.*, 1991; see also below, section III.A.2).

Gross fixed capital formation which refers to produced assets, and other accumulation of non-produced assets together define a new concept in environmental accounting, called *gross capital accumulation*. The capital accumulation concept could replace gross capital formation in integrated growth analysis. Such analysis would thus recognize the usually neglected role of natural assets in the growth of output.

B. Incorporation of environmental costs and capital not reflected in market values

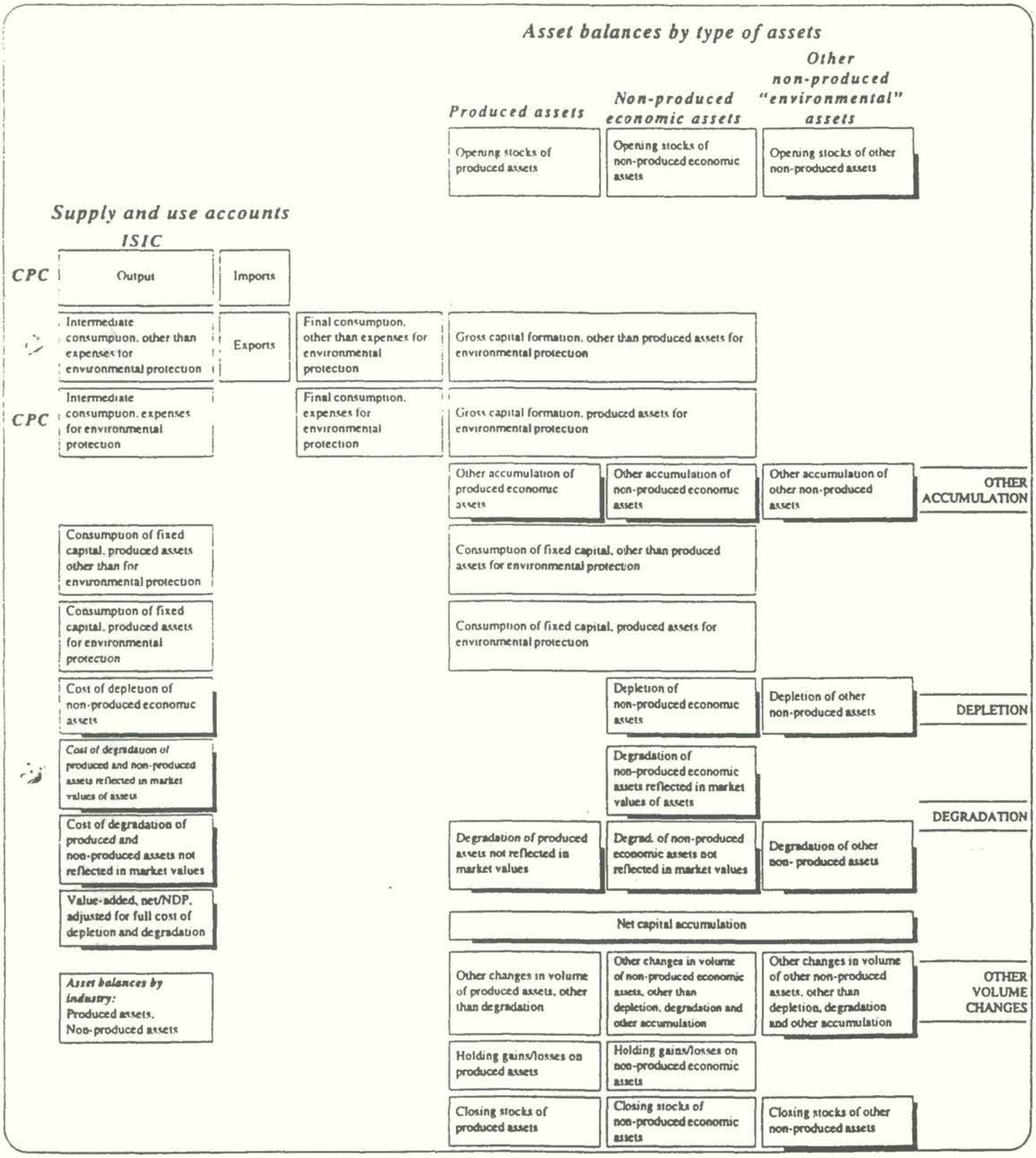
In addition to the elements of other volume changes, reclassified to cost and other accumulation, figure 3 also includes environmental cost and asset categories that are not reflected in the market values of assets. Those elements refer to pollution of environmental media (air, water, land) and the depletion and contamination of wild species and ecosystems that are not economic assets. Degradation effects are included even if they are not recognized in the market values of assets. Alternative valuations can be applied, notably maintenance costing, discussed below in section III.B.

The alternatively valued (costed) environmental cost items are allocated to the industries and consumers causing the environmental depletion and degradation. Degradation or depletion caused by households is treated as cost of household production activities, identified as a separate industry in the SEEA. Environmental degradation caused by the government is recorded as an additional cost item of production of government services. However, if the government removes degradation effects through clean-up activities, such reduction in degradation is treated as a decrease in government consumption and an increase in capital formation because the quality of assets is improved. Cross-boundary effects—across the borders of the nation—are also accounted for in the SEEA according to cost-caused or cost-borne principles (by residents or the "rest of the world").

An important part of depletion and degradation affects non-economic, "environmental" (in a narrow sense) assets. They are assets such as air, oceans, rivers and lakes, forests or lands "in the wilderness", which are not used for economic purposes (see the "environmental assets" column in figure 3). Complete asset accounts can be compiled for most of those assets in physical terms as suggested in figure 3 with the possible exception of air. These physical asset accounts are fully elaborated in the *Integrated Accounting* (Ch.III).

Degradation and depletion effects can be offset by environmental protection (expenses) in the form of produced capital formation. For example, reforestation may replace virgin forests which had been depleted or degraded. Such reforestation is capital formation, i.e. the production of (produced) assets. As those assets do not add to the value of an economic asset, they should be considered as enhancement (increase) of environmental assets.

Figure 3. SEEA, supply and use with asset balances for economic and environmental assets, including costing of depletion and degradation



Explanations: see figure 1.

C. Environmentally-adjusted economic aggregates

When all environmental cost and other accumulation are expressed in value terms, alternative aggregates of Net Domestic Product (NDP), final consumption and capital accumulation can be derived which still meet the basic accounting identities described in box 2 above. Deduction of environmental costs from NDP thus obtains an Environmentally-adjusted net Domestic Product (EDP). The definitory equations of NDP and EDP, in final demand categories, are shown in box 6.

III. VALUATION OF NATURAL ASSETS IN THE SEEA

As indicated in section I.B, natural assets are valued in monetary terms in the SNA only if they are under the controlled ownership of economic agents and provide actual or potential economic benefits to their owners. These *economic* assets are accounted for with a positive monetary value in the balance sheets of the SNA. All other natural assets obtain a zero economic value and are thus not recorded in monetary balance sheets but could be presented in physical asset accounts. Most of the changes in economic natural assets are recorded as "other volume changes"—outside the production and income accounts of the SNA.

The SEEA treats those environmental impacts as cost and introduces them into the production accounts as "imputed" values. However, the limitation of this approach, which deals with economic assets only, is that it excludes per definition all other *environmental* assets. The depletion and degradation of air, water, forests or biota in the wilderness have been considered as "social costs" of economic growth and development for which economic activities should be made accountable (see below, section III.B). Those aspects of natural assets are captured as further environmental costs in alternative valuations of the SEEA.

Integrated Accounting introduces three categories of monetary valuation of natural assets, changes therein, and effects on human welfare therefrom. Accordingly, three different basic versions of the SEEA are proposed. One version (IV.1 in Integrated Accounting applies a market valuation approach which rearranges only environmental changes already contained in the asset accounts of the conventional SNA. A second version (IV.2) uses a maintenance valuation which estimates the costs that would have been required to keep the natural environment intact during the accounting period. The third version (IV.3) combines the market valuation of the first version with a contingent valuation approach in order to assess the environmental costs borne by industries with those borne by households (as welfare losses from environmental deterioration).

The three versions reflect to an increasing degree problems of consistency of valuations and of data availability. The Handbook focuses, therefore, on the first two versions as widely applicable guidelines for environmental accounting. The third version, based on contingent valuation (willingness to pay and similar approaches), and other versions (which extend the production boundary of the SNA) are intended more for ad-hoc analyses and research than for routine data collection. They are not further discussed here.

A. Market valuation of natural resources

The first-step, market-valuation-based version of the SEEA is the closest to conventional accounting in identifying changes in the values of natural assets, already accounted for in asset accounts as other volume changes. These volume changes include the depletion of natural resources, as well as their degradation from pollution and other degrading activities—to the

Box 5: Classification of Environmental Protection Activities (CEPA)

1. Protection of ambient air and climate (prevention of air pollution, treatment of exhaust gases, etc.)
2. Protection of ambient water, excluding ground water (prevention of water pollution, industrial pretreatment plants, sewerage, treatment of cooling water, etc.)
3. Prevention, collection, transport, treatment and disposal of wastes (collection, transport, treatment of waste and prevention of waste generation)
4. Recycling of wastes and other residuals
5. Protection of soil and ground water (decontamination of soil, cleaning of ground water, etc.)
6. Noise abatement (traffic, industrial process noise, etc.)
7. Protection of nature and landscape (protection of species, habitats; erosion, fire and avalanche protection, etc.)
8. Other environmental protection measures (education, training, administration)
9. Research and development

Source: United Nations (1993), Annex III.

Box 6

Box 6: Capital accumulation in EDP calculation

SNA defines Net Domestic Product as:

$$NDP = C + I + (X - M).$$

If net capital accumulation in produced and non-produced economic assets ($A_{p.ec} + A_{np.ec} - A_{np.env}$) replaces net capital formation (I), the identity becomes:

$$EDP = C + (A_{p.ec} + A_{np.ec} - A_{np.env}) + (X - M)$$

where

NDP	=	Net Domestic Product
C	=	Final consumption
I	=	Net capital formation
X	=	Exports
M	=	Imports
EDP	=	Environmentally-adjusted net Domestic Product
$A_{p.ec}$	=	Net capital accumulation in produced assets
$A_{np.ec}$	=	Net capital accumulation in non-produced assets.
$A_{np.env}$	=	Depletion and degradation in environmental assets.

In order to maintain the identity, the negative element for the economic counterpart of changes in natural assets other than economic assets ($-A_{np.env}$) is added. This implies that expenditures and, in particular, net capital accumulation of economic assets are only partly derived from net product of economic activities reflected in EDP; an important part of the expenditures may reflect the transfer of environmental assets and/or their services to economic activities. This can be shown more clearly by re-arranging the terms in the above EDP identity as follows:

$$EDP + A_{np.env} = C + (A_{p.ec} + A_{np.ec}) + (X - M).$$

extent that the underlying environmental impacts are reflected in changed market values of those assets. Section II.A above explained that part of the SNA category of other volume changes is shifted in the SEEA as environmental cost to the production accounts.

Market values have to be compiled or estimated in principle for both the stocks and changes therein. In practice, it might be easier in some cases to value observed (physical) changes only, than to assess the total available stock of a natural resource.

1. Valuation methods

Stocks of non-produced fixed assets which are marketed, such as land, could be valued by applying the market prices observed in statistical surveys of market transactions. If those assets are not marketed, the market prices of similar assets could be used. The flow of services of marketed, but not produced, fixed assets can be estimated by using data on rents or leases which were actually paid for the permission to use these or similar assets.

Stocks of depletable natural assets like subsoil assets or wild biota usually do not have a market price, as they are rarely sold/bought in total. A number of methods to estimate the market price/value of the stocks of scarce (depletable) natural resources, and, by implication, changes in the value of stock (between the beginning and the end of the accounting period) have been proposed and applied in practice. Box 7 presents formalized descriptions of prevalent approaches whose assumptions, advantages and drawbacks are briefly discussed in the following.

(a) Discounted (present) value of natural resources

A market value of natural assets can be calculated by using the prices of the goods extracted or services provided by those assets as the future sales value, reduced by the exploitation costs (net return). If the exploitation is spread over a lengthy period, the flow of future net returns has to be discounted as indicated in box 7. In some cases, the reserves of depletable natural assets and exploitation rights are marketed. The market prices will then reflect to a high degree the expected net returns from the exploitation of the resource, since investors would base their decision of buying an asset on relative present values of future net income streams (Born, 1992, p. 34).

However, it is difficult to estimate future returns and costs of natural resource exploitation by economic sector (agriculture, forestry, mining, construction etc.) or type of natural resource used by different sectors. Those estimates would require information on the availability of future stocks (reserves), prices and interest rates that are usually, if at all, available only at the microeconomic, rather than sectoral, level. In addition, the choice of the discount rate is controversial, with proposed (real) rates ranging between 0 and 17 per cent (Born 1992; for a general discussion see e.g. Pearce, Markandya and Barbier, 1989, Ch.6).

(b) Net-price method

A simplified method which neglects future (discounted) losses of net returns from resource depletion, the "net-price valuation", has been proposed and applied in various studies (notably Repetto et *al*., 1989). As shown in box 7, the value of a natural resource is thus calculated as the product of the quantity of the natural resource stock and the net price. The net price of the asset is defined as the actual market price of the raw material minus its marginal exploitation costs including a "normal" rate of return of the invested produced capital. In the case of non-renewable (mineral) resources, this stock comprises only the "proven reserves" which are exploitable under present economic conditions and, therefore, have a positive net price. The net price method could also be applied in the cases of wild biota and water as long as these natural assets are considered as economically exploitable assets.

This valuation method for estimating stock values can of course also be applied for valuing volume changes of natural assets in the accounting period. In the case of depletion of natural assets such as wild biota, subsoil assets or water, the net price method calculates the value of depletion by multiplying the depleted quantities of the natural assets with the net price.

The general validity of the Hotelling rent assumptions, underlying the net-price method, has been questioned. Where a natural resource reflects different qualities, marginal exploitation costs increase with lower-quality resources extracted, and the rents on marginal tons would increase at a rate lower than the interest rate (Hartwick and Lindsey, 1989). As a consequence, the Hotelling rent would overstate natural resource depreciation. This effect is compounded if average costs are used instead of marginal costs, assuming that in general marginal costs exceed average costs. The net-price method can thus be considered an "upper limit on economic depreciation", an assumption that has been confirmed at least by one empirical comparison of the present values of oil and gas reserves (in Canada) with their net-priced values (Born, 1992).

(c) User-cost allowance

For the depletion of exhaustible resources a "user-cost" valuation has been proposed as an alternative. The idea is to convert a time-bound stream of (net) revenues from the sales of an exhaustible natural resource into a permanent income stream by investing a part of the revenues, i.e. the "user-cost allowance", over the lifetime of the resource; only the remaining amount of the revenues should be considered "true income" (El Serafy, 1989). Given a particular net revenue for an accounting period, the calculation of the user-cost allowance is straightforward, requiring only two additional parameters, the discount rate (r) and the lifespan (n) of the resource (see box 7).

It can be shown that the user-cost method is a special case of defining depreciation as the change in the discounted value of a resource, e.g. over one year of exploitation, assuming that the yearly net returns are the same for the remaining life of the resource (Hartwick and Hageman, 1991). Apart from this—simplifying—assumption, the above-mentioned controversy surrounding the choice of a discount rate and the question of availability of appropriate investments of the user-cost allowance (for maintaining the capital base of production) also impair the general validity of this approach. In addition, this approach does not address the role (availability and consumption) of natural capital in particular production processes, i.e. their

Box 7: Methods of market valuation of natural resource stocks and stock changes

Present-value method: the present value V_0 of a natural resource is the sum of the expected net revenue flows N_tQ_t, discounted at nominal or real interest rates r for the life T of the asset:

$$V_0 = \sum_{t=0}^{T} \frac{N_tQ_t}{(1 + r)^t}$$

where N_t is defined as the total unit value of the resource less the costs of extraction, development and exploration, and Q_t is the quantity exploited over the period t.

Net-price method: the value of the resource at the beginning of period t, V_t, is the volume of the proven reserve R_t (or ΣQ_t over the lifetime of the resource) multiplied with the difference N_t between the average market value per unit of the resource p_t and the per-unit (marginal) cost of extraction, development and exploration c_t:

$$V_t = (p_t - c_t)R_t = N_tR_t$$

The net-price method is based on the Hotelling rent assumption which claims that in a perfectly competitive market, the price of a natural resource rises at the rate of interest of alternative investment, offsetting the discount rate. Accordingly the Hotelling rent, defined as the difference between the price of the resource and the marginal cost of extraction, would reflect the unit value of the natural resource stock.

Replacement-cost estimates: the basic idea is to treat exhaustible resources as renewable because of exploration and discoveries, estimating incremental annual unit costs of adding reserves to the reserve base. The unit cost of booked reserves is multiplied by the number (units) of remaining established reserves to obtain an economic value of total reserves (Born, 1992, p. 43-45). This rather speculative (about expected discoveries) method is more experimental in nature and is therefore not further discussed in the text.

Depreciation/depletion of a natural resource stock: Depreciation of a natural resource stock can be calculated simply as the difference between the values of the stock—as calculated above—at the beginning and the end of the accounting period. An alternative approach, which does not address the valuation of the stock or reserve but focuses on potential income generated from extraction (sales) has been proposed by El Serafy (1989). If R are the annual net revenues from the sales of the resource, assumed to be constant over its lifetime (of n years), a "true income" element X can be calculated such that R - X represents a "capital" element whose accumulated investment at an interest rate r during the n years would create a permanent stream of income of X (per annum). X is calculated as $X = R\,[1 - 1/(1+r)^{n+1}]$ and the user cost $R - X = R/(1+r)^{n+1}$, i.e. the discounted (last) net revenue.

sustainability. If, on the other hand, the maintenance of *income* flows (irrespective of their domestic or foreign origins) is envisaged, the user-cost allowance might gain relevance in estimating a (more) sustainable national income figure.

2. Measurement and valuation in natural resource accounts

Different concepts, definitions, data sources and estimations have to be used for measuring physical quantities of natural resource stocks and changes therein and for applying monetary values to those quantities. For the most commonly applied net-price method, the following steps are required:

(1) Establishment of the physical asset account which, according to the SEEA (*Integrated Accounting*, table 3.6), can be described in simplified terms as:

- (i) Opening stocks
- (ii) Depletion
- (iii) Degradation of land
- (iv) Discharge (and treatment) of residuals
- (v) Other volume changes
- (vi) Closing stocks.

Physical accounts are fully elaborated as a separate version (III) of the SEEA in the *Integrated Accounting*. They represent an <M%-1>important data base, either for the direct management of particular natural assets, or as data input into physical models of environment-economy interaction (e.g. input-output analysis). In principle, general equilibrium models can expand such modelling into the analysis of price formation and consequently the estimation of monetary aggregates. An example of such expansion of physical resource accounts into macroeconomic and general equilibrium modelling is the Norwegian approach to environmental accounting (Alfsen, 1993).Of course, the usefulness of such modelling depends to a great extent on the validity of the underlying assumptions about production, consumption and investment functions and the existence of overall general equilibrium in the real-world markets.<D%0>

(2) Determination of the net price of the resource, consisting of the following steps:

- (i) determining the market price of different resource categories;

- (ii) assessing the total factor cost, including a normal return to capital, of producing one unit of those resource categories;

- (iii) calculating the net price as the difference between (i) and (ii).

(3) Valuation of items (i), (ii) and (v) of the asset account (step (1), above) by multiplying them with the net price of (2)(iii). The valuation of items (iii) and (iv) is carried out (in market

values) by direct observation of (changes in) market values; in other words, quality changes in natural resources are usually neglected by the net-price method unless they affect the productivity of production processes;

(4) Determination of the value of the closing stocks by applying the net price at the end of the accounting period to the remaining resource stock (item (vi) of step 1);

(5) Estimation of a revaluation item as the remaining difference between opening stock plus volume changes and closing stock (neglecting measurement and other errors) in monetary terms.

This generic approach will vary for the measurement and valuation of different types of natural resources. Table 1 gives a synoptic view of some of those approaches actually applied in case studies.

3. A case study: subsoil assets in Papua New Guinea (PNG)

Concrete problems encountered in applying the net-price method in a country with very limited statistics regarding its natural resource base are described in box 8. The box illustrates some of the initial difficulties and provisional solutions that might be typical for establishing natural resource accounts in less developed countries. Those resource-dependent countries are indeed the ones that most urgently need a rational assessment of natural resource stocks and their exploitation for production and consumption purposes.

Table 2 presents an example of accounting for subsoil assets of copper, gold and silver mines in PNG. For the years 1986-88, discoveries, included under other volume changes, contributed to an increase in the value of the mineral stock. The cessation of activities in the Bougainville mine in 1989 led to a negative adjustment of the extractable (and extracted) mineral assets. A slump in mineral prices resulted in negative net prices in the same year. Under the above-discussed assumptions, the net price in this year reflects the pessimistic expectations about the profitability of the mine(s).

Table 1. Measurement and valuation in natural resource accounts

	Forests	*Minerals/Oils*	*Soil*	*Fish*
A. PHYSICAL ACCOUNTS				
1. OPENING STOCKS	Standing volume of timber, trees > 10 cm (20 cm)[a], thereof: actually commercialized	Proven reserves		Estimated biomass for selected species
2. ADDITIONS (part of other volume changes in the SEEA)	Growth, reforestation, plantation[b]	Discoveries, upward revisions		
3. REDUCTIONS (depletion and part of other volume changes in the SEEA)	Harvesting, deforestation (forest conversion[b]), logging damage (waste[b]), fire damage, stand mortality[c]	Depletion	Soil loss and productivity decrease due to soil erosion, volume of soil erosion in fertilizer terms (kg of fertilizer per kg of nutrient lost)	Estimated sustainable yield and actual catch of selected species
4. NET CHANGE (net capital accumulation in the SEEA)	Net change	Net change		
5. CLOSING STOCKS	SEE OPENING STOCKS			
B. UNIT VALUE	Stumpage value of standing timber (FOB export prices minus production and capital costs)	Net price/rent (average wellhead price[d]/FOB export price minus production and capital costs), replacement costs (exploration and development cost) per unit exploited[d]	Per-ha cost of revenue lost from 1% of productivity loss, per-ha cost of replacing lost nutrients with commercial fertilizer	
C. MONETARY ACCOUNTS	Net price/rent valuation of all of the above, user-cost valuation for depletion only[c]	Present value of future net cash flows from production for stocks only[d], reserves at replacement cost value[d], net-price valuation for all of the above, user-cost valuation of depletion only[a,c]	Capitalized value of net revenue lost from soil loss, nutrient replacement cost of soil loss	Depreciation of fishery asset as annual change in the capitalized (sustainable rents) value of assets

Source: Repetto et al. (1989) and/or Solórzano et al. (1991) unless otherwise indicated in footnotes.

a Bartelmus, Lutz and Schweinfest (1992): Papua New Guinea.
b DENR and USAID (1991): Philippines.
c van Tongeren et al. (1991): Mexico.
d Born (1992): Canada.

Table 2. Accounts for subsoil assets in PNG[a]
(Million Kina)

	1986	1987	1988	1989	1990
Opening stocks	1 750.0	2 648.7	3 683.7	1 584.4	-154.7
Depletion	-126.8	-209.7	-106.3	-25.2	-180.7
Other volume changes	9.0	122.8	175.6	-383.3	0.0
Revaluation	1 016.5	1 121.9	-2 168.6	-1 330.6	n.a.
Closing stocks	2 648.7	3 683.7	1 584.4	-154.7[b]	n.a.

Source: Bartelmus, Lutz and Schweinfest (1992), p. 14.

a The data presented reflect various assumptions and do not consider the intermediate stages from initial prospecting until the reserves are "proven". If all the leases for minerals prospecting and developing were auctioned off yearly, the incremental values would reflect additions to the capital stock.

b The negative value is not considered an accurate representation of the value of mineral reserves in PNG by the technical specialists working on the country, illustrating the difficulties in producing quantitative estimates of expected (future) returns from mines operating under uncertain political conditions.

Table 3 compares the calculations of user costs with those of the net-price-based depreciation (see box 7) of mineral resources. The user cost is considerably lower (ranging between 12% and 46% of the depreciation allowance). This is not surprising, considering that the user-cost method would split up the net return from sales (equalling the depreciation amount without appreciation) into a true-income and a user-cost element. Table 3 also illustrates differences in the relative importance (with regard to value added generated) attached to depletion in the mining sector by the two valuation methods. The above consideration of the net-price values as upper limits should be borne in mind when comparing these figures.

Table 3. Comparison of user cost and depreciation of mineral resources in PNG
(Million Kina, percentage)

	1985	*1986*	*1987*	*1988*	*1989*	*1990*
(1) User cost	8.8	16.2	39.6	24.5	9.2	35.8
(2) Depreciation (depletion)	74.1	126.8	209.7	106.3	25.2	180.7
(1) / (2) .100	11.9	12.8	18.9	23.0	36.5	19.8
User cost/value added (mining) (percentage)	3.7	4.9	8.1	4.0	2.6	9.5
Depreciation/value added (mining) (percentage)	31.0	38.4	42.8	17.4	7.1	47.8

Source: Bartelmus, Lutz and Schweinfest (1992), pp. 20 and 22.

B. Maintenance valuation of environmental assets

The market-value approach covers only those natural assets that have an economic value (in the SNA sense), in other words, that are connected with actual or potential market transactions. It does not include environmental assets, such as air, wild land, waters and species. Nor can it account for all environmental functions of "economic" assets if those functions have not been reflected in the economic (market) valuation of natural assets. In order to obtain a more comprehensive picture of the changes in the value of the environment a maintenance cost valuation is introduced in the SEEA as an alternative to market valuation. Considering both the nature of this valuation—focusing on *changes* in environmental quality—and the scope and complexity of environmental functions and values, no attempt is made in the SEEA (at least for comprehensive national accounting) to compile full environmental asset accounts that include stock information. Only changes in environmental assets are accounted for as "capital accumulation" and other volume changes in the production and asset accounts.

Maintenance costs are defined as the costs of using the natural environment which *would* have been incurred if the environment had been used in such a way that its future use had not been affected. These costs are of course hypothetical because in reality an actual use *did* take place which affected the environment. The rationale behind this approach is based on the following two criteria:

- the application of the sustainability concept which has gained a central role in the discussion of integrated (environmentally sound and sustainable) development; and

- the extension of the national accounts concept of replacement cost of the consumption of fixed capital to valuing the use of non-produced natural assets.

The sustainability concept reflects a conservationist view of the environment. The uncertainty about possible long-term hazards from disturbing the natural environment and possible irreversibilities of environmental impacts from economic activities call for a high degree of risk aversion and the maintenance of at least the present level of environmental quality. Also, the use of the maintenance-cost approach for valuing the use of environmental functions is similar to valuing the services of man-made capital in the national accounts through consumption of fixed capital. The consumption of fixed capital is estimated as the amount necessary to keep the level of the man-made assets intact by means of replacement investments. Such calculation of capital consumption is also hypothetical in nature because it is not certain whether actual investment expenditures will be incurred at maintenance-cost levels. From this point of view, maintenance cost valuations of produced and environmental asset use are quite consistent.

In the case of subsoil assets, replacement cost could be calculated in principle in terms of required exploration and development costs. As pointed out in box 7, this approach is highly speculative, and it might be unrealistic to estimate the costs for potential replacement of those stocks. The environmental problems of depleting those assets are usually local and limited in nature (exceptions are surface mining, pollution from mine tailings and oil spills connected with the exploitation and transport of crude oil). The application of a weaker sustainability concept can therefore be justified in the case of subsoil depletion. This concept would include the possibility of substituting subsoil assets by other natural or man-made assets with a view to maintaining income levels (rather than particular categories of natural capital). The above-described user-cost valuation caters to this approach.

The maintenance-cost concept implies that uses of the environment which have no impacts on nature have a zero (monetary) value. If, for instance, water is used, which is available in sufficient quantities, water abstraction has no maintenance costs. The same holds for fishing and logging if natural growth offsets exploitation. The disposal of residuals in natural media has no maintenance costs if nature can safely absorb those residuals. The deterioration of natural assets can also be partly or completely offset by activities which aim at restoring the natural environment. In fact, the value of the environment could even be enhanced. Those restoration/enhancement costs are already included in the conventional SNA as gross capital formation and would be treated in a manner similar to reforestation of virgin forests, discussed above in section II.B.

Obviously, the value of the maintenance costs depends on the—hypothetical—restoration, replacement, avoidance or prevention activities chosen. Box 9 lists some of these activities that could be applied under existing conditions of available technologies and knowledge about possible net effects of pollution and depletion. By applying the maintenance valuation as an *alternative* to market valuation double counting is avoided in costing the environmental effects in the production accounts.

The actual estimation of maintenance costs of environmental quality degradation can be illustrated by the approach taken in the PNG case study. In this study, three steps can be distinguished:

Box 8: The use of net prices for the valuation of subsoil assets of PNG

Data available from quarterly reports of the Department of Minerals and Energy included reserves (t, kg), production (t, kg), unit values (Kina) and estimated lifetimes of the reserves by mine and mineral. In the absence of cost data per unit of mineral extracted, a net price could not be calculated for each mineral and the net value of total annual mine production (deducting also an estimate for a normal return to capital) had to be used instead as the indicator of depletion (cf. table 1). Even those values, based on detailed cost-structure information of the mines were difficult to obtain, and in some cases "net values per unit of ore" had to be extrapolated for years where no cost information was available. Published or otherwise revealed or estimated information on "net earnings before taxation" can thus generally be expected to be fraught with assumptions and uncertainties.

In the next step, opening stocks in monetary terms were calculated by multiplying net revenue with lifetime estimates of the mines. Those estimates were based on assumptions about production patterns and future earnings by the mining companies themselves. Clearly those estimates are quite ambiguous and should be revised by using net prices for different minerals and estimates of proven reserves rather than "hiding" behind opaque lifetime estimations.

Source: Bartelmus, Lutz and Schweinfest (1992) and unpublished material.

Box 9: Prevention and restoration activities in maintenance costing

Five types of measures for preventing or restoring environmental deterioration by economic activities can be distinguished (see also Hueting, Bosch and de Boer, 1991):

(a) reduction or abstention from economic activities;

(b) substitution of the outcomes of economic activities, i.e. production of other products or modification of household consumption patterns;

(c) substitution of the inputs of economic activities without modifying their outcomes (outputs) by applying new technologies, etc.;

(d) activities to prevent environmental deterioration without modifying the activities themselves (e.g. by end-of-pipe technologies);

(e) restoration of the environment and measures diminishing the environmental impacts of economic activities.

The calculation of imputed depletion costs depends on the specific type of activity considered. When depletion, e.g. of biota or freshwater, results in a reduction of economic production, the value added foregone caused by diminished production activities could be taken as the imputed costs at maintenance value. In the case of substitution, additional substitution costs could be used for calculating those costs. If new environment-friendly industries have to be established to avoid a decrease in output, the incremental costs could be calculated for estimating depletion costs. Alternatively, the allocation of a part of the operating surplus, the user-cost allowance, for alternative investment has been proposed.

In the case of discharging residuals, different types of activities could be carried out to adhere to environmental sustainability standards. These activities include the reduction in production and household consumption, modifications of the composition of products and of consumption patterns, technological changes to introduce environment-friendly technologies, as well as end-of-pipe technologies. The choice of activities for calculating the imputed degradation costs of discharging residuals will depend on relative costs and efficiencies. Imputed prevention costs of industries should be based on the most efficient method for meeting environmental standards.

Source: United Nations, 1993, Ch. IV.C.

- ***Review of environmental conditions and socio-economic interdependencies:***

Figure 4 represents the results of a qualitative review of environmental problems and their causes in terms of impacts on environmental media within and beyond (on the "rest of the world") the country from sectors of production, the government, households, nature ("natural events") and the rest of the world.

- ***Measurement of physical impacts from socioeconomic activities:***

The data base for impacts on environmental quality from soil loss/erosion and residuals of economic activities has been weak in PNG. There is no independent nation-wide monitoring of emissions or ambient concentrations of pollutants, nor of the contamination of biota and humans. Information on environmental effects is thus either of a descriptive nature or produced as part of an "environmental plan" or impact assessment for selected projects such as logging, hydropower development or mineral exploration. The situation is similar in the case of soil loss through erosion where only selected local or provincial surveys have been carried out in the country. One obvious conclusion from the data search in this study is thus the need for more comprehensive monitoring and data collection—not only for environmental accounting but also for environmental management. Methodologies for the development and compilation of environmental statistics and indicators have been proposed by UNSTAT (United Nations, 1988 and 1991a).

- ***Valuation/costing:***

Three types of valuation have been applied, in some cases alternatively, in PNG. Avoidance and restoration costs represent maintenance cost valuations. Compensation costs are based on negotiations between those agents causing environmental impacts (companies, government) and those affected by them (landowners). This type of valuation can be interpreted as a simulation of markets for trading environmental effects. Box 10 provides further details on these valuations and their results.

IV. IMPLEMENTATION OF INTEGRATED ACCOUNTING

A. National programmes of environmental accounting

At the outset of any national programme of integrated accounting there should be a clear perception of the overall objectives, the accounting framework, data availability and the mode of implementation. Such an approach would facilitate the effective coordination of data gathering by different agencies. Elements of implementing a strategy could include pilot, benchmark and annual compilations as well as special studies. Initially, gaps would have to be filled with rough estimates; later those estimates should be replaced by more reliable data. A national programme of environmental accounting should be long-term (say 10 to 20 years) as the statistics required take a long time to develop and the analysis of some environmental effects may require long time series.

Box 10: Valuation of environmental impacts in PNG

(a) Avoidance costs: two types of avoidance costs were estimated for the environmental impacts (discharge of tailings destroying downstream aquatic life) of the mining sector. The conservationist option of closing the mines provided an upper-limit value of value added foregone of 432 million K p.a. (1986-1990). The more realistic approach of constructing tailings dams and/or detoxifying wastes and hauling waste to safer dumping grounds provided cost estimates between 35.7 million K and 101.2 million K p.a., if an earthquake-proof solution is applied. The example illustrates the significance of choosing between least-cost and most-efficient strategies that may involve considerable value judgements about environmental risks.

(b) Restoration costs: expenditures to remedy losses from flooding and river bed migration (due to soil erosion and ensuing sedimentation) were based on the cost calculations for a "priority work programme" in this regard. In line with SEEA procedures those costs of natural events (disasters) were accounted as other volume changes rather than production costs.

(c) Compensation values: customary land ownership, in combination with traditional compensation requests for "wrongful deeds", have created a unique negotiation process in the field of natural resource exploitation in PNG. Almost all land and water, and related natural resources are owned by tribal groups or clans. Since local communities shoulder most of the burden of environmental impacts and direct commercial benefits are accrued by means of direct remuneration of services or payments of royalties, additional compensations typically reflect environmental or environment-related social and cultural value losses in connection with resource exploitation. Compensation for losses of social, cultural and ecological values has been established through negotiation of landowners and the government with logging companies. In principle such compensation would be reflected in the cost accounts of these companies and consequently in conventional national accounts. However, actual disbursement of compensations rarely occurred. Those amounts were therefore applied in valuing environmental effects resulting from logging and forest clearing for shifting cultivation.

The actual estimation of maintenance costs of environmental quality degradation can be illustrated by the approach taken in the PNG case study. In this study, three steps can be distinguished:

- *Review of environmental conditions and socioeconomic interdependencies:*

Figure 4 represents the results of a qualitative review of environmental problems and their causes in terms of impacts on environmental media within and beyond (on the "rest of the world") the country from sectors of production, the government, households, nature ("natural events") and the rest of the world.

- *Measurement of physical impacts from socioeconomic activities:*

The data base for impacts on environmental quality from soil loss/erosion and residuals of economic activities has been weak in PNG. There is no independent nation-wide monitoring of emissions or ambient concentrations of pollutants, nor of the contamination of biota and humans. Information on environmental effects is thus either of a descriptive nature or produced as part of an "environmental plan" or impact assessment for selected projects such as logging, hydropower development or mineral exploration. The situation is similar in the case of soil loss through erosion where only selected local or provincial surveys have been carried out in the country. One obvious conclusion from the data search in this study is thus the need for more comprehensive monitoring and data collection—not only for environmental accounting but also for environmental management. Methodologies for the development and compilation of environmental statistics and indicators have been proposed by UNSTAT (United Nations, 1988 and 1991a).

- *Valuation/costing:*

Three types of valuation have been applied, in some cases alternatively, in PNG. Avoidance and restoration costs repre-

Figure 4. Impacts on environmental quality — PNG

On / *From*		*Agriculture*	*Forestry*	*Fishery*	*Mining*	*Energy (hydro)*	*Transport (marine)*	*Manufacture*	*Government (municipalities)*	*Households*	*Natural events*	*Rest of the world*[a]
Water	Fresh	Some			Considerable	Some					Some	
	Marine	Some			Considerable		Some	Some	Some	Some		
Land/soil		Some	Some		Some	Considerable					Some	
Air												
Biota/ habitats	Marine			Some	Considerable	Some	Some				Some	
	Forests	Considerable	Considerable		Some							
	Other			Some	Some							
Cultural values		Some	Considerable		Some	Some						
Rest of the world[a]					Some							

Source: Bartelmus, Lutz and Schweinfest (1992), p. 28.

a Imports/exports of residuals.

(blank) No significant impacts

(grey) Some (potentially significant) impacts

(black) Considerable impacts

1. Pilot compilation

A pilot compilation of environmental accounts would start with the development of an accounting framework and supporting software. When determining the scope and classifications of such a framework, data availability and analytical objectives should be taken into account. Data availability should, however, not be the most restrictive factor as the framework should be designed for long-term analysis allowing for improvement in the database. The pilot compilation would be based on existing statistics. Considerable data gaps can be expected at the start of the programme, requiring estimates as illustrated above in section III.A.3 in the case of PNG.

However weak in terms of data, a pilot compilation serves important purposes. It would familiarize national staff with the concepts and methods of integrated accounting, would assist in setting up coordination mechanisms (see below, section IV.A.5) and, last but not least, it would guide future data development. At the end of the pilot phase, data reliability, compilation methodology, and coordination mechanisms should be assessed and a course of action set for future work.

Based on past experience, it is suggested that the pilot compilation be carried out as an inter-disciplinary research programme in which the statistical office and universities or research institutes play key roles. Approximately one year would be required to conduct a pilot study of integrated accounting in a country.

2. Benchmark compilation

A benchmark compilation would be similar in scope to a pilot compilation, but would be carried out, not at the beginning, but in the course of the long-term programme, possibly every five or ten years. Its purpose would be to update the economic-environmental database as a basis for time series analysis (extrapolations). Benchmark compilations of integrated environmental accounts would thus make use of extensive data sets that accumulate over time and would incorporate the results of detailed environmental studies (see below, section IV.A.4).

Preferably, the benchmark compilation would coincide with a similar benchmark compilation of the national accounts. In this case, the national accounts data could be used as the point of departure for the compilation of the environmental accounts, notably the first-step version of the SEEA (see above, section II.A).

3. Annual compilation of reduced-format accounts

The compilation of pilot and benchmark studies is costly and time consuming since a large variety of economic and environmental data needs to be integrated in a common accounting framework. In general, it would not be possible, therefore, to carry out such compilation annually. Also, the coordination mechanisms between institutions would most probably be overtaxed on an annual basis.

It would be advisable, therefore, to carry out annual compilations in a reduced format and with a lesser degree of integration between economic and environmental data. One possible scenario for an annual compilation would thus be a reduced-format presentation of national accounts, supplemented by environmental data that would summarize the changes in environmental cost and capital used in various economic activities. Summary presentations of the most important natural asset accounts could also be prepared in this approach of reduced-format accounting. UNSTAT has developed a PC-oriented compilation methodology which would serve not only the implementation of the SNA but would also facilitate the implementation of SEEA as (reduced) satellite accounts.

The actual scope of the annual compilation would depend on available staff resources, statistical expertise, the extent to which coordination between the national accounts and environmental accounts compilations have advanced and on analytical requirements and priorities for policy formulation and evaluation (see below, section V).

4. Special studies

Once the framework for environmental accounting has been established, it can also serve in implementing special studies that aim at improving the data contents and analysis of particular sectors of the framework. One type of studies could focus on the asset accounts for in-depth studies of particular natural assets. Those studies would elaborate the highlighted blocks in selected asset columns of figure 3. Detailed inventories of natural resources would measure not only asset stock but also changes therein and their economic and non-economic causes. Examples of such studies are the *Philippines Forest Resources Accounts* (DENR and USAID, 1991) and a more experimental compilation of crude oil and natural gas accounts in Canada (Born, 1992). The use of the SEEA framework would avoid the risk of non-compatibility with national accounts concepts and procedures which is a major drawback of ad-hoc studies carried out outside the national statistical services.

A second type of special studies could focus on the industries causing the depletion and degradation of the environment. They could either deal with one specific aspect of depletion or degradation across all industries, or with specific industries, assessing their contribution to different kinds of environmental impacts. Those studies would reflect data compilation and analysis across the rows of figure 3.

Finally, in-depth studies could also be undertaken at a more restricted geographical level such as an ecological zone of particular interest (value) in the country or an administrative entity (province, state) in which the sustainability of development activity is at a particular high risk. Interest in such a regional approach has been expressed in the context of country projects of integrated accounting in China and Indonesia. There is an advantage in compiling environmental data at the local/regional levels which, however, might be offset by lack of information on economic production and capital formation in the region and transboundary flows, usually unavailable in the required detail at subnational levels.

5. Coordination of national activities

Integrated environmental-economic accounting requires the integration of data from different subject areas. Those data are usually dispersed over a large number of line agencies, departments or institutions, unless a comprehensive programme of environment statistics has been established in the country. From the outset, effective mechanisms of coordination and cooperation among those agencies need therefore be established to ensure the availability of data for their incorporation into the accounting framework.

Coordination could be carried out by an inter-institutional committee with representatives of the national statistical office or the agency responsible for compiling national accounts, departments dealing with different natural resources (forestry, land/soil, minerals/energy, water etc.), the ministry of finance and planning, and relevant research institutes. Given the technical expertise required for compiling national accounts, the national statistical office will usually have to adopt the lead coordination role in implementing integrated accounts.

This does not mean that actual data collection has to be carried out only by the statistical office which usually is not familiar with environment statistics such as monitoring data. Rather, a decentralized approach should be taken in which specialized agencies develop and maintain their own data bases but contribute relevant data to the statistical office for incorporation into the integrated accounting system. The first task of the inter-institutional committee would thus be to agree on a joint work programme in which clear commitments to data production and delivery are made.

B. International cooperation

In the absence of international standards of environmental accounting, many developing and—to a lesser degree—industrialized countries have embarked on one type or other of natural resource accounting in physical terms and/or monetary environmental accounting. As a consequence, there has been a proliferation of concepts, methods and definitions that have undoubtedly advanced the knowledge about "green" accounting but yielded hardly comparable results. Worse, in various instances, countries were faced with different protagonists that all attempted to "sell" their own approach, thus generating a great deal of confusion about the merits and drawbacks of those approaches. In Indonesia, for example, a U.S. non-governmental organization, a U.S. university, several governmental agencies of industrialized countries and a consultancy firm have all carried out accounting studies differing in scope, coverage and methodology.

The publication of a United Nations handbook on *Integrated Environmental and Economic Accounting* is the result of an international effort to collate the more relevant, i.e. feasible, methodological proposals within a common framework. Such a framework would facilitate the interpretation and evaluation of those methodologies as to national use and usefulness. Considering that the generally accepted aim of integrated accounting is the integration of environmental costs and benefits into economic aggregates that account for economic costs and benefits, the obvious choice of a common framework was the world-wide adopted system of economic accounts, the SNA. Moreover, as discussed above, the recently revised SNA already incorporates a great deal of environmental concerns, especially of natural resource depletion, in its asset accounts.

While there is still no full consensus on all methodologies in the field of integrated accounting, the—interim—version of *Integrated Accounting* and its underlying framework, the SEEA, are expected to act at least as the baseline for future national and international activities in natural resource and environmental accounting. Of course, countries or international organizations may modify this baseline approach to better reflect particular environmental conditions, priorities and statistical capabilities. Experience gained from concrete uses and modifications of the SEEA will be essential in future revisions of the *Integrated Accounting*. <M%-2>As part of its generic mandate to coordinate international statistical activities, UNSTAT has been developing joint programmes and projects with other international organizations, in particular the United Nations Development Programme (UNDP), the United Nations Environment Programme (UNEP) and the World Bank. International workshops on natural resource and environmental accounting were conducted jointly with UNDP in Costa Rica (1991) and China (1993) for Latin American and Asian countries respectively. The workshops generally endorsed the SEEA and requested international assistance in implementing national pilot studies or more comprehensive programmes of environmental accounting.

A joint work programme between UNEP and UNSTAT has been agreed upon in which various workshops, seminars and national projects will be carried out. UNSTAT has also promoted the development of environmental satellite accounts as part of its programme to implement the 1993 SNA. A broader "global project" is envisaged for joint activities of UNDP and UNSTAT which will focus on technical cooperation, training and research, as well as the coordination of international activities. The World Bank has focused on integrating environmental concerns in its macroeconomic sector and project work, in particular by means of improved statistics and indicators. Such work will be carried out in close coordination with UNSTAT, UNDP, UNEP and other international organizations, as well as non-governmental organizations interested in this field.

V. USE OF INTEGRATED ACCOUNTING IN PLANNING AND POLICY ANALYSIS

The "compartmentalization" of human activities and their effects within nations into sectors and areas of environmental, social and economic concerns and the neglect of economic and ecological "interdependences" among nations can be blamed as the main reasons for policy failures in both environment and development (WCED 1987). Figure 4 illustrated some of the economic-environmental interactions in a matrix of economic sectors and their environmental impacts in PNG. The obvious response to this situation is *integration* in assessing interactions and interdependencies for integrated policy formulation and evaluation. "Sustainable development" has been advanced both, by the World Commission on Environment and Development and UNCED, as a means of addressing effectively environmental and socioeconomic concerns in an integrative and anticipatory fashion.

Integrated accounts can be used, in particular, in the assessment of two major aspects of economic policy, namely (1) *the sustainability of economic growth* as conventionally measured by increases in NDP and its main determinant capital formation and (2) *the structural distortion of the economy* by environmentally unsound production and consumption patterns (Bartelmus, 1992 and forthcoming). The former would give rise to macroeconomic policies that would reorient economic growth toward a sustainable—natural and produced capital maintaining—path, the latter would make use of economic instruments of cost internalization into the budgets of economic agents.

The following brief discussion of some policy uses of the results of green accounting is quite tentative. It is based on fairly theoretical analogies of the use of conventional indicators and very limited experience with the possible role of integrated accounting in establishing a national sustainable development strategy (Bartelmus, 1993). Clearly, more experience needs to be gained from country projects that do not stop at the establishment of integrated accounts but pursue their use in integrated policies and management of the economy and the environment. It is from such policy use that environmental accounting will earn its ultimate justification or dismissal.

A. Sustainability of economic growth

The above-described definitions of environmentally-adjusted indicators in the SEEA and the application of valuation methods that aim at sustainability of natural (non-produced) and produced capital point to possibilities of modifying key economic policy variables such as output, income and expenditure, capital or profit.

The Environmentally-adjusted net Domestic Product (EDP) accounts for the costs and benefits of natural resource depletion and environmental quality degradation and enhancement. Conventional indicators of national income or product are typically used in the measurement and analysis of economic growth. EDP or similar aggregates could therefore be introduced into such analysis, and a definition of sustainable economic growth as upward trend of EDP could be advanced. Box 11 presents such a definition and discusses its underlying assumptions. Replacing conventional growth indicators, notably GDP or NDP, by EDP and expanding the scope of key variables such as capital and capital formation to include natural capital (use) in dynamic growth models could thus provide early-warning signals about the trends and limits of sustainable economic growth.

Table 4 refers to relatively short time series (1986-1990) for EDP in PNG that would have to be extended and the underlying data base improved for the analysis of the sustainability of growth in the country (Bartelmus, 1993). The table also presents some information on the key determinant of growth, capital formation (<F128M>D<F255D>CAP). A brief analysis of how the modification of conventional indicators may affect capital formation, productivity and final consumption is given in box 12.

A further factor affecting economic growth is foreign trade. In the environmental context, and in particular in PNG, foreign demand for natural resources can be considered as a strong driving force for over-exploitation and under-pricing of non-renewable and renewable resources.

Integrated accounts can provide the basic information for input-output analyses that assess the effects of foreign demand throughout the national economy and on the allocation of environmental (depletion and degradation) costs resulting from such demand.

B. Accounting for accountability

Given the inefficiencies of command-and-control measures in environmental protection and natural resource conservation, the application of market instruments of setting economic incentives and disincentives has generally been advocated (OECD, 1989). Those instruments aim at the internalization of external (dis)economies into the budgets of households and enterprises

Box 11: Definition of sustainable economic growth

Based on possibilities of accounting for the depletion and degradation of natural capital, sustainable economic growth can be defined as

> Positive trend in (real) Environmentally-adjusted net Domestic Product (EDP) which allows for the consumption of produced capital and the depletion and degradation of natural capital, taking into account that trends of depletion and degradation can be offset or mitigated by technological progress, substitution, discoveries of natural resources and changes in consumption patterns.

Other factors such as the effects of natural disasters, changes in the productivity of human capital, or high inflation and indebtedness also affect the sustainability of economic growth. The allowance for produced and natural capital consumption in the above definition reflects therefore only a "more sustainable" growth concept that requires further refinement (modelling) (Bartelmus 1992, p. 244).

Box 12: Capital accumulation and productivity in Mexico and PNG

Environmental costs are mirrored in the SEEA in volume changes of capital (dis)accumulation. Table 4 shows that the depletion of natural resources (as reflected in an "EDP1" calculation) reduced their value, i.e. lowered net capital formation (ΔCAP, net), to nearly half its value, in Mexico (60 per cent in PNG). If all environmental costs (reflected in an "EDP2" calculation) are taken into account an actual "disinvestment" was observed in Mexico, while capital accumulation was reduced to less than half in PNG.

Corresponding increases of the share of final consumption indicate patterns of living off the physical (natural) capital base. There are, however, other criteria to measure "living", notably income, which is closer to the measurement of human welfare than production and can be affected by transboundary financial flows. Before coming to any conclusions about sustainable consumption levels those financial aspects of income and its distribution would have to be analysed.

Reductions in capital productivity are reflected in the overall capital-output ratios (NDP or EDP over CAP). Data on total capital stocks were available in Mexico only. They indicated an overall reduction in capital efficiency from 37% to 10% resulting from natural resource depletion only. Considerable fluctuations among the different economic sectors indicated a quite different picture of capital efficiencies if natural capital is used and accounted for in different production processes.

Table 4. Comparison of conventional and environmental accounting indicators: Mexico and PNG

	MEXICO (1985)			PNG (1986-1990)[a]		
	Conventional accounts	Integrated ("green") accounts		Conventional accounts	Integrated ("green") accounts	
		EDP 1[b]	EDP 2[c]		EDP 1[d]	EDP 2[e]
NDP	42.1 billion P	39.7 billion P	36.4 billion P	2 760 million K[f]	2 580 million K[f]	2 580 million K[f]
EDP/NDP	--	94%	87%	--	92-99%	90-97%
C/NDP	83%	88%	96%	89-100%	93-106%	95-109%
Δ CAP (net)	4.6 billion P	2.4 billion P	-0.7 billion P	463 million K[f]	282 million K[f]	228 million K[f]
Δ CAP/NDP	11%	6%	-2%	12-20%	5-17%	3-16%
NDP/CAP	37%	10%	--	59%	--	--

Sources: Mexico: van Tongeren et al. (1991); PNG: Bartelmus, Lutz and Schweinfest (1992).

a Lowest and highest percentage (during 1986-1990).
b Accounting for oil depletion, deforestation (including forest fires) and land use (excluding fish and other species depletion); net-price valuation.
c Accounting additionally for air and water pollution, soil erosion, ground water use and solid waste disposal; avoidance cost valuation.
d Net-price valuation of mineral resources depletion.
e Potential damage restoration or avoidance cost valuation in the case of waste water discharge (from mining); compensation cost for environmental impacts of forest clearing and dam construction.
f For 1990.

Explanations:

NDP = Net Domestic Product
EDP = Environmentally-adjusted net Domestic Product
C = Final Consumption
Δ CAP = Capital formation/accumulation
CAP = Capital stock

to achieve an optimal allocation of scarce resources in the economy. The rationale behind this cost allocation is reflected in the polluter-pays and user-pays (for the depletion of natural resources) principles. The aim is in both cases to make those who cause environmental problems accountable for their environmental impacts. Economic instruments of cost internalization include effluent charges, user taxes (such as an energy tax based on the carbon context of energy consumed), tradable pollution permits, deposit-refund systems etc. Integrated accounting can help in defining those instruments and measuring the appropriate level of incentives (subsidies) or disincentives (charges etc.).

The deduction of environmental costs from conventional indicators of value added does not necessarily imply that these costs are or are about to be internalized by individual economic agents. These costs are imputations which do not suggest any particular role of environmental costs in actual price formation. Such pricing would have to be modelled according to prevailing elasticities of supply and demand. While such modelling of "shadow prices" is beyond the object of accounting, imputed environmental cost information could provide the initial input into such simulations of market behavior of producers and consumers. In fact, full or partial internalization seems to have been carried out in some of the high-risk (accident-prone) and resource-dependent industries. In those cases, accounting for environmental costs merely adjusts net value added to a more realistic value (Bartelmus 1992, p. 255).

In PNG, estimates of environmental depletion and degradation costs of economic sectors have reached, each, levels of almost half their value added. Together (in the mining sector), environmental costs can be as high as three quarters of value added. This would indeed call for changing the technological and sectoral structure of the economy, shifting to resource-saving and low-waste production and consumption patterns.

C. Outlook: limits and prospects of green accounting

Monetary valuation and economic analysis reach their limits where such valuation becomes arbitrary with increasing remoteness of the results of (non-economic) human activities and natural processes from economic output. Development goals of equity, cultural aspirations or political stability are difficult to quantify, even in physical terms, and quite impossible to value in money terms. An attempt to push monetary valuation further into the realm of non-economic (dis)amenities is the application of the above-mentioned "contingent valuation" to environmental effects on human health and welfare. Well-known difficulties of declared willingness-to-pay in project-oriented cost/benefit analyses seem to disqualify this approach from use in routine accounting at the national level.

A comprehensive concept of development would have to cover all those amenities. The policy focus on monetary measures of economic growth has therefore been criticized by advocates of multi-objective development. Such development should address a variety of social concerns or human needs and aspirations as part of the overall goal of improving the quality of human life. There is now growing recognition that long-term planning and policies are needed at the national level to take into account non-economic social, demographic and environmental variables for achieving sustained development (Bartelmus, forthcoming).

Systems of (environment) statistics and indicators aim at measuring these variables in an integrative, or at least comparable, fashion, providing a synthetic picture of the state and trend of the environment and its links to human socio-economic activities. For example, UNSTAT is actively promoting the application of methodologies of environment statistics, organized in *A Framework for the Development of Environment Statistics* (FDES). The framework links social, demographic and economic statistics of human activities with data on environmental impacts and social responses (United Nations, 1984, 1988 and 1991a). A substantial programme of work in this area has also been set up by the World Bank (O'Connor, 1993).

The desire to obtain more aggregated indices of "development" that do not only focus on economic aggregates but also on other "human values" has prompted the estimation of a "Human Development Index" (UNDP 1991). The index accounts, apart from per-capita GDP, for literacy and life expectancy and can be adjusted for distributionary aspects. It remains to be seen if these efforts of assessing integrated and sustainable development in non-monetary terms can prompt decision makers to formulate and implement consistent sustainable development policies, programmes and projects.

It took many years to develop the original SNA, and environmental accounting will probably also take many more years before a consensus on its concepts and methods can be reached. Some of the challenges facing the implementation of environmental accounts are the availability of environmental data in the accounting format, valuation of physical data, and the linkage of environmental data to socioeconomic statistics and indicators. The SEEA, as presented in the interim version of the *Integrated Accounting,* provides, therefore, a flexible framework which can be modified according to national priorities, environmental conditions and statistical capabilities.

High priority should be given to building national capacities for data collection and accounting, required for the implementation of one or the other version of the SEEA. Perhaps the greatest reward in carrying out national projects of integrated accounting may lie in the process of implementation rather than the actual compilation of modified aggregates. Experience has shown that this process has a strong built-in capacity for data synthesis at different stages of the work, in physical and monetary terms. As a consequence, this process facilitates data interpretation and analysis, already at early stages of an integrated accounting programme.

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Chapter III

INTEGRATED ENVIRONMENTAL AND ECONOMIC ACCOUNTING

Carsten Stahmer

INTRODUCTION

There has already been a long and hot debate on how national accounting should be extended towards environmental accounting (see for example, Ahmad, El Serafy, Lutz 1989; Costanza 1991 part II: Accounting, Modeling and Analysis; Lutz 1993; Franz, Stahmer 1993).

The **revision** of the **System** of **National Accounts** (SNA, United Nations 1994) afforded a unique opportunity to examine how the various concepts, definitions, classifications and tabulations of environmental and natural resource accounting can be linked to the SNA. Such linkage was originally proposed in a framework for a SNA satellite system of integrated environmental and economic accounting (Bartelmus, Stahmer, van Tongeren 1991). Considering the knowledge currently available on environmental accounting and the divergent views on a number of conceptual and practical issues, it was not possible to reach an international consensus at that time for a fundamental change in the SNA. Nevertheless, there was agreement that the SNA should address the issue of its **links** to **environmental concerns**. The 1993 SNA, therefore, devotes a separate section (chapter XXI, section D) to integrated environmental-economic satellite accounts and introduces refinements into the cost, capital and valuation concepts of the central framework that deal with natural assets. This will also facilitate using the SNA as a point of departure in the development of environmental accounts.

The satellite approach to environmental accounting expands the analytical capacity of national accounts without overburdening the central framework of the SNA. The Statistical Commission, as indicated in its report on its twenty-sixth session (United Nations, 1991), endorsed the **satellite approach** and requested that the concepts and methods of integrated economic and environmental accounting be developed by means of satellite accounts. This approach was confirmed by the United Nations Conference on Environment and Development (UNCED), which recommended in Agenda 21 that systems of integrated environmental accounting - to be established in all member States at the earliest date - should be seen as a complement to, rather than a substitute for, traditional national accounting practices for the foreseeable future (UNCED, 1992, resolution 1, annex II, paragraph 8.42).

As a conceptual basis for implementing an SNA (satellite) system for integrated environmental and economic accounting (SEEA), a **handbook** of national accounting was published by the United Nations (United Nations, 1993).

It was not the aim of this handbook to present just another approach to environmental accounting, rather, it reflects as far as possible, the different concepts and methodologies that have been discussed and applied in the past few years and synthesizes the approaches of the different schools of thought in natural resource and environmental accounting. A thorough analysis of those approaches indicates that they are often complementary rather than mutually exclusive. The absence of a general approach seems to be due more to missing linkages among the different approaches than to the existence of contradictory concepts. The handbook, therefore, is not intended to replace existing data systems like the natural resource account or the System of National Accounts (SNA), but rather to incorporate their elements as far as possible into a comprehensive data system.

At the present time, **countries in transition** to market economies have urgent economic problems which seem to relegate environmental questions to the background. On the other hand, long-term successful development of society necessitates integrated economic, social and environmental policies. Environmental (and social) drawbacks should be considered in planning economic activities. An integrated environmental and economic accounting system could support such a strategy.

In the second part of this paper, possible steps for extending SNA towards environmental accounting are described. In the third part, different valuation concepts and their consequences for deriving differing types of eco (green) domestic products are presented. To conclude, implementation problems are addressed briefly.

All parts of the paper are based on the SEEA described in the handbook (United Nations 1993).

1. BUILDING BLOCKS FOR EXTENDING NATIONAL ACCOUNTS

An SNA satellite system describing environment-related extensions of the traditional framework should have a high degree of **flexibility**. The needs of individual countries differ to such an extent that each country should be enabled to develop a data system forsuitable to analyze its own specific problems. In any case, three different **types** of **data sets** can be distinguished which might allow a comprehensive analysis of the environmental-economic interrelationships:

- In the conventional SNA framework in monetary terms, environment-related stocks and flows could be identified by disaggregation. Such a procedure would aim to describe environmental protection activities that prevent and mitigate environmental deterioration or restore the damage (reflected in health expenditures, material corrosion) caused by the deteriorated environment. Such an analysis of **environment-related defensive activities** could reveal the increasing importance of expenditures which do not aim to raise the level of welfare of the population, but merely try to diminish the negative impacts of a growing economy (see Leipert 1991). In this context, environmental protection activities of the **government** are especially important.

  In the revised version of the SNA, accounts for produced assets, as well as for **non-produced natural assets,** are included inso far as they could be estimated at market values. Such accounts could be established without extending the scope of conventional national accounting and its asset boundaries.

- Whereas the monetary building blocks described above are derived from the conventional SNA framework by disaggregating monetary flows and stocks of the SNA, **linked physical** and **monetary accounting** implies extensions of the conventional national accounting system by adding physical data. Such linkages do not necessarily imply changes of the traditional SNA concepts. The additional information in physical terms could be linked with the traditional SNA framework in monetary terms without any conceptual modifications.

  Physical accounting could incorporate the relevant concepts and methods of natural resource accounting, material/energy balances, and input-output tabulations. Special attention could be paid to the flows of **raw materials** as inputs of the economic system, to changes in the economic **use** of **land** and to flows of the **residuals** of economic activities discharged back into nature. As far as possible, inputs of raw materials and outputs of residuals should be linked by showing the different stages in the economic transformation of raw materials which sooner or later leads to residuals which are no longer used within the economic sphere.

  This part might **not** be the most **exciting** aspect of an SNA satellite system describing environmental problems. Attempts to value the economic use of nature seem much more attractive for international discussion. Nevertheless, this part seems to be the **most important** one, because the natural environment can adequately and comprehensively be described only in physical terms, and all attempts to value the economic use of nature need an adequate data basis in physical units and can only provide a limited view of environmental problems.

- Environment-related extensions of national accounting imply an **imputed valuation** of the economic uses of the natural environment. These approaches imply corrections of the net domestic product(NDP) towards an eco domestic product(EDP). As proposed in the SEEA, different types of valuation could be applied depending on the aims of analysis. This paper deals in particular with the task of valuing the economic use of nature. Nevertheless, the data basis in physical terms, which is urgently needed for such exercises, should not be forgotten. All attempts to correct NDP will be discussed. A well-elaborated data system in physical units would form establish a solid basis which would facilitate judgements on different valuation concepts.

These three types of data sets are described in the chapters II, III and IV of the handbook (United Nations, 1993). In chapter V, further extensions of the production boundary towards a complete description of household activities are discussed.

2. TOWARDS AN ECO DOMESTIC PRODUCT

2.1 Imputed environmental costs of economic activities

In the seventies, Nordhaus/Tobin (1973) and the Japanese NNW Measurement Committee

(1973) were convinced that the gross (or net) domestic product could be modified in such a way as to make it possible to measure the **welfare** connected with economic performance. They intended to purify the national product by subtracting "regrettable" parts (like national defense expenses) and added further values of non-market production (like household work or leisure activities) which were classified as welfare-increasing.

The optimistic belief that economic production reflects - with slight modifications - economic welfare has been given up. The increasing deterioration of the natural environment has brought into question the very principles of the conventional measurement of economic activities. Economic output has to comprise not only produced **goods** and services, but also **"bads"** such as the by-products of economic activities, like the depletion of natural resources and the degradation of land, air and water by the residuals of economic performance.

Similarly, inputs of economic production have to contain not only the costs of using produced assets, but also the costs of using non-produced natural assets. More important than identifying products which are still welfare-relevant seems to be the aim of achieving more complete **cost accounting** of economic activities. In this context, the intention is not to estimate environment-related economic welfare, but to show the remaining part of the national product after deducting the costs of using the natural environment for economic purposes.

On the basis of these arguments, an **eco domestic product** can be derived as follows:

gross domestic product (GDP)

\- depreciation of produced fixed assets caused by economic activities

= net domestic product (NDP)

\- depreciation of non-produced natural assets caused by economic activities

= eco domestic product (EDP).

A comparison of NDP with EDP demonstrates the degree to which the results of production activities are achieved only by destroying the natural environment. If economic activities did not cause depletion or degradation of the natural environment, then NDP and EDP would be identical.

This approach aims to complete the economic cost accounts merely by estimating the **additional imputed costs** of economic uses of the natural environment. The **actual costs** which also contain environment-related defensive expenditures (such as environmental protection expenditures) are not used for deductions from NDP. Such modifications would require concepts of economic welfare which no longer seem to be applicable in national accounting. Of course, the proposed concept does not necessarily exclude the identification of the economic costs of defensive activities. It seems increasingly important to identify such defensive costs and to estimate actual defensive costs in relation to GDP or NDP (see Leipert, 1991). This could be done without further modifying macro-economic aggregates (see also chapter II of the Handbook, United Nations, 1993).

2.2 Principles of valuing environmental costs

Figure 1 shows different ways of valuing the environmental costs of economic activities. There are **two approaches** which differ fundamentally:

(i) Whether the analysis should focus on the state of the environment and its effects on the population in a specific country and a specific time-period, irrespective of which economic activities have caused environmental deterioration and when (left side of *Figure 1*); or

(ii) Whether the analysis should focus on the immediate environmental impacts of the economic activities of a specific country, in a specific time-period, irrespective of when and in which country those impacts will cause environmental deterioration (right side of *Figure 1*).

In the first case, the imputed environmental **costs borne** by enterprises, government and households are estimated and deducted from the net value added of the economic units **affected** by environmental deterioration. In the second case, the imputed environmental **costs caused** by economic activities are deducted from the net value added of the economic units **responsible**.

In the first case, only the deterioration of the **domestic** natural environment is taken into account. In the second case, the impacts on nature **abroad** are also recorded as far as they are caused by domestic economic activities. Thus, valuation refers only to domestic **welfare** in the first case, whereas, in the second case, the leading valuation principle is oriented towards **responsibility** for all countries.

It seems to be more and more difficult to **link** the two types of environmental costs. Only if economic activities cause environmental deterioration in the same country and in the same time-period are such linkages possible at all. It is typical of most environmental impacts of economic activities that they cause long-term and international problems. Traditional **cost-benefit analysis** which refers to such linkages is increasingly restricted to specific regional environmental problems (e.g. noise, changes of land use). In the SEEA, no attempt is made to link the approaches of environmental costs borne and environmental costs caused. The optimistic attempt to compare the benefits and costs of economic activities in a specific country and specific time-period seems to have been abandoned after observing the long-term and global problems of environmental deterioration caused by economic activities.

In *Figure 1*, it is indicated that the importing country has to bear responsibility for the environmental deterioration caused by the production of the imported goods in the delivering (exporting) country. A rich country could "export" its environmental problems by importing all goods whose production causes environmental problems. In a similar way, a rich country could export its dangerous wastes in order to store them in poorer countries. It seems to be very important that the environmental impacts of **international trade** are taken into account in calculating the EDP of importing and exporting countries.

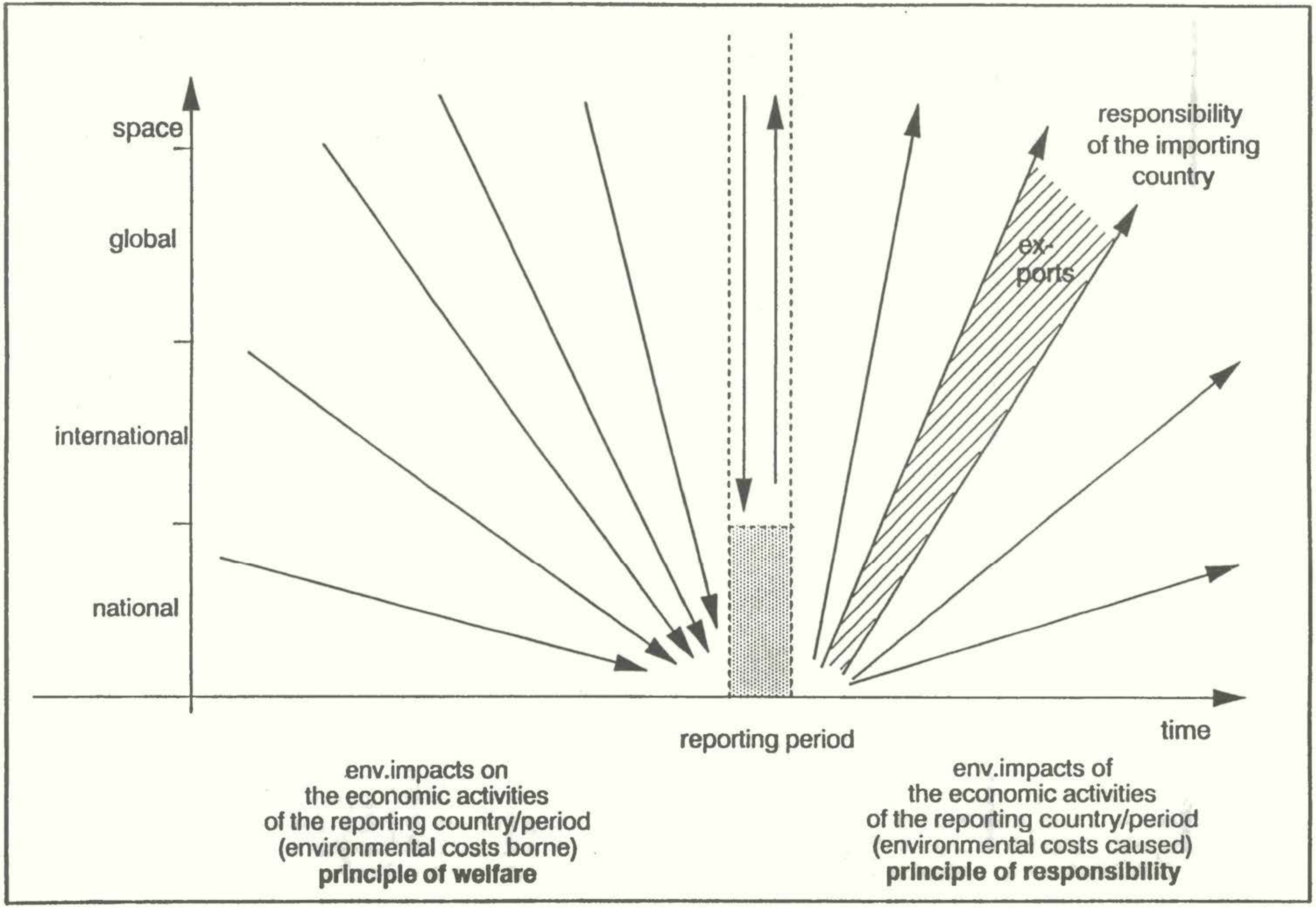
In the following section, different ways of valuing environmental costs borne and caused are described. It should be stressed that these valuation methods are **complementary** and **not mutually exclusive**. It seems impossible to identify a true value of the natural environment and the changes it is subjected to. Valuation can only be oriented towards specific aims and will differ if the analysis focusses on different aspects of environmental-economic interrelationships. Conflict between different schools of valuation results only in wasting time and should be reduced as far as possible. As mentioned earlier, the United Nations Handbook (United Nations, 1993) support concepts which are based on a synthesis of different types of valuation. The problems of environmental deterioration are so urgent that the close cooperation of all scientists working on the analysis of these problems is urgently needed.

2.3 Environmental costs borne

In the revised SNA (United Nations, 1994), not only flow, but also asset accounts are integral parts of the overall system. These asset accounts contain produced assets whose increase is measured as gross capital formation (increase of GDP) and whose decrease is taken into account as consumption of fixed capital (decrease of NDP). The asset accounts of the revised SNA also include non-produced natural assets (such as subsoil assets, water, wild animals and plants, and land), as far as these assets can be assessed at **market values**. Such market values could be derived by using observable market prices, by estimating the discounted value of expected net proceeds or - in the case of depletable natural resources - calculating the net rent of resources (actual market price minus actual exploitation costs, including a normal rate of return of the invested produced capital).

The volume changes of non-produced natural assets are shown in the SNA in separate asset accounts and do not affect the flow accounts relevant for calculating NDP. A first approach to calculate an eco domestic product could be to identify the volume changes (due to economic causes) of non-produced natural assets in the SNA asset accounts and to introduce them as **additional costs** (depreciation of non-produced natural assets) in the flow accounts. Such shifts lead to the following concept of an eco domestic product:

Figure 1: Valuation principles



Net domestic product (NDP)

\- Depreciation of non-produced natural assets at market values

= Eco domestic product (EDP I).

The value of the depreciation of non-produced natural assets could comprise the depletion of subsoil assets, water and non-produced biota or the degradation of land by soil erosion. Of course, such a valuation only covers ecological problems as far as they are reflected by changes in economic values. Only if economic units such as enterprises or society as a whole recognize decreased market values of their assets will an eco domestic product differ from NDP. The **limits** of this approach, which has been supported and applied especially by the World Resources Institute (e.g. Repetto, 1989), are evident. Market values can only reveal pressures on natural assets and cannot reflect the whole range of economic uses of the natural environment. On the other hand, this type of valuation can be relatively easily derived from observable statistics and does not necessitate additional imputations in national accounting. The values are already recorded in the asset accounts. Furthermore, changes of market values might be the type of valuation which facilitates political discussion on the depletion and degradation of natural assets. If they understand that their country is gradually losing its natural wealth even from a narrow economic point of view, they might be willing to pay more attention to environmental problems. The same holds true for enterprises which have to bear decreases of the market values of their non-produced natural assets (like owned land or subsoil assets they have the right to exploit).

As presented, the concept of environmental costs borne at market values is restricted to marketed parts of the natural environment. Such an approach is especially useful for identifying environmental costs borne by **enterprises**, because these economic units normally take into account only the environmental changes reflected by the market. To a certain extent, **households** also suffer from changes in market values due to environmental effects, e.g. changes in the value of dwellings due to increasing traffic noise or air pollution. Nevertheless, most environmental effects on human well-being (e.g. air and water pollution, noise, and the destruction of landscape used for touristic purposes) are not adequately reflected by changes in market values. In these cases, indirect methods for measuring the changes in these environmental services have to be developed. Such estimates could be added to the calculations at market values to achieve a more comprehensive concept of environmental costs borne.

The most prominent valuation method for estimating the non-market costs borne are the different types of **contingent valuation**, especially the so-called willingness-to-pay approach (OECD 1989). The contingent valuation method is not without controversy. In particular, it has been argued that the amount of money that people are willing to pay to improve the natural environment does not necessarily correspond to the amount that they would actually pay (free-rider problem). Furthermore, full knowledge of the quality of the natural environment and of the possible impacts of a deterioration, inter alia, on health generally does not generally exist. It is, difficult, therefore, to translate environmental effects into monetary expenses. Willingness-to-pay will also depend on the income situation of the individuals questioned.

Nevertheless, it is important in a democratic and participatory approach to take the opinions of the people into account, even if their knowledge of the natural environment is incomplete. The SEEA (United Nations, 1993, par. 320-331) proposes to question people on their willingness to **reduce** their **consumption** levels or change their consumption pattern. In this case, the difference between the expenditures connected with existing consumption activities and those connected with the offered change in such activities could be used to represent the value of the environmental quality lost.

The willingness to forgo consumption involves the **actual repercussion costs** of households (for example, environment-related health expenditures, additional commuting and housing costs). If such a deterioration could be avoided, households would of course be willing to reduce their respective defensive expenditures. Studies on the willingness to reduce household consumption levels could, therefore, identify actual repercussion costs as part of the total amount of voluntary reductions and, in a second step, focus questions on the willingness to pay for additional reductions.

When concepts of contingent valuation are applied, more comprehensive estimates of the environmental costs borne lead to a second type of eco domestic product:

Net domestic product (NDP)

\- Depreciation of non-produced natural assets at market values

\- Depreciation of non-produced natural assets at contingent values

= Eco domestic product (EDP II)

Of course, the estimates at contingent values refer only to environmental changes which have not yet been recorded at market values.

2.4 Environmental costs caused

The concept of environmental costs caused is based on the principle of **responsibility** for the long-term development of the earth. This attitude recognizes the same rights for all living beings ,irrespective of where they live, at home or abroad. It is based on the ethical position that people should act in a way that does not adversely affect other living beings, now or in the future. This principle represents a **strong sustainability concept**: economic activities should be limited to those which will not entail a decrease in the natural capital. This concept allows the substitution of one type of natural capital for another, but not the replacing of natural by man-made capital.

The suitable valuation concept for such an attitude is the avoidance (prevention) cost approach (see especially: Hueting, 1980, 1993). The decrease in the level of economic activities is measured by the additional costs necessary to achieve sustainable development. This decrease is interpreted as the value of the depreciation of the natural environment, which reduces NDP.

net domestic product (NDP)

\- depreciation of non-produced natural assets at avoidance (prevention) costs

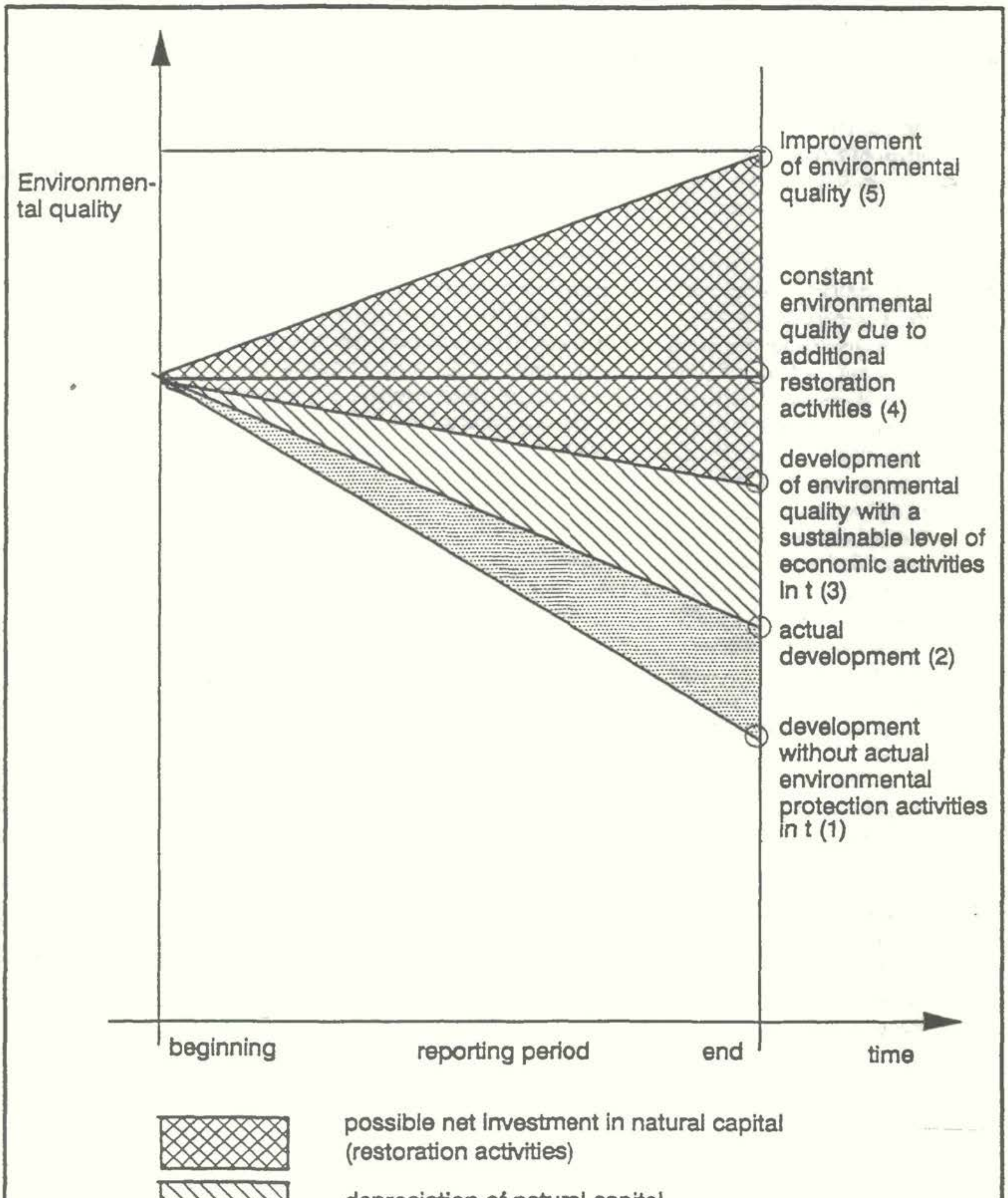
= eco domestic product (EDP III)

It should be stressed that the necessary prevention costs are only calculated for the impacts of **domestic** economic activities during the **reporting period**. Thus, prevention costs comprise the costs of activities which at least prevent further negative impacts of present activities (in the home country or abroad). It could happen that environmental quality would decrease even if no additional negative effects of present activities were added. In this case, the negative development of the natural environment in the reporting period was already recorded in the past by calculating prevention costs for the economic activities of previous periods.

On the other hand, the effects of present economic activities comprise not only impacts in the same period but also in the future. This concept is shown on the right-hand side of *Figure 1*.

In ***Figure 2***, alternative **developments** of the **environmental quality** in the reporting period t are shown. The actual development (2) indicates a diminished decrease in comparison with a (hypothetical) situation of no actual environmental protection activities in t (1). If economic activities in t had no negative impact on the natural environment, the development would be indicated by the (hypothetical) line (3). To achieve a constant level of environmental quality in t, restoration activities in t would be necessary (4) which not only balance the negative impacts

Figure 2: Development of environmental quality in period t



of the economic activities in t (3), but also undo negative impacts of the past. It may happen that the natural environment is already destroyed to such an extent that an improvement of the environmental quality (5) is urgently needed. In this case, further restoration activities will be necessary. Of course, scenarios (4) and (5) will only be feasible if the deterioration of the natural environment is reversible. This assumption seems increasingly unrealistic.

The calculation of avoidance (prevention) costs is only possible on the basis of **modelling**. In the process of thinking about alternative and more sustainable ways of economic performance, the comparison between actual and desirable development can only be hypothetical. The necessary modelling work can be more micro- or more macro-oriented. In the first case, each economic activity is studied with regard to its environmental impacts. In a second step, alternatives are developed which avoid possible negative environmental effects of the actual activities. The difference between the net value added of the two types of activities is treated as (imputed) environmental costs. Adding the differences of all economic activities studied gives the total environmental costs which is subtracted from the net domestic product. The main problem of this approach lies in the dependencies between the economic activities and their impacts on the natural environment, which allow only a restricted additivity of the environmental costs calculated at the micro-level. An alternative way of calculating avoidance costs is to introduce limits (standards) of environmental effects of economic activities first and to calculate, in a macro-economic model, a sustainable level of economic activities (especially of final consumption of products). The difference between the actual net domestic product and the hypothetical net domestic product could be interpreted as the necessary environmental costs. In this case, the eco domestic product would be the net domestic product of the hypothetical economy without negative impacts on the natural environment.

A crucial point of all estimates of avoidance (prevention) costs is the determination of the level of economic activities whose effects on the natural environment could be assimilated without long-term negative impacts. This determination is especially difficult because effects have to be taken into account which could be both long-term and widespread. If knowledge of these effects is limited, a risk-averse attitude should be applied. Furthermore, setting **sustainability standards** also means solving distribution problems. If, for example, global limits on the production of carbon dioxide have been set, the proportion of globally allowed pollution of carbon dioxide as acceptable for individual countries will have to be decided. Theoretically, the principle that pollution per head should be equal worldwide, seems acceptable. Especially if developing countries accept a lower level of pollution they should receive compensation from the (normally richer) countries whose pollution per head exceeds the average.

The strategies to avoid the negative environmental impacts of economic activities differ according to the **type** of asset and **economic use** of the **natural environment**:

- The quantitative decrease of depleting non-renewable natural resources (like subsoil assets), could be diminished by developing more efficient ways of using raw materials. Nevertheless, a decrease in these assets will normally be unavoidable. Thus, their replacement by other types of natural capital is necessary to achieve at least a constant level of natural capital as a whole (Daly 1991). The substitution costs could be used as estimates of the environmental costs.

- For depleting **renewable cyclical** natural assets, natural growth (biota) or natural inflow (groundwater) should be balanced against the quantities lost. If depletion exceeds natural increase, the necessary reduction in net value added of the depleting industries can be used as an estimate of environmental costs;

- **Land use**, sustainability implies a constant qualitative and quantitative level of landscapes and their eco systems. If an increase in economic activities results in a decrease in this level, the necessary reduction in economic activities and in their net value added involved will have to be calculated;

- With regard to **discharging residuals** into nature, numerous possible prevention activities have to be analyzed: the replacement of products (by increasingly more environmentally friendly goods and services), technological changes towards technologies producing low pollution, and a reduction in economic performance, especially lowering the consumption level of the population. To reach specific standards, the strategy based on minimal costs should be chosen, and these prevention costs represent the deterioration of non-produced natural assets caused by pollution.

If additional **restoration activities** were undertaken which balanced the negative impacts of present economic activities (see (3) in *Figure 2*); or even prevented a decrease in environmental quality (4) or increased the quality of the natural environment (5), the costs incurred could be recorded as **gross capital formation** in non-produced natural assets which balance or exceed the depreciation of natural assets caused by the impacts of economic activities in the present reporting period. It seems important to show in an integrated environmental and economic accounting system not only failures, but also all attempts to improve the quality of the natural environment. This could influence the environmental protection activities of the **government**. If restoration activities were observed, an eco domestic product could be derived in the following way:

net domestic product (NDP)

\- depreciation of non-produced natural assets at prevention costs

\+ increase of non-produced natural assets by restoration activities (gross capital formation)

= eco domestic product (EDP IV)

In the case - unfortunately at present unrealistic at present - of a positive net capital formation (gross capital formation minus depreciation) in non-produced natural assets, the eco domestic product will be higher than the domestic product.

An important extension of the concept of environmental costs borne takes into account the environmental impacts of **international trade**. After estimating environmental costs borne in line with the method described, an input-output analysis could be carried out to calculate the direct and indirect environmental costs connected with goods and services exported. These costs should be subtracted from the environmental costs of the exporting country and added to the environmental costs of the importing country. Such corrections could be done for all internationally traded products whose production involves severe environmental problems. In this case, the corrected eco domestic product would be as follows (without taking into account restoration activities):

3. IMPLEMENTATION OF INTEGRATED ENVIRONMENTAL AND ECONOMIC ACCOUNTS

To allow an adaptation of the SEEA to different environmental and socio-economic conditions in individual countries, the SEEA has been designed to be as comprehensive, flexible and consistent as possible. The aim of **comprehensiveness** refers to both a variety of patterns of economic development or categories of environmental deterioration, and alternative theoretical approaches. Data availability and the potential of further improvement of the data base restrict the application of SEEA concepts. These constraints necessitate a **flexible** system which should comprise a variety of building blocks which could be used independent of each other. This necessary flexibility of the SEEA should not affect the consistency of the system. A **consistent** data system will be ensured if the versions of the SEEA remain an extension of the national (economic) accounts and apply the accounting rules of extended accounts.

net domestic product (NDP)

- depreciation of non-produced natural assets at avoidance costs (caused by all domestic economic activities)

+ depreciation of non-produced natural assets at avoidance costs caused directly or indirectly by exported products

- depreciation of non-produced natural assets at avoidance costs caused directly or indirectly by imported products

= eco domestic product (EDP V)

The implementation of the SEEA should focus on **high-priority concerns** and related economic activities. The restricted funds for statistical work do not allow a complete description of environmental-economic interrelationships. In ***Table 1***, possible priorities for implementing the SEEA are shown (see United Nations, 1993, p. 153). This list divides priorities according to the type of statistical unit (data in physical or monetary terms) and according to the type of country (developing or developed). Priorities for implementing the SEEA in countries in transition to market economies have not been shown. One of the results of this workshop could be that a list of priorities is drawn up for integrated environmental and economic accounting.

Implementation will be further limited by **data availability**. It seems useful, therefore, to start by implementing those parts of the SEEA that have high priority and a sufficient data base. After improving the data base, more complete versions of the SEEA can be implemented. In ***Figure 3*** (see United Nations, 1993, p. 150) an overview is given of possible building blocks of the SEEA. Of course, each building block comprises a variety of specific items that have to be compiled separately (for example, accounts for different types of products, raw materials and residuals).

The arrows in *Figure 3* represent **dependencies** between the **compilation** of data for the different building blocks. Data collection for the implementation of some building blocks may require data compiled for other parts of the system. For example, monetary data can, in many cases, be compiled only on the basis of sufficient physical data.

The compilation dependencies among the different parts of the SEEA indicate that **physical** data and accounts need to be established first. **Monetary** data could then be estimated in a second step. This procedure does not exclude the immediate implementation of monetary building blocks that are either already available or less dependent on physical data.

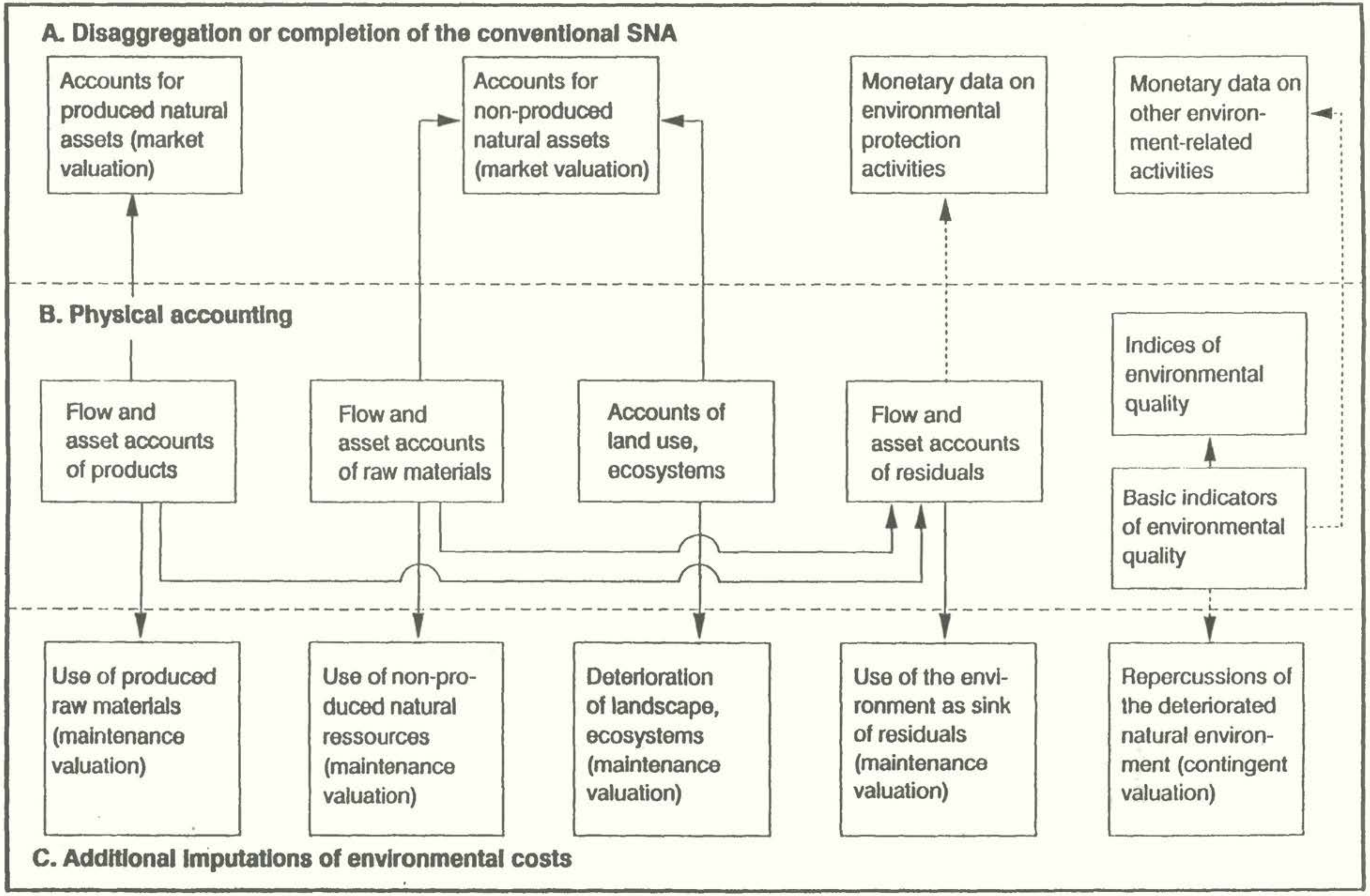
Table 1: Priorities for implementing the SEEA*)

Environmental issues	Physical accounting		Monetary accounting	
	developed country	developing country	developed country	developing country
1. Use of natural assets (except discharge of residuals)				
Depletion of				
1.1 Biological assets	+	++	+	++
1.2 Subsoil assets	+	++	+	++
1.3 Water	0	++	0	++
Degradation of land (landscape)				
1.5 Restructuring (urbanization, changes in land use)	++	++	+	0
1.6 Agricultural use (soil erosion)	0	++	0	++
1.7 Recreational use	+	+	+	+
2. Product flow analysis	++	0	0	0
3. Degradation of the natural environment by discharge of residuals				
3.1 Wastes and land contamination	++	0	+	+
3.2 Waste-water	++	+	+	+
3.3 Air pollution	++	+	+	+
4. Actual environment costs				
4.1 Environment protection activities			++	+
4.2 Damage costs			+	0

++: high priority, +: medium priority, 0: low priority

*) SEEA: Satellite System for Integrated Environmental and Economic Accounting

Figure 3: Building blocks for Implementing the SEEA*)



*) SEEA: Satellite System for Integrated Environmental and Economic Accounting.

The complexity of the task of describing the environmental-economic interrelationships should not discourage statisticians involved in this work. Basing the development of the data system on a **stepwise approach,** with limited aims at the beginning, may reduce the danger of being disappointed and overwhelmed by the difficulties. The task of supporting an integrated economic and environmental policy is so important that every effort should be made to overcome the obstacles.

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Chapter IV

NATURAL PATRIMONY ACCOUNTS AND ENVIRONMENTAL STATISTICS: THE FRENCH APPROACH

Claire Grobecker

Introduction

Demand for reliable and aggregated information on the environment has been growing strongly over the last years as concerns about the environment and the sustainability of economic development have increased. This demand is expressed at several levels:

- in terms of scope. The demand can range from data and indicators related to an aspect of one environmental issue to indicators aggregated over one or several issues and, in some countries, to an indicator integrating environment and economic evolutions (green GDP). It also covers data related to human activities (pressures, environmental protection) and to the state of the environment. This reflects the various uses of environmental data for designing, implementing and assessing environmental policies at different levels;

- in terms of geographical resolution. It is important for environmental decision-making to localise where what happens and to cross reference data since the consequences of human activities on the environment can depend strongly on local natural conditions. As a result, information and indicators are required at national level, but also at international, regional and sub regional levels and sometimes for natural entities, such as water basins.

For the statistician, accounting represents one of the main methods that can be used to answer these various demands:

- Accounts help in the organization of data in a global framework and the checking of data consistently;

- Accounts provide a number of results and aggregates from which indicators can be derived.

As the demand for environmental information and indicators and thereby for accounts increased, the inadequacy of macro-economic theories on which national accounts are built for environmental assessment was recognized. The fact that the depletion of natural resources, the degradation of the environment due to pollution and the goods and services provided by nature was not taken into account was criticized. The necessity of developing another system of accounts to include environmental aspects emerged.

The need for environmental accounts was recognized in France in the seventies - shortly after the Ministry of Environment was created. A commission was set up in 1977, entrusted with developing the conceptual basis for a system of environmental accounts. Their conclusions, laying the basis for the French system of Natural Patrimony Accounts, were published in 1986.

1. *Conceptual basis of the French System of Natural Patrimony Accounts*

Strong orientations were adopted for the commission's work, including:

- The objective of the accounts was to describe the relations and links between the economic system and the natural environment. These relations had first to be described in physical terms before they may be valued. Thus, the focus was placed at the beginning on physical accounts;

- The accounts were to be linked with but not included in the core system of national accounts.

The natural patrimony represents the natural elements and the systems they form which can be transferred to future generations. The concept of patrimony, therefore, integrates the concept of sustainability. The components of the natural patrimony were classified as follows:

- Physical media (soil, inland waters, air, seas);

- Fauna, flora;

- Mineral resources;

- Ecosystems;

In order to describe the relationships between the economic system and the environment, three types of accounts were defined: element accounts, ecozone accounts and actor accounts linked together through linkage matrices, as described in Fig.1. The organization of the system around three accounts makes it possible to apply the double-entry principle and to develop the accounts in a flexible, modular way.

Element accounts describe in a balance sheet the stocks and flows of the prime components of the natural patrimony. Flows are classified according to the origin/destination of the flow and the process causing it. Thus, flows can occur between the natural system and the economic (users) system, between the territory under consideration and the rest of the world or between components of the natural system. They can be due to natural processes or be induced by human activities (Fig. 2).

Fig. 1: Structure of the Natural Patrimony Accounts

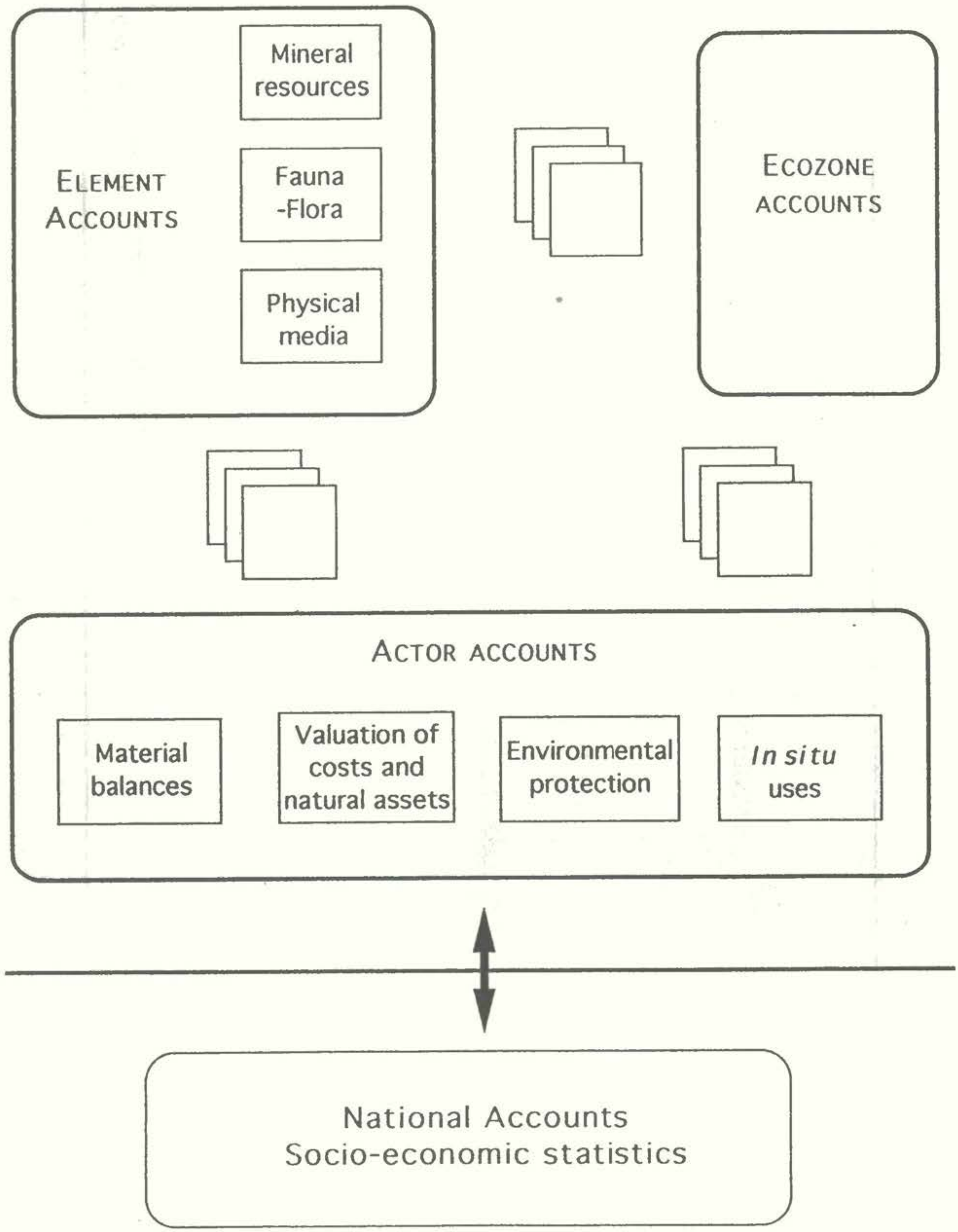
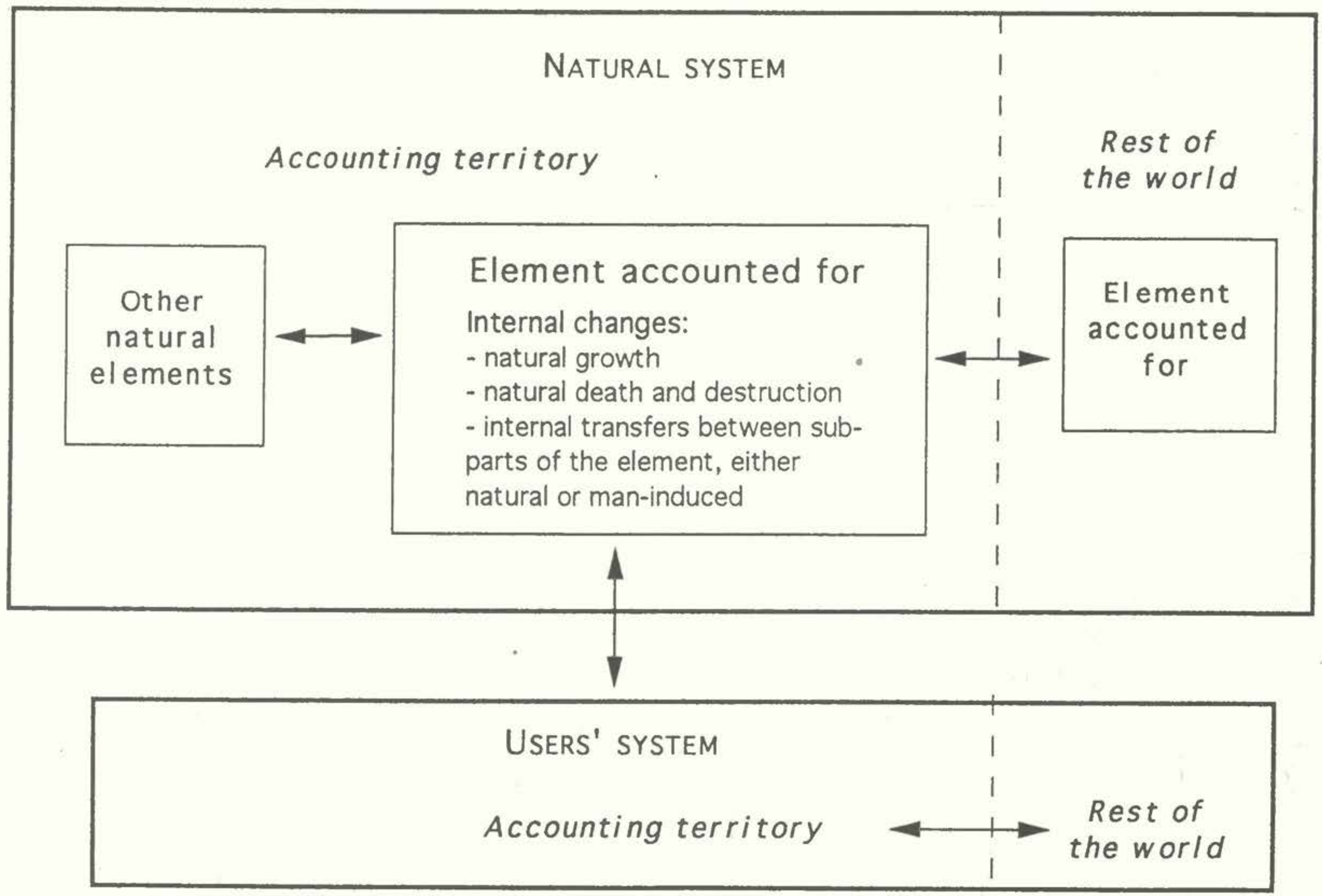


Fig. 2: Systemic analysis of element accounts



Quality aspects can be integrated by establishing stocks and stock variations by quality classes: the total (quantitative) stock of the element is partitioned into classes of quality and stocks by quality classes are recorded at the beginning and at the end of the accounting period, so that stock variations can be estimated.

Ecozone accounts describe the stocks and flows relating to the ecozones defined as a statistical representation of ecosystems. Changes are recorded in terms of change in the nature of ecozones (e.g. a forest becomes an arable land or is built up) and in terms of internal changes within types of ecozones. These internal changes are related to changes in the composition of the ecozone and are discerned at two levels:

- the level of elementary components (biotic and abiotic);
- a global level, reflecting the health/quality of the ecozone.

The field potentially covered by actor accounts is shown in Fig. 3. The specification and development of actor accounts, however, has been fragmentary, related to parts of material balances and environmental protection.

Material balances describe the flows of natural resources from the economic system, as entries from the natural system or the rest of the world, transfers between economic sectors and returns to the natural system as emissions and discharges. Part of this account (flows between natural and the economic systems) is the counterpart of the element account of natural resources.

The account of environmental protection is expressed in monetary units and describes national expenditure for environmental protection, associated production and its financing through transfers between institutional sectors.

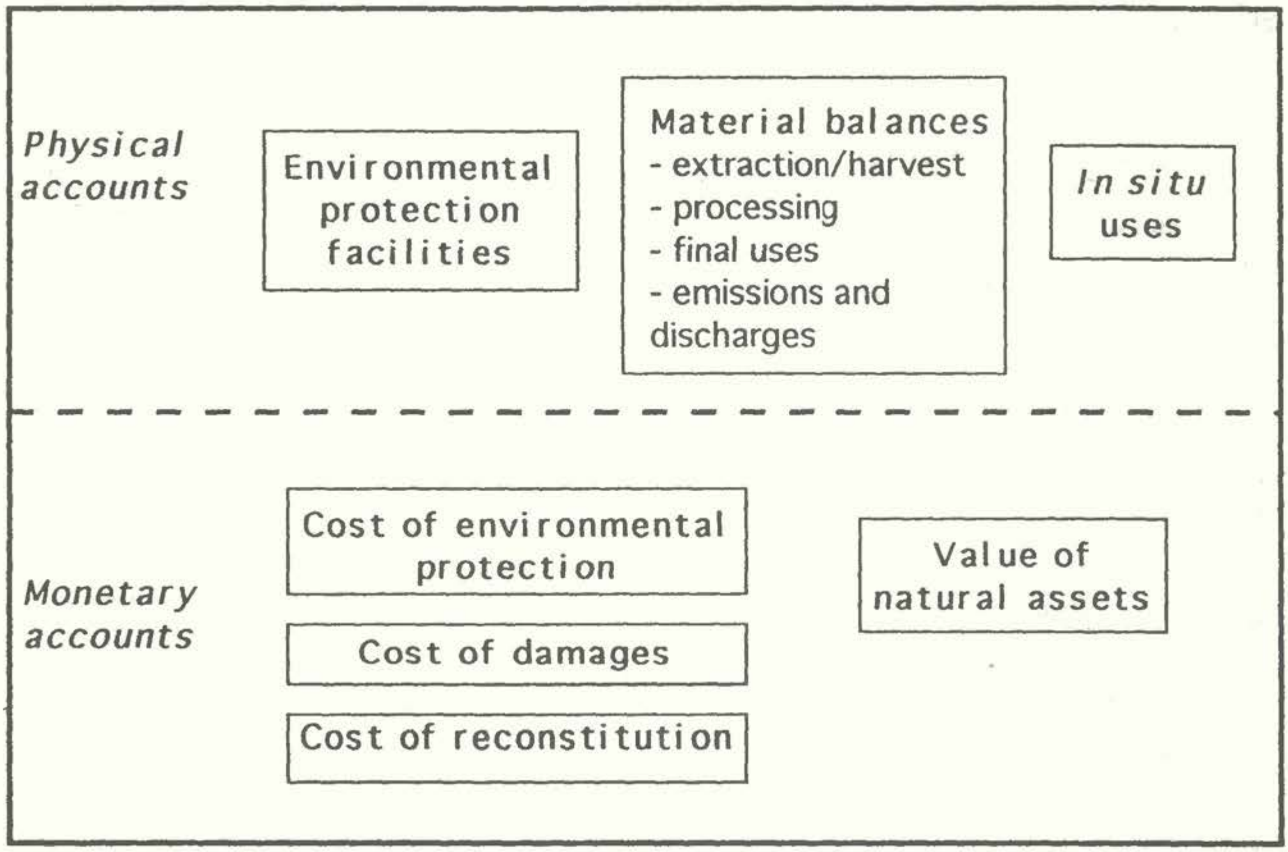
2. *Pilot realizations*

The Commission of Natural Patrimony Accounts carried out a few pilot studies to test the feasibility of the accounts. The methods have been further developed and results computed for some elements, such as inland waters, forest and fauna-flora, and for satellite accounts.

The present paper presents only the inland waters accounts, which are the most fully developed, and the environmental protection accounts. For the accounts of fauna-flora and forest, the reader is referred to appendices 1 and 2, for a summary of results, and to the literature.

Figure 3

Fig. 3: Field of the actor accounts



2.1 ***Inland water accounts***

Element quantitative accounts and material balances for France and for the water agencies [for the calendar year 1981] were developed and computed (Table 1). These accounts describe in volumetric units the formation, management and utilization - by economic activities or by natural processes - of water resources and stocks. An account of water quality was also established for one river.

Classifications were developed for the natural inland water system, economic actors and flows. The classification of economic actors was derived from the analysis of the water cycle within the users' system (producers, distributors, consumers, sanitation) and the consumer classes were based on those used by water agencies for their estimations of water withdrawal (industry, agriculture, energy, public supply).

River quality assessment for the quality account was based on the classes defined by water agencies. The river was divided into segments of homogenous quality, and the quantity of water was estimated for each segment in standard river kilometers (1 standard river km = 1 km of river with a flow of 1m/s). Thus, stocks of water per quality class could be obtained for three years, and stock variations were established (Table. 2).

Several indicators can be derived from the water accounts, some of which were adopted in the OECD system of environmental indicators:

- *Intensity of water use; intensity of water consumption:*

These indicators are defined as:

$$\frac{\text{water withdrawal}}{\text{flow of renewable water}} \quad \text{and} \quad \frac{\text{water consumption}}{\text{flow of renewable water}}$$

The flow of renewable water corresponds to the natural outflow of surface water and groundwater. The accounts establish the natural outflow, since measured outflows are disturbed by various human uses and have to be corrected.

Water consumption reflects the water withdrawn from and not returned to the inland water system.

A ratio of water of consumption over 100 per cent indicates that part of the water demand is covered by the exploitation of stock and that quantitative water management is not sustainable; however, lower ratios, from 10 per cent for water consumption and 25 per cent for water use indicate risks of degradation of water quality and ecosystems and of local water shortages.

Table 1: Inland water quantity accounts - Results of 1986

A. Global balance sheet

Period: calendar year 1981 Unit: 10^9 m^3 Area: France

Source: Les Comptes du Patrimoine Naturel

STOCKS AND FLOWS / ELEMENTS	INITIAL STOCK	T1. PRIMARY INPUTS: F111 Precipitation	T1. PRIMARY INPUTS: F112 + F132 Influents & transactors inflows from the outside	T1. PRIMARY INPUTS: A TOTAL PRIMARY INPUTS	T2. NET INTERMEDIATE INPUTS: INTERNAL TRANSFERS BALANCE	T2. BACKFLOWS AND INFLOWS: F311 + F312 Backflows, discharge	T2. BACKFLOWS AND INFLOWS: F321 Irrigation	T2. B TOTAL NET INTERMEDIATE INPUTS	C = A+B GROSS ANNUAL AVAILABILITY	T3. PRIMARY WITHDRAWALS AND FINAL USES: F411 Primary withdrawals	T3. F221 Evapo-transpiration	T3. F121 Natural ---> sea	T3. F121 outflow ---> outside territory	D TOTAL WITHDRAWALS AND FINAL USES	E = C-D NET ACCUMULATION	FINAL STOCK
E9 Land/Atmosphere Interface		332,0		352,0	-302,0			-302,0	50,0		50,0			50,0	0,0	0,0
E5/E6 Soil and vegetation cover	80,0			0,0	249,4		3,5	252,9	252,9		252,9			252,9	0,0	80,0
E41 Underground waters	2 200,0			0,0	19,1	7,0		26,1	26,1	6,6		1,0		7,6	18,5	2 218,5
E42 Snow and glaciers	26,3	20,5		20,5	-17,0			-17,0	3,5					0,0	3,5	29,6
E43 Lakes and dams	52,3	1,5		1,5	0,2			0,2	1,7		1,1			1,1	0,6	32,9
E44 Rivers: E441 Irregular stream		1,0	17,0	18,0	166,6			166,6	184,6	3,6		153,0	28,0	184,6	0,0	0,0
E44 Rivers: E442 Regular stream	7,0		21,0	21,0	83,7	23,0		106,7	127,7	27,0	0,7	77,0	23,0	127,7	0,0	7,0
TOTAL	2 365,6	575,0	38,0	613,0	0,0	30,0	3,5	33,5	646,5	37,2	304,7	231,0	51,0	623,9	22,6	2 388,2

B. Water use

TRANSACTORS	INTERMEDIATE INFLOWS	PRIMARY WITHDRAWALS from surface water	PRIMARY WITHDRAWALS from underground water	TOTAL INPUTS	TRANSFERS BETWEEN TRANSACTORS MATRIX: A1 Drinking water distribution	A3 Manufact industries	A6 Agriculture	A7 Households	A8 Public authorities: A81 Sanitati	A8 Public authorities: A82 Other	S/TOTAL INTERMEDIATE OUTPUTS	OUTPUTS FROM THE UTILISATION SYSTEM: F31. Backflows: F311. Losses & leaks	F31. Backflows: F312. Returns, discharg	F32. Irrigation	F43. Evaporation	F14. Backflows to the outside: ==>sea	F14. Backflows to the outside: ==>other territor	S/TOTAL OUTPUTS FROM THE UTILISATION SYSTEM	TOTAL OUTPUTS
A1. Distributors/drinking water	0,60	2,10	3,50	6,20	0,47	0,66	0,19	2,42		0,56	4,30	1,90						1,90	6,20
A2. Distributors/irrigation	0,60	0,33		0,93	0,08	0,08	0,11	*		*	0,27	0,06						0,06	0,33
A3. Manufacturing industries	0,82	3,47	1,70	5,99					0,46		0,46	0,64	4,60		0,29	*		5,53	5,99
A4. Power producers	0,60	19,53		20,13							0,00	*	16,83		0,17	2,53		19,53	19,53
A5. Mining industries	0,82		0,07	0,89	0,03	0,03					0,06					0,01		0,01	0,07
A6. Agriculture	0,30	2,90	1,30	4,50						*	0,00	1,05	*	3,45		*		4,50	4,50
A7. Households	2,42		0,05	2,47					1,27		1,27	0,60	0,47		0,13	*		1,20	2,47
A8. Sanitation, local authorities	2,74	2,22		4,96	0,02	0,05			0,35	0,10	0,52	2,19	1,75		0,07	0,42	0,01	4,44	4,96
TOTAL	8,90	30,55	6,62	46,07	0,60	0,82	0,30	2,42	2,08	0,66	6,88	6,44	23,65	3,45	0,66	2,96	0,01	37,17	44,05

- *Proportion of used water in rivers*

This is defined as the ratio $\frac{\text{discharge of used water}}{\text{flow of surface water}}$

The indicator shows the proportion of water in rivers accounted for by used water. High ratios indicate risks of river degradation and probable high costs for the production of drinking water.

2.2 *Satellite accounts*

The objectives of environmental satellite accounts are to provide a precise picture of the economic aspects of environmental protection and its place in the global economy. More particularly:

- how much is spent for each type of actions and what are the costs?

- who finances and who benefits from expenditures for environmental protection?

- what are the impacts?

Existing satellite accounts (such as health and research) provide the basic structure for environmental satellite accounts. These latter were to include both monetary and physical accounts and to be formed by sub-sets of tables corresponding to the areas of intervention of the Ministry of the Environment: management of inland waters (including water production and waste water treatment), waste (including waste collection, treatment and recycling), protection of the marine environment, protected areas and hunting.

For each area, a list of characteristic activities was established and tables were computed to estimate expenditure by actor (producers of characteristic activities, financiers, beneficiaries). In fact, only the waste account was fairly extensively developed. The accounts for the other sectors remained incomplete and only a few or incomplete tables were computed because of the lack of data. Further, it was not always possible to use the official sectoral classifications because of difficulties in disaggregating data.

[The results of the waste account are given as an example in appendix 3 (in French).]

The tables and figures published in 1985 have not been updated. An estimate of expenditure for environmental protection, derived by main sectors is published every year by the Ministry of the Environment, but it is not based on accounting results and is of questionable quality.

Table 2: Inland water accounts - results of 1981
River quality

Unit: standard river kilometer (km.m^3/s) - River Vire

Quality classes	Weighting factors (a)	1972 Sections 1	2	3	4	5	TOTAL	Variations 1972-1976	1976 Sections 1	2	3	4	5	TOTAL
1A	1	13					13	0	13					13
	0,9		42	344			386	-386						0
	0,8						0	0						0
1B	0,6						0	0						0
2	0,6						0	257		28	229			257
3	0,4				140		140	-140						0
	0,2					68	68	70				70	68	138
TOTAL		13	42	344	140	68	607	-199	13	28	229	70	68	408
Average overall quality		1	0,9	0,9	0,4	0,2	0,54		1	0,6	0,6	0,2	0,2	0,36

Quality classes	Weighting factors (a)	1976 Sections 1	2	3	4	5	TOTAL	Variations 1976-1981	1981 Sections 1	2	3	4	5	TOTAL
1A	1	13					13	47	13	47				60
	0,9						0	344			344			344
	0,8						0	280				280		280
1B	0,6						0	204					204	204
2	0,6		28	229			257	-257						0
3	0,4						0	0						0
	0,2				70	68	138	-138						0
TOTAL		13	28	229	70	68	408	480	13	47	344	280	204	888
Average overall quality		1	0,6	0,6	0,2	0,2	0,36		1	1	0,9	0,8	0,6	0,78

2.3 *Use of the results*

The results are little used for environmental management, perhaps because the results of the physical accounts were too scattered and resources were not available for completing them. In addition, the presentation of the results in a rather raw way as accounting tables was not adapted to the needs and practices of managers, who are not used to information presented in this complex form.

Although all the projects launched were not successful, the pilot studies proved the feasibility of accounting and the potential of this approach for data work, namely organizing data and improving their consistency. They provided methodological and practical results which can be useful for the implementation of environmental accounts on a larger basis.

The results also raised a considerable interest at international level, as different approaches and conceptions of environmental accounting were discussed. A large part of the French experience in environmental protection accounting was taken over by Eurostat in its system of economic information on the environment (SERIEE).

3. *Present developments*

On its creation in 1992, the French Institute of the Environment began a programme to develop Natural Patrimony Accounts.

Because resources for such accounts were limited, priority was given to a limited number of modules: inland waters, land cover/land use and environmental protection accounts. Priorities were decided according to demand for information and data availability in the various areas.

3.1 *Inland waters*

A preliminary study was conducted to specify modalities for developing water accounts on a regular basis, precise users' needs and data availability and also to propose alternative scenarios. This was largely achieved through consultations of potential users and experts as well as through analyzing the experience gained from the pilot study.

The way data were obtained was analyzed, which showed a great diversity of sources and estimation methods (Figure 4). It appeared that parts of the accounts rely largely on expert estimations or on data from the literature representing average values rather than data related to a definite period.

A simplified element account was proposed (Table 3), which could be established every year and completed every 5-10 years by an extensive account on the model of 1981. In the simplified model, the inland water system is considered as a whole: transfers between the

Fig. 4 method of estimation of accoun' g items

		Primary inputs			Intermediary inputs			Primary withdrawal and final uses				
		F111	F112	F13	F23 + 33	F311 + 312	F321	F411	F221	F121	F14	
	Initial stock	Rainfalls	Influents	Importations	Internal transfer balance	Backflows & discharges	Irrigation	Primary withdrawal	Evapo-transpiration	Natural outflow	Exportations	Final stock
E5-E6 Soil & végétation												
E41 Underground waters												
E42 Snow and glaciers												
E43 Lakes & dams												
E44 Rivers												
E0 Total inland waters					0							

	Primary inputs		Transfers between actors				Outputs from users' system				
	F411	F13	F42a	F42b	F42c	F42d	F311	F312	F32	F43	
	Primary withdrawal	Importations	Transfers producers-distributers	Water supply	Sanitation	Waste water treatment	Backflows	Discharges	Irrigation	Net consumption	Exportations
A11 Producters and/or distributers of drinking water											
A12 Other producers and/or distributers of water											
A2 Industries											
A3 Power production											
A4 Agriculture											
A5 Public authorities											
A51 Households											
A52 Other users											
A53 Sanitation											
A54 Waste water treatment											

Key

- value derived from independant measures
- value provided by the literature and inventories
- value derived from statistical imputations
- expert estimation
- value derived from accounting balances

Table 3: Inland water account - Simplified element account

Initial stock		
Primary inputs		
F111	Rainfalls	
F112	Influents	
F13	Importations	
A Total		
Intermediary inputs		
F311	Backflows	
F312	Discharges	
F321	Irrigation	
Intermediary outflows		
F411	Primary withdrawal	
B Total		
Final uses and outflows		
F221	Evapotranspiration	
F121	Natural outflow	sea
		rest of the world
F14	Exportations	
C Total		
Final stock		

different components and regulations through dams are not analyzed. The model does , however, allow a global assessment of the balance between water resources and uses and the computation of the above indicators. The simplification also largely reduces the part of data relying on expert estimations, so that a better comparability in time and space can be expected.

Strong needs for localized and not only national results, and for intra-annual accounts on the low-water period were expressed. There was consensus to compute accounts on the geographic basis of river commissions (about 30-40 entities in France, with an average surface of 15,000 km2).

Accounts for one water basin are to be drawn up soon, in order to assess more precisely the difficulties, costs and possibilities of developing automatic procedures for regular production.

On water quality accounts, it was concluded that the statistical reliability of data on the river quality had to be improved before accounts could be reasonably produced. Although maps of river quality have been established, they depend heavily on expert estimations for the extrapolation of point-measures to river segments and comparability in time and space is poor. The priority in statistical terms, therefore, was thought to be the improvement of comparability of data and harmonization of extrapolation methods. Accounting methods alone cannot in this case contribute to data consistency and help mainly present and aggregate data and identifying data deficiencies.

Land use/land cover

3.2 Land use/land cover accounts form a first step towards ecozone accounts, since land use/land cover classes can be considered as a representation of the nature of ecozones. The description of internal states and changes within ecozone types would be the next logical step towards ecozone accounts.

The work on land use/land cover started on an experimental basis as the method had first to be developed and tested. It forms of a larger pilot project initiated by the United Nations Economic Commission for Europe (UNECE) on environmental physical accounts. The objectives of this project are to develop a conceptual basis and test the feasibility of environmental accounting around two issues, land use/land cover and nutrients. The working group on land use/land cover includes Austria, France, Germany, Poland and the United Kingdom and is steered by France.

Three building blocks - human activities, land use/land cover, environmental effects were defined, which are to be developed and linked together. The group opted for an issue-oriented approach, whereby each participant works on issues most relevant to local considerations. The following issues were defined:

- soil sealing

- partitioning of space
- naturalness/articiality
- biodiversity
- impact of tourism

The modules corresponding to the various issues are to be linked to a core set of land use/land cover accounts which is to be investigated by all countries. Thus, work modules can be integrated in a global data model as shown in Fig. 5. This model ensures flexibility for module development as well as consistency through linkage to a core set of accounts.

The broad structure of the core set was further defined (fig. 6). Accounts are in surface units and include:

- a description of present land use, land cover and of the relations between land cover and land use on one hand and between land use and activity sectors on the other hand.

- a description of changes; changes can be apprehended in terms of inputs/outputs but also in terms of processes responsible for the changes. The analysis of processes should help in particular to identify and qualify those changes due to human activities and those due to natural processes.

  The second account of changes differs from the input/output matrix in two ways:

- disaggregation of certain flows, e.g. a change from a moor to a forest can result from the colonization by trees (natural process) or from the plantation of trees (process resulting from human activities).

- aggregation of certain flows, e.g. forests which were planted during the accounting period result from a process of afforestation, whatever the initial land cover.

The presentation of changes in the second way, therefore enhances the analytical power of the account over an input/output matrix. It will probably imply the compilation and integration in a single framework of additional data sources, which means that difficulties, but also improvements in the consistency of data, are to be expected.

The specification of accounting schemes, classifications and units, as well as data work are beginning or underway and results are expected by the end of the year for the participating countries. Developments at IFEN have concentrated so far on accounts of changes and a simplified version of the account structure is shown in Table 4. The classification of flows is provisional and may require modification during data work.

<u>Table 4:</u> Land cover accounts
Summary tables

A. Stocks

Land cover class	Initial surface	Variation	Final surface
Inland waters Open wet land			
Water surfaces and wet land			
Snow and glaciers Bare rocks Sand, beaches			
Open and bare land			
Forests Other woods, hedges Moors and ancient fallows			
Areas with natural/semi natural vegetation			
Arable land Grassland Permanent crops			
Agricultural land			
Gardens and recreational grassland Altered soils (quarries, mines, constructions...) Transport networks Built-up land			
Artificial land			
Total	S	0	S

Fig. 5: Global model of land use/land cover accounts

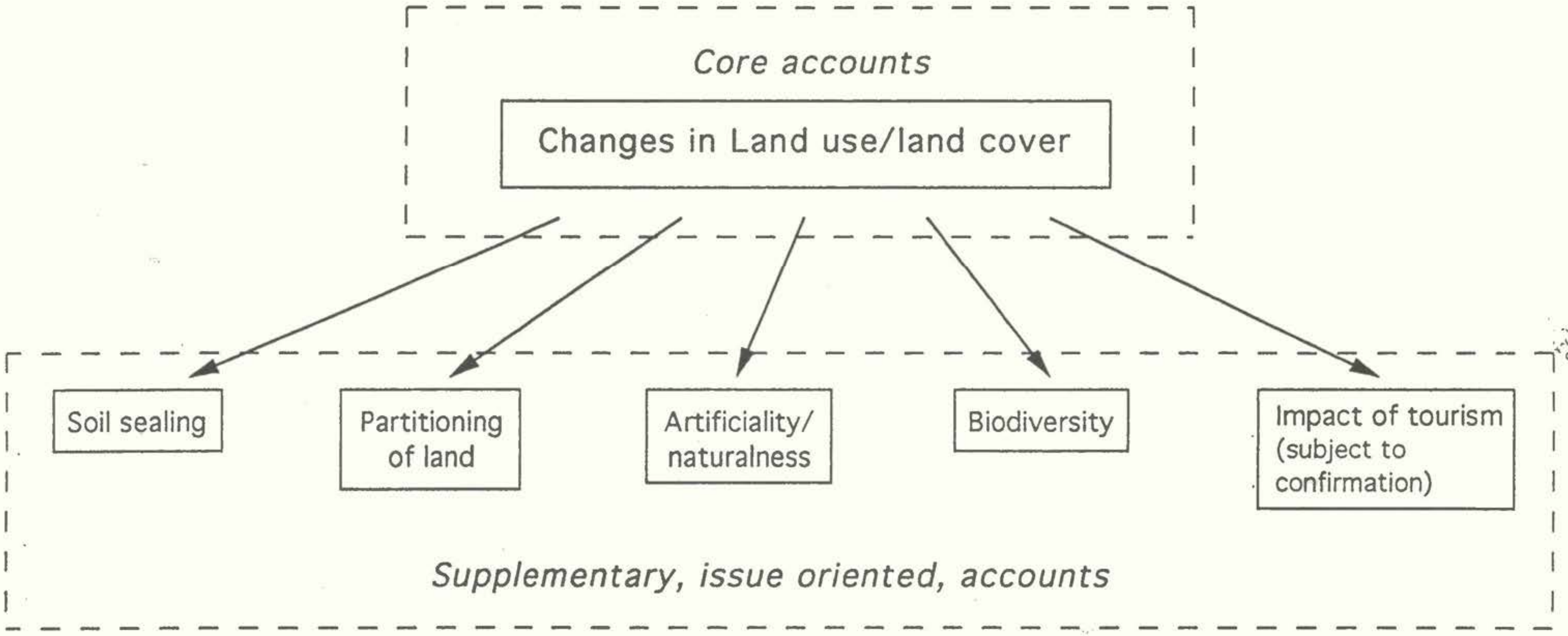
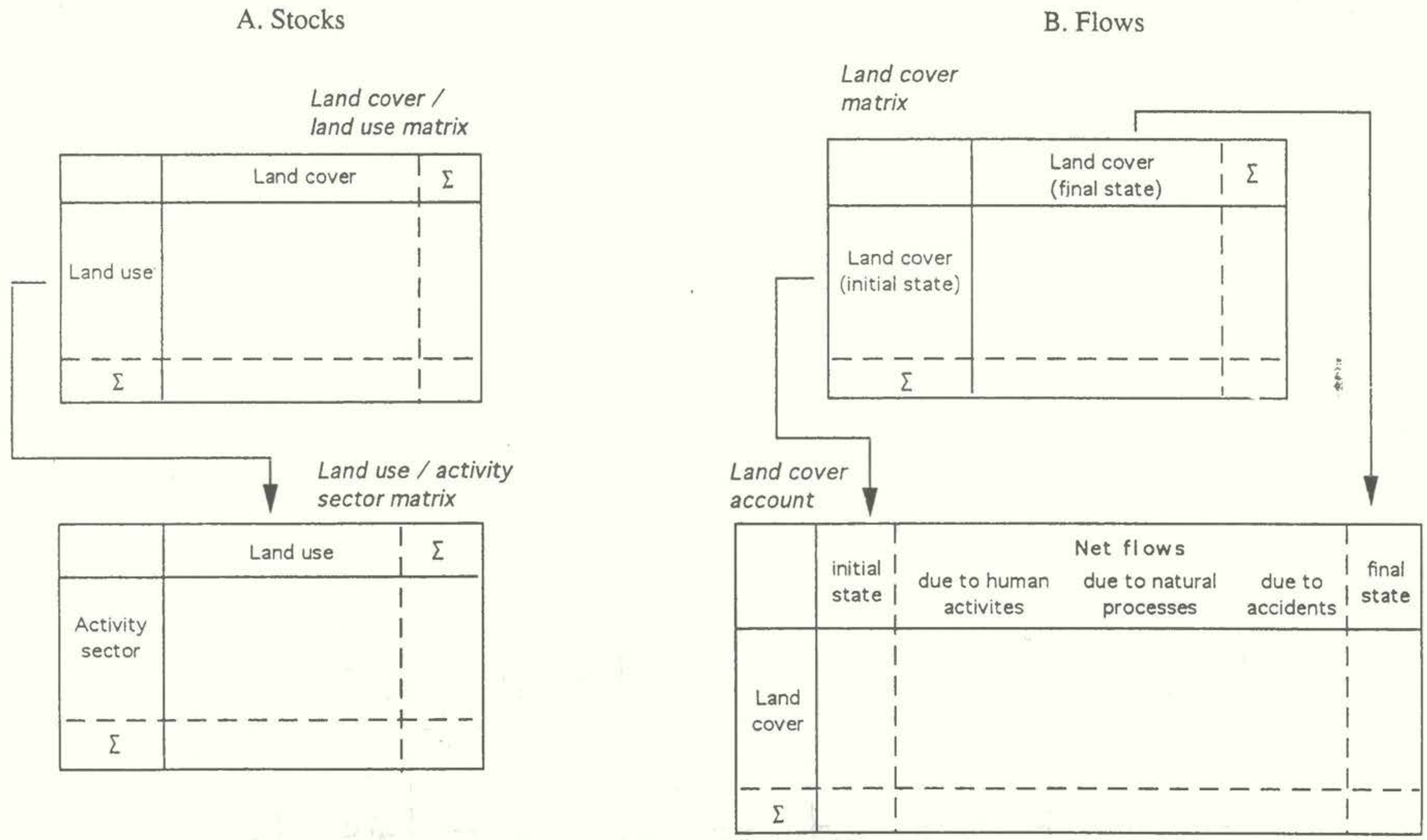


Fig. 6: Structure of the core set



B. Flows

	Process of change	surface affectée
F11 F12 F13 F14-15-16 F17 F18 F19 F110	Extension of housing Extension of commercial and industrial zones Extension of transport networks Extension of mining & building activities, dumpings Water management Coastal management Development of amenities Others	
F1	*Total Urbanisation et aménagement*	
F21 F22 F23 F24 F25	Extension of agricultural land Modification of land cover by/for grazing Management of hedges and groves (plantation/cutting) Change in cropping system Others	
F2	*Total agricultural activities*	
F31 F32	Afforestation Others	
F3	*Total forestry activites*	
F4	*Changes due to other human activities*	
FI	**Total Human activites**	
F51 F52 F6 F71 F72 F8	Natural colonisation/ Naturel regression Natural changes in water regime Erosion Sédimentation Others	
FII	**Total Natural processes**	
FIII	**Accidents** Fire Avalanches...	
F0	TOTAL	Surface concerned by a change of affectation

In France, the main source of data available on a national basis for the account is the land use survey carried out annually by the Ministry of Agriculture since the seventies (enquete Ter-Uti). Input-output matrices are available, from which the account of change can be derived by a two-fold process of disaggregation and aggregation.

3.3 *Accounts of environmental protection*

Accounts of environmental protection are developed at IFEN with priorities on waste and water. A preliminary study was conducted in 1993 and with results planned for 1994.

Present French work on environmental protection is entirely based on the SERIEE method, which was developed by Eurostat as the central part of the European Programme of Economic Statistics on the Environment. The concepts and methods presented here are, therefore, those of SERIEE.

SERIEE is composed of the following modules, which include economic and physical data:

- environmental protection activities;
- the management of natural resources;
- environmental heritage.

Work has started on the first module, which has been assigned the following objectives:

- to provide the data necessary to evaluate the application of the polluter-pays-principle and the internalization of environmental costs.

- to assess the cost of environmental protection for producers and the consequences in terms of international competitiveness;

- to value the activities linked to environmental protection in order to provide market insights for specialized facilities and clean products;

- to evaluate the effectiveness of protection measures by comparing their financial cost and their impact on pollutant emissions and pollution levels of the environmental media. This part implies the establishment of linkages between monetary and physical data.

At present, the development of SERIEE is limited to environmental protection expenditure and its financing. Work has concentrated on definition of the environmental protection fields, the accounting framework for describing protection activities and methods of data collection.

(i) Field of environmental protection

Environmental protection includes all the measures and activities aimed at abating pollution of media and damage to habitats and species. Classifications of environmental protection activities and of associated facilities have been established jointly by Eurostat and UNECE.

Excluded from environmental protection are activities to manage natural resources which are described separately, and expenses for safety in the work place or for technical requirements of the production process.

In addition, a list of products whose use satisfies an environmental protection goal is being established; these are so-called "connected" products (such as catalytic converters and bin liners) which reduce the pollution discharged into the environment, or "adapted" products which reduce pollution resulting from consumption (such as phosphate-free washing products and unleaded petrol, etc).

(ii) Accounting framework

The Environmental Protection Expenditure Account includes for each environmental field and for all fields together [three sets of tables]; these describe national expenditure on environmental protection, economic activities induced by environmental protection and the financing of expenditure.

In order to ensure international comparability, the operational accounting rules and classification of actors have been defined as closely as possible - given the specificities of the various environmental fields - to those used in the European System of Integrated Environmental Accounting (ESA) and the revised SNA.

(iii) Determination of the national expenditure:

The first aggregate is national expenditure for environmental protection, which is equal to the part of the uses of goods and services and transfers intended for environmental protection that is nationally financed.

National expenditure (Table 5) is valued for the different categories of actors in terms of current expenditure (consumption of goods and services and current transfers) and capital expenditure (investments and capital transfers).

Table 5: Components of the National Expenditure

BENEFICIARY	General Govt & NPI as collective consumer			Producers			Hholds as actual cons.	Rest of the World	Total
				Specialized		Oth.			
	CG	LG	NPI	GG & NPI	Oth.				
1 Current expenditure in G&S									
characteristic services	x	x	x	-	-	x	x	-	x
adapted products	-	-	-	-	-	x	x	-	x
connected products	-	-	-	-	-	x	x	-	x
2 GFCF and other capital expenditure of EPS producers	-	-	-	x	x	x	-	-	x
3 Transfers									
subsidies									
for EPS	-	-	-	-	-	x	x	x	x
for ACP	-	-	-	-	-	x	x	x	x
other transfers	x	x	x	x	x	x	x	x	x
current	x	x	x	x	x	x	x	x	x
capital	x	x	x	x	x	-	-	x	x
4 Uses of resident units (1)+(2)+(3)	x	x	x	x	x	x	x	x	x
5 Financing by the Rest of the World	x	x	x	x	x	x	-	-	x
6 National expenditure (4)-(5)	x	x	x	x	x	x	x	x	x

Source: SERIEE manuel

Abbreviations

GC General Government
CG Central Government
LC Local Government
NPI Non-Profit Institutions
EPS Environmental Protection Services
ACP Adapted and Connected Products

(iv) Description of production:

Financial flows (Table 6) are computed for the "internal production" realized by the different actors (current or capital outlays, net transfers, subsidies, subsidies and grants received) and for specialized activities (purification of waste water, collection and treatment of wastes). Thus, the impact of environmental protection activities on national economies (such as the demand for intermediate products and labour engaged in environmental protection activities) can be analyzed. The cost of protection measures can also be linked to emission trends so far as the latter are known.

(v) Financing:

The detailed description of the financing of national expenditure (Table 7) helps to establish transfers and identify the ultimate financiers. Thus, it is possible to assess to what extent and according to which modalities the polluter-pays-principle is actually implemented.

By providing a valuation of the net burden borne for internal measures, external services or taxes and charges, it is also possible to characterize the extent that producers are penalized in relation to their competitors.

(vi) Data sources:

Data are to be provided by the national statistical system in order to reduce collection work and ensure compatibility with general economic data. There are, however, some difficulties with the present system to disaggregate environmental protection expenses from other expenses. Thus, additional questions will probably have to be included in present surveys and new surveys, e.g. for some government bodies, may be required. For example, an industrial survey on pollution abatement investment has been conducted in France and another one on current expenditures is being considered.

3.4 *Difficulties in developing environmental accounts and limits*

The main difficulty to obtain a balance between long-term considerations and short-term constraints. Thus, rapid results are necessary and at the same time, a consistent accounting system integrating the many environmental areas and linked with economic datamust be built. Difficulties relate to the following aspects:

Table 6: Simplified account of characteristic producers

PRODUCERS	Specialized				Non Special.
	General Government & NPI			Other Sectors	
	CG	LG	NPI		
CURRENT TRANSACTIONS					
Current uses[1]					
Intermediate Consumption (P20)[2]	x	x	x	x	x
Compensation of employees (R10)	x	x	x	x	x
Consumption of fixed capital (A1)	x	x	x	x	x
Other taxes (R222)	x	x	x	x	x
Net operating surplus (N12)[3]	-	-	-	x	-
less (if any)[4]					
Resources from rel. products[5],residual sales	x	x	x	x	x
of which own consumption					
of which sales					
less (if any)					
Other subsidies (R312)	x	x	x	x	x
	x	x	x	x	x
Output (basic price)[6]					
less subsidies on products (R311)[7]	x	x	x	x	x
plus taxes on products (R221)	x	x	x	x	x
Output (producers' price)[8]					
non-market	x	x	x	-	-
market	x	x	x	x	-
ancillary	-	-	-	-	x
Current resources					
Sales of EPS[9]	x	x	x	x	-
Partial Payments linked to EPS[10]	x	x	x	-	-
Current transfers[11]	x	x	x	-	-
CAPITAL TRANSACTIONS					
Gross fixed capital components (P41)	x	x	x	x	x
Other capital uses (P71 + P72)	x	x	x	x	x
Investment grants received (R71)				x	x
Capital transfers received (R79)	x	x	x	-	-
Financing by producers	x	x	x	x	x
Labour input[12]	x	x	x	x	x
Stock of fixed capital[13]	x	x	x	x	x

Source: SERIEE manuel

(i) Data:

Some data to complete accounting balance sheets required may be missing, as all the flows/stocks necessary to complete the accounts are not necessarily monitored. As a result, accounts may rely largely on expert estimations, so that problems of comparability over time and space can arise.

Though accounts can help in checking the overall consistency of data, the data to be entered in the accounts still have to be checked, assessed for their quality and statistically treated before they are entered and rules must be defined to decide which data are the cornerstones of the accounts.

(iii) References to space and time:

Periods other than the calendar year, e.g. the hydrological year for inland waters, may provide results which are much more significant in environmental terms and better adapted for policy-making in a given environmental area. The use of such periods, however, makes linkages between environmental and economic data difficult. Similar problems may arise when geographical accounting units have to be chosen on the basis of either natural or administrative criteria.

Classifications of economic actors:

Often, data collection and action for a particular environmental area are based on specific classifications of economic actors, which are not necessarily compatible with official nomenclatures. Thus, official nomenclatures are often difficult to use because there are no data based on them; they are also often inadequate to describe the interactions between environment and the economy. For example, part of the land is used by productive sectors (agriculture, industry, administration), part is used by households ("consumptive" activity) and part (roads, public areas) is used by all sectors for productive and consumptive activities. Public services run by local governments, such as water supply and waste collection often address an aggregation of households and that part of productive activities which make use of the public service rather than internal facilities, so that compiling data on a sectoral basis implies disaggregating data on local governments services and reaggregating them with sectoral data.

Although the statistician has little choice but to use what is existing for short-term production, the problem of harmonizing of classifications be addressed if the long-term consistency between building blocks and the construction of an integrated system is desired. Progress could be obtained by developing an environmental classification of economic actors which could be used across environmental fields for physical accounts; this option is under consideration at IFEN. As the new SNA is implemented, revisions of some classifications may help to improve their adequacy for economic environmental accounting.

(iv) ***Accounts of environmental quality:***

Many conceptual problems have to be solved before quality aspects can be included in the accounts. The use of the method proposed in the Natural Patrimony Accounts for an environmental element implies that the following conditions are met:

- A system of quality assessment defining quality classes for the element must exist and be widely accepted;

- The whole stock of the element is known and can be assigned to quality classes. This implies a regular monitoring of quality and sufficiently reliable methods for extrapolating the observations to the whole stock of the element.

At this stage, there is no model for double-entry quality accounts and, in most cases, variations of stocks cannot be checked against the balance of flows. Flows between classes can be basically due to a few processes - changes in pressure, self regeneration and spontaneous change in natural conditions. Such flows are not monitored and general quantitative models to predict them data on pressures are rare. This means that the quality of the accounting depends entirely on the quality of the collected data and the extrapolation method. The account must be considered only as a method of presentation and aggregation.

(v) ***Articulation between economic and physical accounts:***

The construction of the system of Natural Patrimony Accounts began with the two extremes, economic accounts of environmental protection, which are close to and linked to national accounts and physical accounts. The consistency of and articulation between these building blocks will have to be investigated at some point and the missing parts between them constructed. The physical part of the account of environmental protection, which Eurostat plans to develop, complementary to the monetary accounts, could serve as starting point for establishing these links.

4. ***Conclusion***

Environmental accounting has been much discussed internationally following the Rio Conference in 1992 on one hand and developments at international statistical offices on the other (development of the SEEA by the United Nations Statistical Office associated with the revision of the SNA, SERIEE). Many countries, therefore, are considering implementing environmental accounting, but operational results so far are rather scarce. In some cases, some reluctance to launch environmental accounting projects stems from the complexities of the task and the scarcity of resources.

When developing environmental accounting, it is important to remember that the ultimate objective is not accounting, but the construction of a statistical information system on the environment which fulfill some criteria (reliability of information, usefulness for decision-making, comparability of data). Accounting represents an important element in this information system and is a powerful method of improving the global consistency of data, organizing and aggregating them and establishing linkages between economic and physical information. Accounts must, however, be seen in the context of the construction process and in a global reflection on the integrated use of available methods. Thus, as previously mentioned, complementary methods are required for checking the quality of data before using them in the accounts. Considerable work is needed to adapt traditional statistical methods to the specificities of the environmental field. Thought is also required on the use of the accounts to derive products (such as indicators and simplified tables) which are adapted to the needs and practices of the the users.

Table 7: Financing table

BENEFICIARY	General Govt & NPI as collective consumer			Producers			Hholds as actual cons.	Rest of the World	Total
				Specialized		Oth.			
	CG	LG	NPI	GG & NPI	Oth.				
FINANCER									
General Government and NPI									
CG									
LG									
NPI									
Enterprises									
specialized producers									
non specialized producers									
Households									
NATIONAL EXPENDITURE									
Rest of the world (of which EC)									
USES OF RESIDENTS UNIKTS									

Source: SERIEE manuel

Appendix 1

Forest accounts: summary of the results of 1986

Only element accounts were developped and computed in forest surfaces and in volume of wood.
The National Forestry Inventory provided all the data and participated in defining the structure of the accounts.

Surface balance sheet

Accounting period: 1969-1979 Unit: ha Area: department of Lozère

Source: Les Comptes du Patrimoine Naturel

		Initial stock	192300
Natural degeneration (return to moor)	1600	Natural colonisation by forest	6200
Deforestation	900	Afforestation	10100
Net accumulation	13800		
Final stock	206100		

Volume balance sheet

Accounting period: 1969-1979 Unit: 1000 m3 Area: department of Lozère

Source: Les Comptes du Patrimoine Naturel

		Initial stock	16288
Harvest	390	Natural growth of individuals	691
Natural mortality	72	Natural reproduction	66
Net accumulation	295		
Accidental and exceptional losses	0		
Final stock	16583		

Appendix 2

Fauna accounts: summary of the results of 1986

Only element accounts were developped and computed. These include a set of accounts:
- an account describing the genetic patrimony in terms of number of species
- accounts describing the spatial distribution of individual species and their extension/regression. They include the stocks and variation of stock expressed as the area where the species has been observed.
- population accounts of individual species describing their demography.

Balance sheet of species: land and marine vertebrates (except fishes)

Unit: number of species   Area: France

Source: Les Comptes du Patrimoine Naturel

CLASSES	T1 Observed annual stock 1900-1930	Reconciliation due to science advancement		T1 Corrected annual stock 1900-1930	New species regularly present on national territory since T1	Changes in status (breeding/ non breeding)	Missing species from national territory and sea	Annual stock 1970-1980 without artificial introduct.	Durably present intro-ducted species	T2 Annual stock 1970-1980
		Taxonomic updatings	Presence recently discovered							
AMPHIBIA	24	+5	0	29	0	0	0	29	0	29,00
REPTILES	28	+4	+3	35	0	0	0	35	1	36
Breeding	(27)	(+4)	(+3)	(34)	(0)	(-1)	(0)	(33)	(1)	(34)
Non breeding	(1)	(0)	(0)	(1)	(0)	(+1)	(0)	(2)	(0)	(2)
BIRDS	335	+1	0	336	+4	0	-2	338	+4	342
Breeding	(255)	(+1)	(0)	(256)	(+4)	(-4 +8)	(-2)	(262)	(+4)	(266)
Non breeding	(80)	(0)	(0)	(80)	(0)	(+4 -8)	(0)	(76)	(0)	(76)
MAMMALS	106	+3	+2	111	0	0	-3	108	+5	113
Breeding	(106)	(+3)	(+2)	(111)	(0)	(-1)	(-3)	(107)	(+5)	(112)
Non breeding	(0)	(0)	(0)	(0)	(0)	(+1)	(0)	(1)	(0)	(1)
TOTAL	493	+13	+5	511	+4	0	-5	510	+10	520

Appendix 3

Satellite accounts: waste elimination and recycling

Compte global de l'élimination et de la récupération des déchets : Dépense nationale

(en milliards de francs)

1978	1979	1980	1981
13,7	16,6	19,6	20,0

Le compte de l'élimination et de la récupération des déchets(*)

(en millions de francs)

Emplois	1978	1979	1980	1981	Ressources	1978	1979	1980	1981
Dépenses de fonctionnement . .	13 500	16 029	18 374	19 382	Ventes de biens et services	7 635	9 935	10 910	11 345
Transferts courants payés.	746	1 546	1 497	752	Transferts courants reçus.	700	124	140	160
Epargne brute.	1 019	934	1 139	1 411	Financement sur fonds propres.	6 930	8 450	9 960	10 040
Total charges courantes. .	**15 265**	**18 509**	**21 010**	**21 545**	**Total produits courants . .**	**15 265**	**18 509**	**21 010**	**21 545**
Investissements.	1 372	1 320	1 166	1 146	Epargne brute.	1 019	934	1 139	1 411
Transferts en capital payés. . . .	–	–	–	–	Transferts en capital reçus. . . .	307	338	320	258
Flux net d'actif financier	15	17	336	561	Flux net de passif financier . . .	61	65	43	38
Total charges en capital. .	**1 387**	**1 337**	**1 502**	**1 707**	**Total produits en capital .**	**1 387**	**1 337**	**1 502**	**1 707**

(*) n.c. les biens et services connexes

Elimination et récupération des déchets (*) : Financeurs et producteurs

(en millions de francs)

Financement \ Exécution	Producteurs (activités caractéristiques) – Collectivités locales 1978	1979	1980	1981	Négociants récupérateurs 1978	1979	1980	1981	Industrie 1978	1979	1980	1981
APU C.	120	142	142	146	–	–	–	–	13	49	61	33
APU L.	855	255	228	210	–	–	–	–	35	41	42	47
Ménages	2 380	3 160	3 645	4 120	–	–	–	–	–	–	–	–
Industries	145	205	255	275	800	1 200	1 400	1 400	7 840	9 420	10 970	11 190
Institutions de crédit . . .	45	40	30	20	–	–	–	–	–	–	–	–
Reste du monde	–	–	–	–	3 400	4 400	4 600	4 400	–	–	–	–
Total = exécution de la dépense intérieure	**3 545**	**3 802**	**4 300**	**4 771**	**4 200**	**5 600**	**6 000**	**5 800**	**7 888**	**9 510**	**11 073**	**11 270**

Financement \ Exécution	Biens et services connexes 1978	1979	1980	1981	Total = financement de la dépense intérieure 1978	1979	1980	1981
APU C.	–	–	–	–	133	191	203	179
APU L.	–	–	–	–	890	296	270	257
Ménages	250	300	350	420	2 630	3 460	3 995	4 540
Industries	–	–	–	–	8 785	10 825	12 625	12 865
Institutions de crédit . . .	–	–	–	–	45	40	30	20
Reste du monde	–	–	–	–	3 400	4 400	4 600	4 400
Total = exécution de la dépense intérieure	**250**	**300**	**350**	**420**	**15 883**	**19 212**	**21 723**	**22 261**

Financement \ Exécution	Reste du monde 1978	1979	1980	1981	Total = dépense nationale 1978	1979	1980	1981
APU C.	–	–	–	–	133	191	203	179
APU L.	–	–	–	–	890	296	270	257
Ménages	–	–	–	–	2 630	3 460	3 995	4 540
Industries	1 240	1 750	2 480	2 100	10 025	12 575	15 105	14 965
Institutions de crédit . . .	–	–	–	–	45	40	30	20
Reste du monde	/	/	/	/	/	/	/	/
Total = exécution de la dépense intérieure	**(1 240)**	**(1 750)**	**(2 480)**	**(2 100)**	**13 723**	**16 562**	**19 603**	**19 961**

* Nette de la valeur des déchets récupérés

Source: Les Comptes Satellites de l'Environnment - Méthodes et résultats

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Chapter V

A NATIONAL ACCOUNTING MATRIX INCLUDING ENVIRONMENTAL ACCOUNTS
Concepts and First Results

Mark de Haan and Steven J. Keuning*

Summary

A linkage between economic environmental data and National Accounts is often limited to production accounts. This paper argues that the consequences of economic actions on ecosystems and vice versa do not only relate to production processes, but also to other parts of the System of National Accounts (SNA). The concept module presented in the first sections of this paper distinguishes both environmental matter accounts (including 'free' gifts of nature, as well as various types of 'free' disposals) and environmental assets accounts (i.e. ecosystems). To begin, an attempt should be made relating volume flows of environmental matter to the standard economic accounts. This is done in a so-called National Accounting Matrix including Environmental Accounts (NAMEA), a format which incorporates all (simplified) accounts of the next SNA in a flexible way.

In the numerical example of the Netherlands, emissions of all kinds of polluting agents are recorded by industry and by consumption purposes. In order to build a bridge between environmental burdens and environmental effects, these agents are grouped into five environmental themes: greenhouse effect, ozone layer depletion, acidification, eutrophication and waste accumulation. These themes can be viewed as a practical solution for the presentation of an environmental assets account in the NAMEA. The contributions of agents to certain themes are expressed in theme-related environmental stress equivalents. Per theme, these stress equivalents are confronted with policy norms set by the Netherlands Government for the year 2000. In this way, five environmental indicators are conceptually integrated into a NAMEA for 1989. As a consequence, these estimates are directly comparable with outcomes of major macro-economic aggregates in the conventional accounts. This NAMEA may serve as a data base and analytical device for modelling interactions between the national economy and changes in the environment.

Introduction

The standard System of National Accounts (SNA) is an integrating framework for the description of monetary activities and balance sheets in an economy. This does not imply that it gives an account of all economic events in society. On the other hand, broadening the scope of the SNA by introducing large scale imputations in order to account for non-monetary phenomena like the use of the environment would affect the relevancy for many practical purposes of largely financial parameters like Gross Domestic Product (GDP). A solution to this dilemma has been found in the development of so-called satellite accounts. Satellite accounts can be defined as data sets on particular subjects which supplement the central economic data as described by the SNA. Their purpose is to enable more detailed analyses than is possible with the information contained in the SNA or analysis using different definitions, while maintaining an explicit link with the traditional overall system. A major advantage of this approach is that the results of detailed studies can be put in the perspective of the full (financial) economy.

In this paper, a comprehensive approach will be advocated, by linking systematically all kinds of environmental information to the complete revised SNA. In this way, it is hoped that a clearer view of the entire impact of environmental phenomena on the economic system and vice versa can be obtained. At the same time, great stress is laid on applicability. By systematically distinguishing between physical data and their valuation it is hoped to have adopted a practical and flexible approach to one of the most intricate problems connected with the construction of an environmental module.

Further, this paper contains an application of the NAMEA-framework to the Netherlands. From this NAMEA, interrelated economic and environmental indicators can be derived. The economic indicators are the well-known macro- figures such as Net Domestic Product, Net National Income and the current external balance. The environmental indicators used in this application have been designed at the Netherlands Ministry of Physical Planning and the Environment (VROM, 1992a). These are pressure indicators, expressed as the quotient of current emission levels and policy targets for the year 2000. The selection of these indicators was mainly motivated by the availability of data. For the time being, the module focuses on emissions of a number of important environmentally hazardous substances and wastes. At the present stage, neither stench, noise and toxic substances, nor the use of natural resources have been incorporated. The environmental indicators are directly comparable with the major macro-economic aggregates from the national accounts. While others have suggested making this comparison by monetarizing environmental flows (e.g. Repetto, 1991 and Hueting et al., 1992), the conceptual difficulties of valuation are completely avoided in this approach.

The NAMEA not only serves to derive aggregate indicators from a consistent meso-level information system, but because of its set-up as a system of accounting matrices, it also provides data in the required format for all kinds of analyses. These can vary from the very simple calculations presented in section 5 of this paper, to 'quick and dirty' multiplier experiments based on the matrix inverse to advanced general equilibrium model simulations. Such simulations can then also serve to explore the trade-offs between economic, social and environmental objectives at the macro-level.

The general features of the environmental module will be discussed more extensively in section 1. Section 2 introduces environmental accounts in the framework of a National Accounting Matrix. In section 3, environmental themes are introduced as a practical solution to the implementation of changes in environmental assets accounts and subsequently on the aggregation problem of pollutants. Subsequently, in this section the compilation of environmental indicators is further explained. Section 4 continues with an analysis of the contribution of each economic activity to environmental problems. The paper winds up with some conclusions in section 5.

1. General features

1.1. Aims of an environmental module to the SNA

In general terms, the aim of the environmental module is to provide a complete account of all links between the environment and the transactions, 'other changes in assets' and balance sheets recorded in the main national accounts. The module should show these links where they occur in reality. Within this general framework the first aim is to provide a systematic and complete account of the effects of economic activities on the environment. In the environmental module a clear connection between data on production, consumption and data on all kinds of changes in the environment is made. Changes in the environment can take many different forms, such as the depletion of a resource, changes in the use of space or the pollution of the environmental media; water, soil and air.

The module should provide step by step information, on the human-induced flows of agents, species and energy (commodity flows), as well as on the resulting effects on the environment (changes in ecosystems) and on the nuisance experienced by the population, thus linking economy, environment and society. In several countries, data on changes in the environment are collected within the framework of environment statistics. The special advantage of the environmental module approach is that it gives a complete and systematic account of all changes caused by production and consumption processes, in a way which is explicitly linked to the overall SNA framework. In the first instance, the basic tables of an environmental module contain all changes in the environment in physical units. These are supplemented with a systematic survey of all current expenditures to prevent, reduce or repair damage to the environment in relation with the entries of these data in the SNA. Although this paper does not focus on the inclusion in a NAMEA of stocks of environmental assets and liabilities, all damage to the assets as they are defined in the standard accounts is included.

Because of its completeness and because of the linkage between production/ consumption activities and environmental data, the environmental module may provide information in a format which is suitable to further analysis and modelling exercises. In particular, an objective is to provide analysts and policy makers with a data framework which can be used to sketch the trade- offs between the objective of environmental sustainability and other macro-economic policy objectives. This has led much attention being paid to the linkage of environmental indicators not only to GDP-growth, but also to other important policy objectives like employment and balance of payments equilibrium (see tables 2 and 12). The environmental module proposed contains cross-classifications which are relevant for specific purposes, like analysis of the impact of taxation alternatives or a quantification of the income generated in the 'environmental industry'. Building upon the full integration of different kinds of data, the environ-mental module should also provide basic material for designing indicators on the relation production - environment. Examples are presented in sections 3 and 4.

Finally, an environmental module should be presented in a clear and easily accessible format. This implies that there is a need for one or two schemes which provide an overview of the whole module. These can then be complemented with a set of tables which follow the same pattern for each environmental problem. This is elaborated in the next section.

1.2. A matrix approach to the SNA including environmental accounts

The environmental module centres around a set of tables which give an overview of all relevant relations between the SNA and an environmental data system. As the burden on the environment originates from the emission of a multitude of agents into a whole range of ecosystems on the one hand, and from the extraction of many different resources on the other, a detailed picture cannot be given in one table. A coherent, generally applicable system should thus be designed, where specific tables for each relevant substance can be easily related to the overall picture.

For this purpose, it is most suitable to put the national accounts in a matrix format (see table 1). This means that the whole system at the macro- level can be shown on one sheet of paper. This in turn facilitates substantially the understanding of the interrelations between various types of (monetary and physical) flows and their impact on each of the balancing items (NDP, NNI, Savings, Changes in Net Worth etc.) distinguished within the system. Subsequently, more detailed tables then serve to elaborate a single vector or cell in the macro-matrix. These tables are labelled according to their position (row and column account number) in the reference matrix. In this way, the link between detailed figures and the overall system remains transparent throughout the whole set of tables. The sub-tables use the type of classifications given in parentheses in the row and column headings of the main matrix.1 note) Another advantage of the matrix format is that it always reveals which entities and which accounts are involved at both ends of all monetary and physical flows (origin and destination), and this has clear advantages if the data in the environmental module are to be used in subsequent (general equilibrium) modelling exercises (cf. Pyatt, 1988).

Table 1 shows a so-called National Accounting Matrix including Environmental Accounts (NAMEA). This matrix is based on a design for the standard accounts as proposed by Keuning (1991) in his paper on a Social Accounting Matrix which fits into the next SNA. In table 1, this SAM has been expanded and slightly re-arranged. As a consequence, table 1 integrates a) the revised SNA sequence of accounts as well as a set of supply and use tables, and b) separate accounts for the relations between the economic flows and changes in the environment. A crucial aspect of these interactions is that the eventual effect on ecosystems is transmitted through all kinds of environmental 'matter': emission of pollutants on the one hand and depletion of resources on the other. This is recognized in the present framework by inserting a special account for all kinds of environmental 'matter' in between the conventional accounts and the account for environmental assets (i.e. ecosystems). Matter is to be read here as polluting agents as well as noise, radiation and species.

The distinction between an environmental matter account (#16 in table 1) and an environmental assets account (#17) is expedient to both the supply and the use of the data. Often, emission and waste statistics can be detailed by discharging industry or final demand category, but it is almost always impossible to attribute the degradation of ecosystems directly ble 1. NAMEA: A National Accounting Matrix Including Environmental Accounts

COUNT lassification)			Goods and Services (Product groups)	Goods and Services (Consumption Purposes)	Production (Production Activities)	Production (Household (Waste)Prod. Activities)	Income Distribution and Use a. National (Sectors) Primary Inc. Distribution	Income Distribution and Use a. National (Sectors) Secondary Inc. Distribution	Income Distribution and Use a. National (Sectors) Use of Income	Income Distribution and Use b. Rest of the World (ROW)	Indirect Taxes (Tax/Subsidy Type)	Worth Generation a.National (Sectors)	Worth Generation b. Rest of the World (ROW)	Other Accumulation a.National (Sectors)	Other Accumulation b. Rest of the World (ROW)	Financial (Financial Assets)	Other Asset Changes (Asset Types)	Environmental Agents (Agents/ Resources)*)	Environmental Assets Change(Ecotopes/Res)	Changes in Balance Sheet (Sectors)	TOTAL
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
ods d	Product groups	1	Trade&TransportMargins		Intermediate Consumption	Househ.Cons. Expenditures			Government Consumption	Exports				GrossCapital Formation							CommodityUse (mp,exVAT)a)
. i	Consumption Purposes	2							FinalHouseh Consumption												Final Within Househ. Use
:- :-	Production Activities	3	Output (basic prices)															'Free'Emission by Production			Total Output (basicprice)
on	Household (Waste)Prod	4		Within Hh.Output														'Free'Emission by Consumption			Total Prod. WithinHouseh
Na- tio- nal (Sec tors)	Primary Distrib. of Income	5			NDP (factor cost)		Property Income Flows			Wages and Property Income from Abroad	Net Indirect Taxes										Primary Income Origin
	Secondary Distrib. of Income	6			Consumption of Fixed Capital		NNI (market prices)	Current Transfer Flows #)		Current Transfers from Abroad #)									Current Effects,Past Emissions		Secondary Income Origin
	Use of Income	7						Gross Disposable Income and Future Effects											Natural Cleansing		Total Income
	Rest of the World	8	Imports				Wages&Property Inc.toROW	Current Transfers to ROW #)										'Free'Emission from Abroad			Current Payments to ROW
direct Taxes ax/Subsidy Type		9	Net General Product Tax		Net Other Tax on Production	Consumption Taxes, Net			Spec.NetTax onGov.Cons.	Specific Taxes on Exports, Net				Investment Taxes, Net							Net Indirect Taxes
rth ne-	National (Sectors)	10							Net Saving			Capital Transfer Flows #)	Capital Transfers from ROW								Finance of Generated Worth Change
on	Rest of the World (ROW)	11								Bal. of Payments Current Account Deficit		Capital Transfers to ROW									FinanceofROW Generated Worth Change
ner cu- la-	National (Sectors)	12							Consumption of Fixed Capital					Transactions in Non-prod. Assets	Sales of Non prod. Assets to Abroad	Borrowing	HoldingGain & Economic Appearance			NetWorthChanges,Saving & Cap.Transfer	Finance of Gross Worth Accumulation
on	Rest of the World (ROW)	13												Purch.of Non prod. Assets from Abroad		Net Lending to Abroad	Holding Gains			NetWorthChanges,Curr.Acc &CapTransfer	Capital Payments to Abroad
nancial inancialAssets)		14												Lending							Increase in Assets
ner Changes in ets sset Types)		15												Holding Losses and Destruction	Holding Losses and Destruction					NetWorthChanges, Other AssetChanges	Oth.Assets' Changes in Gross Worth
vironmental nts (Agents esources)		16			'Free' Extraction (Net)				Current Consumption of Pollutants	'Free' Emission to Abroad				Net Losses due to Natural Causes			ReferableDamage,due to EnvironmEff		Immission		Extraction & Destination of Emissions
anges in Environmental Assets cotopes/Res.)		17							Current Effects, Past Emissions					Non-referable Degradation				Net Depletion		Changes in Worth of Ecosystems	Depletion and Degradation
anges in lance Sheet ectors)		18										NetWorthChange,Sav&CapTr incl.Env.Eff	NetWorthChanges,Curr.Acc &CapTransfer	NetWorthChange,OthChange incl.Env.Eff	NetWorthChanges, Other AssetChanges						Total Changes in Net Worth
O T A L			Commodity Supply (mp, excl.VAT)a)	Within Household Supply	Input (at basic prices)	Input into Production Within Housh	Primary Income Destination	Secondary Income Destination	Total Expenditures	Current Receipts from Abroad	Net Indirect Taxes	Generated Worth Change	Generated Worth Change by ROW	Gross Worth Accumulation	Capital Receipts from Abroad	Increase in Liabilities	Oth.Assets' Changes in Gross Worth	Origin of Extraction & Emissions	Depletion and Degradation	Total Changes in Net Worth	

'Free' Emission refers to positive volume flows at a zero price (in reality) or at a negative price (in model simulations).
mp,excl.VAT = Valued at market prices, but excluding indirect taxes which apply only to some specific (final) demand categories (like Value Added Tax).
Including the transfer of 'free' emissions.

to certain economic activities (United Nations, 1993: 39). In addition, environmental policy instruments will generally also focus on certain environmental matter instead of directly on ecosystems.

Therefore, account #16 in the framework serves to register the emissions and extraction of all kinds of environmental agents, while account #17 serves to sketch the effects on ecosystems and provide a general description of changes in the state of the environment. Eventually, this may yield a rough indication of the total effects of economic activities on environmental assets which are not absorbed during the current period: changes in net worth of ecosystems. This balancing item is combined with the changes in conventional balance sheets to arrive at a final evaluation of the economically relevant position at the end of the current period.

Separating these accounts is also advantageous because part of the environmental effects has a current character, while another part precipitates on (the value of) assets already distinguished in the standard national accounts. In the present system, this is catered for by recording first, for example, the (total negative value of) all kinds of emissions by a certain activity, e.g. air transport, and then their impact on a) current accounts - in this example, the 'consumption' of noise by household groups neighboring the airport, b) conventional assets - such as a decrease in the value of houses as a consequence of the enlargement of a nearby airport, and c) environmental assets - like air quality.

Generally, table 1 reflects thinking that the interrelations between national accounts and the environment are not limited to the production accounts, and that these effects should be shown where they actually occur. This means that, if shadow prices for these effects were available, all major national accounts balances would be affected. The effects cascade down the balancing items until finally, in the total changes in net worth, all (lasting) effects have been incorporated. In table 1, all important balancing items have been framed.

A possible adjustment of the net product measure should incorporate, as far as possible, all environmental effects of current production. An adjusted income measure should focus on those effects which are currently absorbed; that is, including present effects of past disposals and excluding future effects of present disposals. Analogous to these intertemporal flows, cross-national flows should also be settled in the income accounts. The distinction between these concepts corresponds with an interest in the environmental effects of current domestic production and consumption on the one hand and in the current quality of the national environment on the other hand. Obviously, adjusted savings should incorporate all those effects not absorbed in the present period. Finally, adjusted changes in net worth should take into account all changes in the condition of the environment. In this way, each balancing item has a different purpose to serve. The balancing items and the other concepts are elucidated step by step in the next sections which explain the NAMEA matrix presented in table 1.

2. Set of National Accounting Matrices including Environmental Accounts

2.1 Goods and services account

The first row and coproduction processes. These amounts appear in cell (16,3) in this matrix. It is probably most convenient to book this extraction of depletable resources net of the natural growth which may be expected under average circumstances. In this way the net depletion of fish etc. is recorded here. Note 3) As in the case of emissions, their monetary value remains equal to zero and the balancing items are not affected, in the first instance.

The fourth account shows the transformation of household consumption expenditures into household output (i.e. the same products as were bought) and 'free' emissions. As soon as the disposals are valued, the value added generated by these household waste production activities becomes negative. In the column of this account, net consumption taxes (like VAT) are added. The treatment of consumption taxes in this matrix serves to provide the data required for simulation experiments with (changes in) specific consumer subsidies or taxes. These policy instruments may in fact aim to shift expenditure patterns into a more environmentally-friendly direction.

2.3 Income distribution and use accounts

The balancing item of each production account equals net value added. Since net indirect taxes have already been subtracted, this item is recorded here at factor costs. Value added adds up to Net Domestic Product (NDP), and this is booked on the primary distribution of income account. In this account, institutional sectors receive several types of primary income: NDP at factor costs, property income received from other (domestic) institutional units, wages and property income received from abroad, and net indirect taxes, which accrue to the government.

In the columns of the income account, outlays covering incurred liabilities (i.e. payments of property 'income') are also settled for each sector. Moreover, wages and property income may have flowed abroad. The residual equals Net National Income (NNI), at market prices. NNI reappears on the credit side of the secondary distribution of income account. Further, flows of transfers from and to other institutional units and the rest of the world are shown here. Transfer outlays are recorded on the debit side and the balance is known as Disposable Income (of each sector).

It has been explained above that in the income accounts the focus should focus be on the current effects. This implies that current effects of past disposals should be added, as a kind of (negatively valued) transfer from the past to the present (cell 6,17), and that future effects of present disposals and extraction should be singled out (in cell 7,6), because they entail a transfer from the present to the future. In this way, an adjusted Disposable Income concept is arrived at. To remain consistent, this procedure should also be followed for the 'ordinary', positive intertemporal transfers. This implies that consumption of fixed capital (production in the past, consumption now) is added (cell 6,3) and that the future effects of present investments (production now, but consumption in the future) are also shown separately (in cell 7,6). It should be noted that this adjusted, Gross Disposable Income concept is not necessarily equal to total consumption (i.e. total expenditures minus net saving) in the present period. A decision may still have been made to consume either more or less; or in other words, net saving is not necessarily equal to net investment. On the other hand, the gap between adjusted Disposable Income and adjusted consumption expenditures will typically be lower than the one between the original variables.

The way of recording described above presumes the possibility of monetary valuation directly from currently experienced nuisance. This is probably less complicated than a valuation of the total expected nuisance of current economic activities. In this respect, it is important to record the experienced nuisance in relation to a realistic reference period. Grief over deteriorating water quality should refer to this year's change in water quality only. The implication is that once consumed nuisance will not re-appear again in a later year.

In an environmental module in physical terms it will still be difficult, however, to separate changes in the environment induced by pollution in previous years from those in the current year. Usually only the total environmental burden which is currently 'consumed' i.e. cell (16,7) + cell (17,7) is known. In a few situations, such as the release of pollutants into the soil, it is possible to judge changes in the quality of groundwater as the effect of past disposals, while current pollution is still underway in the soil above the aquifer. In many cases it is academic how large the future effects of present emissions will be. These future effects are merely incorporated in cell (7,6) in order to show a consistent approach to an adjustment of the income measure.

The use of income account records how Gross Disposable Income is 'spent'. Government and household groups have outlays on consumption, and the balance, (net) savings, is put on the capital account. In the case of corporations, all disposable income is saved. In addition, the environment absorbs some of the pollution by means of natural cleansing. Here this is shown in the row, with a positive sign of course. Finally, this column also contains items called 'current consumption of pollutants', originating from the environmental agents account, and naturally the absorption of the current effects of past disposals.

These cells may need some further explanation. Most environmental effects of economic actions have a capital character, in the sense that the impact is not, or not only, felt during the current period. A notable exception is noise, where at least part of the effect disappears when the noise stops. Noise can be seen as a particular kind of environmental 'agent', emitted by production and consumption processes (and included in column 16). If sufficient information on the identity of the victims were available, this noise could be recorded as a 'free' delivery in kind to them in (a detailed version of) the secondary distribution of income account -it is then included in 'current transfer flows'-, followed by its consumption in the use of income account (cell 16,7). Noise and other disposals with a non-capital character (e.g. stench) can thus be seen as an unappreciated gift from the producers to the consumers. If a shadow price were attached to this noise, GDP, NNI and Disposable Income and total consumption expenditures would be negatively affected. Clearly, net saving and the balancing items further down the system would remain unaltered.

Another example of current consumption of pollutants refers to the current effects of past disposals. An adjusted concept of final expenditures would thus add the current consumption of past disposals to ordinary final consumption as shown in the first two cells of this column. By now, it may be clear that the registration method ensures that the current effects of past disposals will be taken into account in adjusted current income and final expenditures, but not in adjusted net product and saving measures. Conversely, the likely future effects of present disposals and extraction would only appear in adjusted net product and saving measures, but not in the adjusted income and final expenditure aggregates.

In accordance with international practice, the income distribution and use accounts for the rest of the world (in table 1 sometimes abbreviated as ROW) have been combined. The traditional registration method of national accounting systems is followed here: current receipts of the rest of the world appear in the row and current outlays in the column. The balance is transferred to the capital account of the rest of the world. The framework in table 1 can easily accommodate physical flows of pollutants across borders (see the registration of trans boundary flows of NOx, SO2 en NH3 in table 2). In row 8 various disposals, emitted abroad, flow into the national territory (cell 8,16). Obviously, the shadow price of these imports is negative. This should then also be reflected as a (negative) monetary transfer from the rest of the world (cell 6,8). Conversely, pollutants are also exported, as shown in cell (16,8), and this is counterbalanced by a transfer to abroad (cell 8,6). The 'transit' of waste can also be recorded in this way. The balance of these flows affects Disposable Income as well as all other balancing items further 'down' the system.

2.4 Capital accounts

Because the registration of all effects on the balance sheets is an important objective of this matrix, the capital account is extensive. The first capital account describes the generation of net worth due to net savings and actual capital transfers received (from other institutional units and from abroad) minus capital transfers paid. Capital transfers include a (negative) imputation for the flow of 'free' emissions with a capital character, from the dumping sector (in the column) to the stricken sector (in the row). If the latter cannot be identified, it may be assumed that the national or even global common heritage is affected (For this reason, the capital account in the NAMEA for the Netherlands is aggregated to one single account, see table 2 and the annex). Like ordinary saving, the net environmental effects of present activities which are not completely absorbed during the present period, are transferred to the changes in balance sheet accounts.

The second capital account (#12) records the use of funds for the accumulation of assets as defined in the standard accounts. The row adds depreciation, sales of land and other non-produced (non-financial, non-environmental) assets (like antiques), borrowing (i.e. incurring various types of liabilities), and not elsewhere classified increases in the volume and price of assets to the balancing item (excluding the environmental effects) of the first capital subaccount. Environmental effects are taken up again in the other changes in assets and changes in environmental assets accounts. All elements of this row taken together yield total funds available for gross worth accumulation, which is presented in the column. It consists of: gross capital formation, purchases of non-produced assets (from other institutions and from abroad), lending (net purchases of financial assets), not elsewhere classified decreases in the volume and price of (non-environmental) assets, net losses of environmental assets to natural causes, non-referable degradation of environmental assets, and the sum of the other changes in assets (here including 'other' changes in environmental assets) Note 4). Net losses in environmental assets due to natural causes refers to capital gains and losses not resulting from human activities, or which are an unexpected result of human activities. It also includes net growth of uncultivated species. The item non-referable degradation of environmental assets has been added because demonstrable deterioration of an ecosystem may not be attributable to specific economic activities or even to a specific period. Thus, it has not been included in the environmental effects of any activity. Examples are the unexpected detection of polluted soil, or a reduction in the number of seals in the North Sea. This deterioration, however, should be incorporated when assessing total changes in net worth. The solution is to put this damage in cell (17,12) for the moment, with a counterbalancing value in the changes in net worth of ecosystems (cell 17,18) Note 5).

Similar accounts are drawn for the rest of the world. Foreign saving, which may bear a negative sign, agrees with the deficit on current account of the balance of payments of the national economy. The rest of the transactions are analogous to those for the domestic sectors.

2.5 Financial and other changes in assets accounts

Subsequently, the financial accounts (#14) are presented. These indicate which sector (including the rest of the world) has acquired which types of assets (and liabilities) during the reference period.

The next row and column of table 1 contain the other changes in assets accounts. The character of this account differs from the others since it does not really relate to flows (consequences of actions), but to changes in states (other economic events). Not elsewhere classified changes in the volume and price of assets claimable by institutional sectors and the rest of the world are recorded here, as well as the balance of those adjustments, called changes in net worth due to other changes in assets. On the credit side, it concerns the economic appearance of non-produced assets (e.g. discovery of subsoil resources), nominal holding gains of all kinds of assets etc. On the debit side, the destruction of assets by non-insurable risks, disappearance of non- produced assets, nominal holding losses etc. are recorded.

In the standard national accounts, changes in national worth due to environmental effects are already partially shown here, at least in theory. For instance, this concerns holding losses and destruction of capital goods which are demonstrably due to pollution. This implies that the losses exceed depreciation due to normal wear and tear. Other examples are: destruction of assets as a consequence of a nuclear disaster, or a fall in house prices when the enlargement of a nearby airport has been approved. In the environmental module, these losses are singled out and shown as a separate (negative) item, called referable damage due to environmental effects, in the column of this account. In this way, the balance of this account does not change.

An interesting consequence of this registration method is that if a) the size of the damage to these non-environmental assets can be estimated from actual data, and b) this damage can be clearly attributed to a certain economic activity, this value can be re-routed within the statistical framework of the environmental module. It implies putting a negative value in e.g. cell (3,16), and concomitantly reducing NDP (cell 5,3), NNI (cell 6,5), Future Effects (cell 7,6), Net Saving (cell 10,7), Capital Transfer Flows (cell 10,10), Net Worth Changes due to Saving and Capital Transfers including Net Environmental Effects (cell 18,10), and Holding Losses and Destruction (cell 15,12). The same negative value then appears in cell (16,15), while Net Worth Changes due to Other Changes in Assets including Net Environmental Effects (cell 18,12) is increased with a positive amount. It can be easily checked that in this sequence all account numbers appear just as frequently in the rows as in the columns, except for accounts #12 and #18 where a negative adjustment is compensated by an equally large positive adjustment. This ensures that the equality of all row and column totals is maintained in this re-routing. The consistency of the system is, therefore, not affected by the adjustment of balancing items.

A similar procedure can be followed for the appraised value of the depletion of natural resources which are subject to ownership (e.g. standing wood, some mineral resources). Only in this case the capital loss is usually not thrust upon another party (cell 10,10 remains empty). Here, cell (16,3) contains a positive value followed by a subsequent reduction of all the balancing items through Net Worth Changes due to Saving and Capital Transfers including Net Environmental Effects (cell 18,10) and of Holding Losses in cell (15,12). Again, a negative value appears in cell (16,15) while Net Worth Changes due to Other Changes in Assets including Net Environmental Effects (cell 18,12) is increased, so that consistency is restored. Note that in this way a written off depletion of natural resources subject to ownership is recorded as other changes in (non-produced) assets and not as changes in environmental assets (ecosystems). This is in accordance with the treatment in the standard national accounts.

Environmental damage to the standard assets which is not referable to specific economic activities in the present period remains included in cell (15,12) (holding losses and destruction).

2.6 Environmental changes and changes in balance sheet accounts

In the above, all interrelationships between the economy and the environment have been discussed where they actually occur. This means that now it suffices to sum up the balances which are implicit in accounts 16 and 17. The sign of the variables in simulation experiments with non-zero prices is given in parentheses in front of each term. The balancing items, which are computed residually, have been printed in bold letters.

<u>Account #16:</u>

1) for natural resources (e.g. fish, trees of various kinds, mineral deposits): (+)net 'free' extraction (cell 16,3) + (+)net losses due to natural causes (cell 16,12) + (-)referable damage of owned assets due to environmental effects (cell 16,15) = (+)net depletion of (not owned) environmental assets (cell 17,16)

2) for environmental agents without a capital character (e.g. noise): (-)'free' emissions by production (cell 3,16) + (-)'free' emissions by consumption (cell 4,16) = (-)current

consumption of pollutants (cell 16,7)

3) for environmental agents with a capital character (e.g. acid rain, carbon dioxide, waste): (-)'free' emissions by production (cell 3,16) + (-)'free' emissions by consumption (cell 4,16) + (-)'free' emissions from abroad (cell 8,16) = (-)'free' emissions to abroad (cell 16,8) + (-)referable damage of owned assets due to environmental effects (cell 16,15) + (-)emission into ecosystems (cell 16,17). It is clear that in simulation experiments all (shadow) values in the first equation are positive, with the exception of the referable damage, while those in the last two are negative. Finally, the equalities underlying account 17 are given here:

4) for national ecosystems (e.g. air, seas etc.): (-)current effects of past disposals (cell 6,17) + (+)natural cleansing (cell 7,17) + (-)emission (cell 16,17) = (-)current effects of past disposals (cell 17,7) + (+)non-referable degradation (cell 17,12) + (+)net depletion (cell 17,16) + (-)changes in worth of ecosystems (cell 17,18)

Current effects of past disposals appear both on the left-hand side and on the right-hand side of this equation. For the rest, it can be seen that total worth of national ecosystems decreases in proportion to an absolute increase of all other elements in this equation, except natural cleansing. It goes without saying that filling in this equation is a lot easier said than done, if only because the total effect on an ecosystem may deviate from the sum of the individual effects.

At the bottom and at the right-hand side, changes in the balance sheets close the full sequence of accounts and balancing items. The totals of this account reflect in principle all changes in net worth, including changes in the worth of ecosystems. Total changes in net worth should be added to the opening balance sheets to arrive at the closing balance sheets.

It is obvious that insufficient data are currently available to fill this matrix completely, even in physical terms. For that purpose, an abbreviated table focusing on a few environmental agents with a known origin and destination may be more practical at present. In such a matrix, some of the accounts could be deleted. A more simplified NAMEA for the Netherlands is illustrated in section 3.

2.7 Matrices behind cells (16,17) and (17,16)

In the module, agents and natural resources are described in column and row 16 as physical quantities. They are included because Emission (cell 16,17) and net depletion (cell 17,16) cause changes in the ecosystem. These effects are described in column and row 17 as changes in the quality of the ecosystem.

At the intersection of columns and rows 16 and 17 are found two very important cells in the present module, because there the relation can be found between the Emission c.q. net depletion on the one hand and the consequences of this for the quality of the ecosystem on the other. The problem with these cells is, however, that depending on the side from which they are examined, they have a different dimension: along column and row 16 physical changes and along column and row 17 ecological changes. In the module this can be solved by imputing two figures in the same cell: one gives the Emission or net depletion (cause) and the other the effect on the ecosystem that is caused by this Emission or net depletion (effects). Immediately, the relation between these two is shown. In the Netherlands' NAMEA in section 4, a practical solution is found in the conversion of pollutants into 'potential stress equivalents' (see sub-matrix #9,10 in table 2).

The two figures in cells 16,17 and 17,16 are the summations, respectively of all Emissions c.q net depletions and all effects on the ecosystem. The detailed information behind these totals is given in matrices. The two matrices behind cell 16,17 (Emission) have as column head environmental assets change with a subdivision into ecotopes and natural resources. As row head these matrices have environmental agents, subdivided into agents and natural resources. The two matrices behind cell 17,16 (net depletion) have as column head environmental agents and as row head environmental assets change. Both column and row head of the matrices behind cell 17,16 are subdivided as behind cell 16,17. The confrontation of both pairs of matrices gives a detailed picture of the relation between causes and effects in the use of the environment. The construction of detailed cause and effect matrices for Emissions (16,17), which concerns mainly the top left side of the matrices (agent/ecotopes), will be difficult: all agents must be spread over the ecotopes on which they produce effects and all the ecotopes that are influenced by agents, must be analyzed to see which agents are causing these effects. These difficulties could be reduced by accepting some aggregation (e.g. to ecozones) or the introduction of dummy columns. Such additional columns can 'absorb' various agents which have a collective effect on one or more ecotopes.

The construction of the cause and effect matrices for net depletion (17,16) will be relatively easy because the relation between net depletion and changes in the stock of resources (bottom right side of the matrices) is direct. Only when the depletion effects also ecotopes (top right side of the matrices), e.g. damage to the vegetation by the production of groundwater, do the same problems arise as with the construction of the cause and effect matrices for Emissions.

3. A NAMEA for the Netherlands

3.1 General accounts

Table 2 shows, an aggregated NAMEA for the Netherlands in 1989. Unfortunately, it was not possible to provide all the data to fill in the complete NAMEA system presented in section 2. A household production account is not included, while emissions from households are directly connected to consumption purposes. Income distribution and use are combined in one account. Accounts for worth generation, other accumulation, other changes in assets and changes in balance sheets are excluded. Instead, one capital account is presented in the Netherlands' NAMEA, which includes five aggregated environmental indicators apart from gross capital formation, consumption of fixed capital, net saving and capital transfers. In the Dutch NAMEA, NDP is valued at basic prices and not at factor costs, because of the omission of a separate indirect taxes account. Table 2 gives an overview of all the macro indicators in the NAMEA for the Netherlands. These indicators reflect the Dutch economy and the environment in 1989. The

Table 2. A NAMEA illustrated for the Netherlands, 1989 (account 1 - 8 in billion guilders)

ACCOUNT (Classification)	Goods & Services (Prod. Groups) 1	Consumption (Purposes) 2	Production (Production Activities) 3	Income Generation (Prim.Inp.Cat.) 4	Income Distribution and Use (Nat. Sectors) 5	Capital 6	Rest of the World Current 8a	Rest of the World Capital 8b	Emissions (in million kg, CFCs and halons in 1000 kg) CO2 9a	N2O 9b	CH4 9c	CFCs & Halons 9d	NOx 9e	SO2 9f	NH3 9g	P 9h	N 9i	Waste 9j	Themes Greenhouse 10a	Ozone Depl. 10b	Acidificat. 10c	Eutrophic. 10d	Waste 10e	Depositions Acidification PAE 11	TOTAL
Goods & Services (Product Groups) 1	Trade and Trans.Margins 0.00	Household Consumpt. 284.49	Intermediate Consumption 460.19		Government Consumption 71.77	Gross Capital Formation 108.54	Exports 267.68																		Commodity Use 1192.66
Consumption (Purposes) 2					Household Consumption 284.49				'Free' Emissions, Consumption 32133	2	13	3157	151	4	10	13	103	7226							Consumption Use 284.49
Production (Production Activities) 3	Output (basic prices) 903.81								'Free' Emissions, Production 125886	31	557	12626	425	207	238	153	1213	18239							Output (basic prices) 903.81
Income Generation (Primary Input Categories) 4			NDP (basic prices) 388.74				Wages from ROW 1.12																		Generated Income 389.86
Income Distribution and Use (National Sectors) 5	Product Taxes - Subsidies 40.09			NGI (market prices) 388.59	Property Income, Current Transfers 948.43	Net Investment Taxes 0.97	Property Inc.& Transf.fr.ROW 60.33																		Current Income 1438.41
Capital 6			Consumption of Fixed Capital 54.88		Net Saving 71.54	Capital Transfers 86.01		Cap.Transfers fr. ROW 0.93																	Fin.of Gross Worth Accum. 213.36
Financial Balance 7						Net Lending from ROW 15.62		Net Lending to ROW -15.62																	Financial Balance 0.00
Rest of the World (ROW) Current 8a	Imports 248.76			Wages to ROW 1.26	Property Income, Transfers to ROW 62.19				'Free' Emissions from ROW				109	101	24	a)	a)	-							Current Payments to ROW 312.21
Rest of the World (ROW) Capital 8b						Capital Transfers to ROW 2.22	Bal. Payments Curr.Acc.Def -16.91																		Capital Payments to ROW -14.69
Emissions (in mln kg, CFCs and halons in 1000 kg)			Incineration				'Free' Emission to ROW												Allocation to Themes						Absorption of Emissions
CO2 9a																			158019						158019
N2O 9b																			33						33
CH4 9c																			570						570
CFCs and Halons 9d																				15783					15783
NOx 9e							504														181				685
SO2 9f							166														146				312
NH3 9g							146														126				272
P 9h							a)															166			166
N 9i							a)															1316			1316
Waste 9j			10728				-																14737		25465
Themes						Emission-Indicators																		Depositions	Stress Equivalents
Greenhouse Effect (GWP) 10a						1.02																			173199
Ozone Depletion (ODP) 10b						1.56																			12451
Acidification (PAE) 10c																								15918	15918
Eutrophication (PEE) 10d						2.83																			298
Waste Production (KG) 10e						2.94																			14737
Deposition Account Acidification (PAE) 11						Deposition Indicator 1.95																			Depositions 15918
TOTAL	Commodity Supply (market prices) 1192.66	Household Consumption 284.49	Input (basic prices) 903.81	Allocation of Generated Income 389.86	Current Outlays 1438.41	Gross Worth Accumulation 213.36	Current Receipts from ROW 312.21	Capital Receipts from ROW -14.69	Supply of Emissions 158019	33	570	15783	685	312	272	166	1316	25465	Stress Equivalent Conversions 173199	12451	15918	298	14737	Depositions 15918	

a) These data are available but not recorded in the NAMEA because the concomitant policy objectives have been formulated for emissions and not for depositions

-: Data are not available

annex gives a more desaggregated presentation.

Accounts 1-8 are in billions of Guilders and for each account the receipts are again presented in the rows and outlays in the columns. Of course, for each account, total outlays equal total receipts. Accounts 1-8 reflect the goods and services account, the production account, the income generation, distribution and use accounts, the capital account, the financial balance and a rest of the world account. The balancing items of accounts 3-6 and 8a are the following: net domestic product, net generated income, net saving, net lending from the rest of the world and the deficit on the current account of the balance of payments. The accounts related to the environment only reflect unpriced quantities and do not influence the monetary column and row totals of accounts 1-8. This aspect is emphasized by placing the figures in accounts 9-11 in slightly different positions. The row sums of the environmental accounts also correspond with the totals in the columns.

3.2 Emission accounts

In the emission account, total supply of pólluting agents is given in kilo grams. In general, three sources are responsible for this supply:

The emissions from production processes (vector #3,9).

Agents that are disposed of during the consumption of products by households Note 6). This is shown in vector #2,9.

The quality of the environment is also influenced by imports of agents from abroad, including emissions from foreign vehicles in the country Note 7). Table 3 details the emissions by source and by environmental agent. Table 4 registers the absorption of these emissions. In sub-matrix #9,3, the share of total waste production that is incinerated is recorded as an input into incineration plants (these are part of services and other production activities). If sufficient data become available, this can also be done for the use of waste as input into composing plants, separating installations or other uses. In this way, the NAMEA allows for the transformation of pollutants by means of an economic activity. The environmental impact of waste incineration is here reflected by the emission of air pollutants and the disposal of combustion waste by the industry concerned.

In sub-matrix #9,10 all agents are allocated to a smaller number of so-called 'environmental themes'. Distinguishing environmental themes is a fairly new approach in the Dutch environmental policy. A growing need for integration over environmental compartments (soil, water and air) led to the selection of environmental themes. The difficult connection is thus avoided between the accumulation of agents and changes in ecosystems mentioned in section 2.7. These themes concern the effects of environmental changes on people, plants and animals, grouped in the following broad categories: climate change (greenhouse effect and depletion of the ozone layer), acidification, eutrophication, disposal of waste (including sewerage and soil clean-up), nuisance (including external safety), pollution with toxic and hazardous substances and fresh water deficit. These categories can be considered as broad environmental problems. Due to a lack of data, the last three themes in this list have not yet been incorporated in the Netherlands' NAMEA.

Table 3. The supply of emissions, column #9 (#2,9, #3,9 and #8a,9) in the NAMEA (mln KG; CFCs and halons in 1000 KG)

year 1989	CO2	N2O	CH4	CFCs+halons	NOx	SO2	NH3	P	N	Waste(net)
	mln kg			1000 kg	mln kg					
Household Consumption										
o.w. Transport	12833	0	4	0	132	3	0	0	39	162
Other Purposes	19300	2	9	3157	19	1	10	13	64	7064
Total (#2,9)	32133	2	13	3157	151	4	10	13	103	7226
Production										
Agriculture	7511	24	393	0	13	1	230	127	1067	962
Manufacturing	50582	1	6	6786	121	125	8	26	61	7381
o.w. Oil Refineries	10732	0	1	0	21	70	0	0	6	40
Chemical Industry	19981	0	4	6313	44	27	8	19	25	3167
Basic Metal Industry	6636	0	0	0	13	15	0	0	4	150
Other Manufacturing	13233	0	0	473	44	13	0	6	26	4024
Electricity Generation	38452	1	2	0	78	43	0	0	23	146
Construction	958	0	0	3157	9	1	0	0	3	3782
Transport	7876	1	2	789	125	23	0	0	36	2294
Services and Other	20507	5	155	1894	78	14	0	1	23	3674
Total (#3,9)	125886	31	557	12626	425	207	238	153	1213	18239
Total Inland Supply	158019	33	571	15783	576	211	248	166	1316	25465
Import of Foreign Emissions (#8a,9)					109	101	24	.a)	.a)	.
Total Supply (Column Sum #9)	158019	33	570	15783	685	312	272	166	1316	25465

a) These data are available but not recorded because the concomitant policy objectives have been formulated for emissions and not for depositions.

Sources: CO_2, NO_x, SO_2, Waste, P (Phosphorus) and N (Nitrogen) emission data from CBS; NO_x, SO_2 and NH_3 import data based on information from RIVM; P (Phosphorus) and N (Nitrogen) import data from CBS; NH_3, N_2O and CH_4 emission data from RIVM; and CFC/halon emission data are intrapolations based on VROM-data.

Table 4. The absorption of emissions, row #9 (#9,3 #9,8a and #9,10) in the NAMEA (mln KG; CFCs and halons in 1000 KG)

year 1989	CO2	N2O	CH4	CFCs+halons	NOx	SO2	NH3	P	N	Waste(net)
	mln kg			1000 kg	mln kg					
Incineration (#9j,3)										10728
Export of Emissions (#9,8a)					504	166	146	.[a)]	.[a)]	.
Allocation to Theme (#9,10)	158019	33	570	15783	181	146	126	166	1316	14737
Total Absorption (Row Sum #9)	158019	33	570	15783	685	312	272	166	1316	25465

a) These data are available but not recorded because the concomitant policy objectives have been formulated for emissions and not for depositions.

Sources: CO_2, NO_x, SO_2, Waste, P (Phosphorus) and N (Nitrogen) emission data: CBS (1991b) P (Phosphorus) and N (Nitrogen) export data: CBS; NO_x, SO_2 and NH_3 export data based on information from RIVM; NH_3, N_2O and CH_4 emission data: RIVM; CFC/halon emission data are interpolations based on VROM-data

The column-wise clustering of agents in sub-matrix #9,10 of table 2 shows their relationship with an environmental theme. In some cases an agent is connected to more than one theme. For instance, NOx and NH3 emissions are related to both acidification and eutrophication. Theoretically, these successive contributions should be expressed in the 'allocation to themes' matrix (#9,10). In cell #9e,10d of this matrix, the contribution of NOx to the eutrophication problem should then be shown. Recording the nitrogen contents of NOx emissions twice in a single row, would, however, lead to inconsistent row and column totals for account #9e. A separate nitrogen (N) emission account has, therefore, been inserted (#9i). In consequence, the nitrogen contents of NOx emissions are expressed twice in the rows recording emissions (e.g. cells #2,9e and #2,9i), but these emissions are anyhow not added up row- wise. The column totals of account #10 cannot be computed by an ordinary summation. An aggregation of agents per environmental theme requires that the contents of each cell are expressed in so-called 'environmental stress equivalents'. In this way, the contribution of all agents involved in a certain environmental theme is transformed from kilograms into theme-related environmental stress equivalents. These equivalents express the potential environ mental burden of each agent in relation to a particular environmental problem. This is further elaborated in the next section.

Ideally, a NAMEA summarizes its description of changes in environmental quality within the borders of a country by means of environmental quality indicators. Unfortunately, the linkages between emissions and effects are still unclear in many instances. In this application, therefore, a stop had to be called at an earlier stage and environmental pressure indicators were presented instead. Such theme-related indicators may pertain to emissions or to depositions. In general, pressure indicators measure the deviation of current emission or deposition levels from certain standards. These standards should in fact reflect sustainability levels, but only in a few cases have such threshold levels already been converted into maximum emission or deposition levels. In this NAMEA, a second-best solution is found by using policy targets formulated in documents of the Environment Ministry. Hence, the indicators in this article reveal environmental pressures within the borders of the Netherlands, in relation to policy targets for the year 2000.

For one theme, acidification, the indicator is not based on emissions but on depositions in the Netherlands, that is emissions plus imports minus exports and re-intake into the economic system. Since environmental quality is more closely related to depositions than to emissions, deposition indicators should be designed, if sufficient information is available (including policy norms for depositions instead of emissions, see #10,11 and #11,6). In this case, no emission indicator is presented as that would amount to double- counting. In addition, it would be possible to give a regional subdivision of deposited agents and environmental quality indicators in account #11. This is elaborated in sub-section 4.3 below for acidification. For the other themes, only emission indicators could be constructed (cf. vector #10,6).

3.3 Environmental themes

In the Netherlands' NAMEA, available information on environmental 'stressors' and 'effects' is brought together under the heading 'environmental themes', as designed by the Netherlands Ministry of Physical Planning and Environment (VROM, 1992a). Table 5 presents the environmental themes used in this article. In the second column, the agents that correspond to each theme are given. To enable an addition of agents, the themes are expressed in environmental stress equivalent units. Each of the themes is reviewed below.

Table 5. Environmental agents and themes taken into account in this article

Environmental Themes	Agents	Environmental Stress Equivalents
Greenhouse Effect	CO_2, N_2O and CH_4	Global Warming Potentials (GWP)
Depletion of the Ozone Layer	CFC's and halons	Ozone Depletion Potentials (ODP)
Acidification	SO_2, NO_x and NH_3	Acidification Equivalents (PAE)
Eutrophication	N and P	Eutrophication Equivalents.(PEE)
Accumulation of Waste	waste	Kilograms (mln KG)

Greenhouse effect

Among the expected consequences of atmospheric pollution are global climate changes. The changes in concentration of so-called greenhouse gases in the atmosphere will probably affect the climate, due for example to, a rise of surface temperatures. Significant human-related emissions of greenhouse gases in the Netherlands concern carbon dioxide (CO2), methane (NH4) and nitrous oxide (N2O). CFCs and halons have also been mentioned as greenhouse gases but their contribution to the greenhouse effect is inconclusive (IPCC, 1992). The relative contribution of each gas to the greenhouse effect can be expressed in CO2-equivalents; these are also called Global Warming Potentials (GWP). This is the CO2 concentration that would have about the same effect on the radioactive properties of the atmosphere as the concentrations of the greenhouse gas concerned. In this paper, the conversions into GWPs have been based on IPCC (1992). Table 6 covers approximately 88 per cent of all greenhouse gases emitted in the Netherlands, assuming that CFCs and halons are not greenhouse gases (calculated from van den Born et al., 1991).

Table 6. Conversion of greenhouse gas emissions into GWP, 1989 (# 9a-9c,10a)

	Emission in mln kg	Global Warming Potential GWP/kg	Emission in GWP
CO_2	158019	1	158019
N_2O	33	270	8910
CH_4	570	11	6270
Total (#10a)			173199

Source: CO_2 emission: CBS; N_2O and CH_4 emission: RIVM; global warming potential: IPCC (1992).

Depletion of the Ozone Layer

Oxides of hydrogen, nitrogen, chlorine and bromine can act as catalysts in the reaction chains that lead to the depletion of stratospheric ozone. Ozone in the stratosphere is a filter for solar UV-radiation. A decreasing ozone concentration leads to a higher exposure to UV-B-radiation, with effects on human health and possibly ecosystems too.

Chlorofluorocarbons (CFCs) and halons are supposed to be important gases in this process. The use of CFCs and halons is regulated by the Montreal Protocol as recently adjusted in Copenhagen. The protocol now aims at a complete ban of CFCs in the year 1996, while the production and use of halons was banned from the beginning of 1994. The European Community countries plan to issue a regulation banning CFCs from 1995 onwards (Second Chamber, 1993). In the Netherlands, there is no direct information available about the yearly release of CFCs and halons into the atmosphere. The use of CFCs and halons, however, is registered because of the Montreal protocol. In the NAMEA this indirect information is used by way of emission data. The rationale is that eventually all use of products containing CFCs or halons will cause emissions, namely when the depreciated commodities are discarded. Besides, the purchase of these products will also lead to emissions in the reference period, in so far as they replace worn out products (e.g. refrigerators) of the same type. The practice of recovering CFCs and halons from discarded products was still very limited in 1989. It should, however, be realized that the NAMEA figures do not provide an exact estimate of present emissions.

In addition to the substances mentioned in table 7, HCFCs and methylbromide are supposed to contribute to the depletion of the ozone layer, although their relative contribution is probably smaller. A conversion into Ozone Depletion Potentials is shown in table 7. The ODP-value is an indication of the degree to which a specific gas influences ozone concentrations relative to CFC-11.

Table 7. Conversion of the use of ozone depleting gases into ODPs, 1989

	Use in kg	Ozone Depletion Potential ODP/kg	Use in ODP
CFC-11	5747	1	5747
CFC-12	1477	1	1477
CFC-13	3	1	3
CFC-113	1222	0.8	978
CFC-114	85	1	85
CFC-115	101	0.6	60
halon-1211	250	3	751
halon-1301	191	10	1907
carbontetrachloride	754	1	754
1,1,1-trichloroethane	5633	0.1	563
Total (#9d and #10b)	15783		12451

Source: VROM (1992b); use: interpolation of 1986-1990 data.

In order to keep table 2 and the annex within manageable limits, only the total and not each individual ozone gas is shown. The indicator presented here differs from VROM (1992a) by the inclusion of carbontetrachloride and 1,1,1-trichloroethane. Data on HCFCs and methylbromide were too scarce to allow for their incorporation in this NAMEA.

Acidification

The deposition of acid substances has led to changes in the composition of soil and surface waters in the Netherlands. This process will cause large-scale disturbance of ecosystems, deterioration of groundwater quality and damage to materials and crops. The most important agents leading to acidification are nitrogen oxides (NO2), sulphur dioxide (SO2) and ammonia (NH3). The potential contribution to acidification of each of these substances can be expressed in Potential Acid Equivalents (PAE). This measure reflects the amount of an agent that is necessary to form an acid with a certain amount of H+-ions. One acid equivalent equals 1/2 mol (32 grams) SO2, or 1 mol (46 grams) NO2, or 1 mol (17 grams) NH3 (Schneider and Bresser, 1988).

Emissions as well as depositions can be expressed in potential acid equivalents. Because the transformation of ammonia into HNO3 requires a number of reactions, involving bacteria in soil and water, ammonia emissions expressed in potential acid equivalents may somewhat overestimate the contribution of NH3 to actual acidification. In table 8, the conversion from kilogrammes of acidifying substances into PAE is further specified. Emissions as well as depositions are presented.

The dispersion of acid-forming substances plays an important role in the cause/effect chain. A major part of total emissions in the Netherlands is distributed into other countries while the damage from acidification in the Netherlands is the result of Dutch and foreign emissions. In the NAMEA these trans-boundary exchanges are included (table 2).

Table 8. Conversion of acidifying emissions into PAE, 1989 (#9d-9f, 10b)

	Emissions in the Netherlands (mln kg)	Potential Acid Equivalent (PAE/kg)	Emissions in 1000 PAE
NO_x	576	1/46	12522
SO_2	211	1/32	6594
NH_3	248	1/17	14588
Total			33704
	Depositions in the Netherlands (mln kg)	**Potential Acid Equivalent (PAE/kg)**	**Depositions in 1000 PAE**
NO_x	181	1/46	3937
SO_2	146	1/32	4548
NH_3	126	1/17	7433
Total (#11c)			15918

Source: Emissions: CBS; depositions: RIVM; PAE: Schneider and Bresser, 1988.

The combination of data on emissions within the Netherlands and on the inflow and outflow across the border given in the deposition total on the Dutch territory. It is possible to provide more details underlying cell #10,11, for instance concerning the depositions by province (see table 9). In turn, these depositions can be juxtaposed with indicators on changes in environmental conditions such as the vitality of forests. Evidently, this relationship is a complicated one, as the health status of forests in the Netherlands depends on more factors than deposition of acid substances. Variations in soil quality, weather conditions, the occurrence of pests and management of the forests also cause differences between provinces.

Table 9. Depositions and vitality of forests by province in the Netherlands

	Depositions 1989			Forest Area 1989		Vitality of Forests: Good 1989	1990	1991	Reasonable 1989	1990	1991	Bad 1989	1990	1991
	PAE	%	PAE/ha.	100 ha	%	%								
Drenthe	1115	6.9	4200	264	8.8	42.0	55.2	62.6	40.3	29.3	25.8	17.7	15.5	11.6
Overijssel	1655	10.3	4955	352	11.7	34.8	52.5	54.9	34.3	32.2	29.2	30.9	15.3	15.9
Gelderland	3421	21.2	5319	863	28.7	48.0	48.0	47.6	34.6	31.4	33.3	17.4	20.6	19.1
Utrecht	666	4.1	5000	179	6.0	48.2	49.9	45.5	24.4	33.6	39.7	27.4	16.5	14.8
N-Brabant	2915	18.1	5893	659	21.9	57.1	45.5	45.6	25.9	27.1	29.4	17.0	27.4	25.0
Limburg	1276	7.9	5881	285	9.5	63.7	67.8	59.1	24.6	20.2	24.2	11.7	12.0	16.7
Other provinces	5098	31.6	3902	401	13.4	n.a			n.a.			n.a.		
The Netherlands	15918	100.0	4757	3003	100.0	50.1	52.5	52.0	30.7	28.7	30.2	19.2	18.8	17.8

Note: The sample size in the other provinces is too small to enable comparisons.
Sources: Depositions: Heij and Schneider (1991);
Vitality of forests: Bosbouwvoorlichting (Netherlands Ministery of Agriculture, Fishery and Nature Protecting 1992)

Eutrophication

Eutrophication occurs when an abnormal quantity of nutritious substances for plants disturbs ecological processes. Among the effects are: loss of species and algae bloom in surface water, leading to impoverishment of other species and a decreasing quality of drinking water. The most important eutrophicating substances are nitrogen (N), phosphorus (P) and potassium (K).

The focus was on nitrogen and phosphorus because of data availability. Phosphorus and nitrogen are present in emitted substances like manure, fertilizers, ammonia and waste water and in some air emissions (NOx and NH3). In the NAMEA these emissions have been converted into kilograms P and N.

A common unit linked to the (potential) effects of both substances does not yet exist. Nevertheless a preliminary equation factor is introduced here: see VROM (1992a). Based on the average appearance of nitrogen and phosphorus in natural circumstances, a 1 to 10 ratio between nitrogen and phosphorus is assumed to arrive at Potential Eutrophication Equivalents (PEE) (table 10). The depositions (or emission) into the Netherlands is the net result of emissions plus inflow minus outflow across the borders. In the case of both nutrients, borders are crossed via rivers, mainly the Rhine. Transboundary phosphorus and nitrogen flows are also presented in table 10. As the policy targets were only formulated for emissions and not for depositions, eutrophication has not been incorporated in the deposition account of this NAMEA.

Table 10. Conversion of eutrophying emissions and depositions into PEE (#9h-9i, 10d)

Emissions	(mln kg)	Potential Eutrophication Equivalent (PEE/kg)	(mln PEE)
Phosphorus (P)	166	1	166
Nitrogen (N)	1316	0.1	132
Total (#10d)			298

Imports, exports and depositions	(mln kg)	Potential Eutrophication Equivalent (PEE/kg)	(mln PEE)
Imports of foreign emissions			
Phosphorus (P)	20	1	20
Nitrogen (N)	417	0.1	42
Total			62
Exports of emissions			
Phosphorus (P)	25	1	25
Nitrogen (N)	584	0.1	58
Total			83
Depositions			
Phosphorus (P)	161	1	161
Nitrogen (N)	1149	0.1	115
Total			276

Source: Emissions and depositions: CBS (1990b)
PEEs: VROM (1992a)

Accumulation of Waste

How to get rid of waste without damaging the environment is a major problem in the Netherlands. Dumping waste requires not only space, but also facilities at waste dumps to prevent the leakage of environmentally hazardous substances. Dutch environmental policy thus focuses on reducing the amount of waste generated (VROM, 1989). Of the many aspects of waste, such as composition and toxicity, only one is covered in the indicator as developed by VROM (1992a): the amount of waste that is dumped.

A further delimitation is the exclusion of waste that results from clean-up actions. This concerns, for example, polluted dredging spoil for which separate dumping facilities have been created. Apart from the practical argument, this waste cannot be seen as presently generated waste; because the pollution is not the result of current economic activities. Excess manure is also excluded. As the limited capacity of waste dumping sites is the main point of interest, the common unit for all types of waste is the kilogram (cf. cells #9j,10e and Total #10e). A volume measure (m3) would perhaps be preferable, but for some types of waste such data are lacking.

Dumped waste should be presented in the NAMEA as total waste production minus the amount of waste that is re-inserted into the economic system (e.g. recycled, composed or incinerated waste) Note 8). Because it is not yet possible to present re-used and recycled amounts by utilizing industry, these amounts have been subtracted from gross emissions. In addition, a complete specification of transboundary flows of waste cannot yet be given. In the NAMEA, waste emissions only include waste that is incinerated or dumped and these emissions are called 'net waste'. On the other hand, the transformation of incinerated waste is incorporated in this NAMEA (cf. cell #9j,3).

3.4 Compilation of environmental indicators

Among the objectives of the NAMEA is the derivation of a limited number of environmental indicators from a consistent national accounting framework, and from the physical accounts in the module. In theory, these indicators can be formulated at different levels: emissions, depositions or changes in environmental quality. Obviously, for each environmental theme not more than one indicator should be specified. For instance, if a deposition indicator is computed then a separate indicator for the concomitant emissions is not incorporated, in order to avoid double- counting.

The indicators in table 11 are mainly related to emissions because most policy targets have been formulated at that level. Only for acidification does the indicator refer to depositions. In order to denominate all indicators into a common dimension, they are expressed as the quotient of the current level of the environmental burden and a concomitant policy target set for the year 2000. In table 11, actual emissions and depositions in 1989 are compared with these targets Note 9).

An alternative approach has been used in the compilation of a CFC/halon indicator. The scheduled complete ban of CFCs and halons in 1995 will necessitate the formulation of a different target value. In the CFC/halon indicator, a comparison is made between actual and planned CFC/halon use in 1989, assuming a linear reduction pattern between 1980 and 1995.

Table 11. The confrontation of emission/deposition levels and policy targets

Emissions:	1989	Policy Goal 2000	Indicator Value
Greenhouse Effect (GWP)			
CO_2	158019	150494	1.05
N_2O	8910	10800[a]	0.83
CH_4	6270	9258[a]	0.68
	173199	**170552**	**1.02**
Depletion of the Ozone Layer (ODP)	**12451**	**8000[b]**	**1.56**
Eutrophication (PEE)			
P	166	47	3.53
N	132	58[c]	2.27
	298	**105**	**2.83**
Accumulation of Waste (mln KG)	**14737**	**5000**	**2.94**
Depositions:			
Acidification (PAE)	**15918**	**8146**	**1.95**
(PAE/Ha*10^3)	4757	2400	1.95

Note: Only the indicators printed in bold are implemented in the NAMEA.

a) These policy targets are slightly corrected to account for adjusted GWP-conversions in comparison with VROM (1992a), see section 3, greenhouse effect.

b) Intrapolated policy target for 1989, in this case based on a complete ban of CFCs and halons in 1995.

c) This policy target is slightly corrected in comparison with VROM (1992a): in addition to emissions into water and soils it encompasses nitrogen containing air emissions.

Source of policy goals: VROM (1989, 1992a and 1992c).

4. The potential impact of economic activities on the environment

This section contains an analysis concerning the potential impact of economic activities on the environment. This analysis is based on the data contained in the NAMEA. In table 12, the emission data in table 3 have been converted into environmental stress equivalents and subsequently aggregated by themes. In this way the contributions of consumption purposes and production activities to specific themes are illustrated.

Table 12. Contributions by production and consumption activities to Net Domestic Product, employment, exports and a number of environmental themes in the Netherlands, 1989.

	Economic indicators				Environment indicators				
	Net Domestic Product	Labour volume	Exports	Consumption expenditure	Greenhouse effect	Depletion of ozone layer	Acidification	Eutrophication	Waste Accumulation
	1	2	3	4	5	6	7	8	9
	%								
Industry branches					81	80	88	92	72
Private households					19	20	12	8	28
Total					100	100	100	100	100
Industry branches	100	100	100		100	100	100	100	100
of which:									
Agriculture	4	4	6		13	0	47	85	5
Manufacturing industry	20	19	69		36	54	24	11	40
of which:									
Oil refineries	0	0	6		8	0	9	0	0
Chemical industry	3	2	16		14	50	8	8	17
Basic metal industry	1	1	3		5	0	3	0	1
Other manufacturing	16	16	44		9	4	5	3	22
Electricity plants	1	1	0		28	0	10	1	1
Construction industry	6	8	1		1	25	1	0	21
Transport	5	5	10		6	6	12	1	13
Services and other ind.	64	65	16		17	15	7	1	20
Private households				100	100	100	100	100	100
of which:									
Own transport				6	39	0	89	17	2
Other consumption				94	61	100	11	83	98

These contributions are connected to other information derived from the same NAMEA: net domestic product per production activity and private consumption per purpose. Besides, employment and export figures are presented in column 2. It applies to each theme that at least 80 per cent of production-related emissions originate from production activities which generate only 36 per cent of total value added and 35 per cent of total employment. Comparatively little pollution is caused by services etc. (excluding transport), and by 'other' manufacturing, that is, excluding oil refineries, chemical and basic metal industries.

Manufacturing contributes most to the global warming problem. In relative terms however, electricity generation is far more important (1 per cent of value added versus 28 per cent of production related emissions). More than 40 per cent of the emissions of acid substances (production and consumption related) are caused by agriculture (4 per cent of value added). This is due to the substantial agricultural emissions of NH3. The largest emitters of waste are manufacturing and households with contributions of 29 and 28 per cent, respectively. It is not surprising that the eutrophication problem is largely caused by agriculture, while chemicals manufacturing contributes most to the ozone depletion problem.

Among household consumption expenditures, 'other purposes' cause most of the emissions of global warming gases while almost all acid emissions come from 'transport'. Only a small part of total waste generation by consumers is related to transport because a major part of discarded car wrecks is re-cycled and is, therefore, subtracted from the waste data.

5. Conclusions

The robustness of the NAMEA-design to advances in knowledge on environmental issues and improvements in basic data collection implies that a regular compilation and publication can already start. When more or better data become available, or a consensus is reached on an amendment of aggregation functions, this can then be implemented with the help of a revision strategy similar to the one followed in the core national accounts. The limitations of the presented NAMEA for the Netherlands comparing to the complete NAMEA system presented in section 3 may be reduced when more information become available. Since the current presentation of environmental themes is somewhat limited, additional information on other environmental problems or changes in environmental assets can be inserted, without a change in methodology, as soon as the data become available.

The NAMEA presented in this paper serves to demonstrate that economic and environmental data can be placed into a single information framework in which monetary and physical units are combined. In particular, the Netherlands' NAMEA shows the relationship between production and consumption activities and all kinds of environmental problems, grouped into a limited set of themes. No specific assumptions are needed at this stage, apart from a harmonization of classifications.

The emission data have been converted into theme equivalents (see tables 6-8 and 10) and finally into theme indicator values. This yields five aggregate environmental indicators which fit into the macro-framework presented in table 2. This table thus provides an integrated presentation of economic indicators, such as NDP and the current external balance, and environmental indicators on the following themes: greenhouse effect, depletion of the ozone layer, acidification, eutrophication and waste disposal. The value of these environmental indicators can be directly related to the levels of economic activity in the reference year, or, in other words, the macro-indicators in table 2 are consistent, both conceptually and numerically. When NAMEAs become available at regular intervals, then the rates of change in economic and environmental macro-indicators can be juxtaposed and it can be seen at a glance in which direction the economy and environment has been heading.

Notes

1) Consult Keuning and de Ruijter (1988) for general issues of classification.

2) Since final consumption expenditures of government and private non-profit institutions consist only of goods and services they produce themselves, all their 'free' emissions can be ascribed to a (conventional) production process.

3) If total extraction is surpassed by expected natural growth, a negative number should not be recorded here. Instead, this net expected positive change should be subtracted from net losses due to natural causes, as recorded in the capital accounts (discussed below).

4) Strictly speaking, a separate 'other changes in environmental assets' account should have been included as well, as a supplement to this type of account for the conventional

assets. In that case, the present cells #16,12 and #17,12 would have appeared in the column of that account and the row of the account would have put the sum of those items in the other accumulation account (#12). Such a more refined registration method would, however, not deviate much from the present one.

5) It is possible that the non-referable degradation refers to a specific type of matter (in our example: seals). In that case this may be booked first in #16,12 (+), than in #16,17 (-), and finally in cells #17,18 (-) and #18,12 (-).

6) In the full matrix shown the annex, consumption related to private transportation is separated from other consumption.

7) No information is available on emissions of Dutch vehicles abroad. While these emissions have not been added in the emission account, emissions from foreign vehicles in the Netherlands have not been sub-tracted. It is thus assumed that these inaccuracies in the data cancel out.

8) Recycling of waste within the same establishment is not shown in this NAMEA, as it is concerned with outputs that can be delivered or provided to other units (including the environment) only (see: United Nations, 1992, Chapter VI, page 2 and De Boo et al (1991)).

9) This procedure is very similar to the presentation of environmental indicators and targets in VROM (1992a), as copied in the annual government budget report (Netherlands Ministry of Finance, 1992), but a few of the themes presented there could not yet be included in the comprehensive national accounting framework, due to lack of data.

ANNEX A disaggregated NAMEA 1989 (account 1-8 in billion guilders)

			1. GOODS AND SERVICES													2. CONSUMPTION		3. PRODUCTION							
			Product groups													Purposes		Production Activities							
			1a	1b	1c	1d	1e	1f	1g	1h	1i	1j	1k	1l	1m	2a	2b	3a	3b	3c	3d	3e	3f	3g	3h
1. GOODS AND SERVICES	Food, Beverages, Tobacco, Ores & Minerals	1a														0.00	47.27	15.20	0.01	0.74	0.01	49.97	0.08	0.11	0.28
	Textiles, Clothing & Leatherwear	1b														0.00	22.99	0.04	0.01	0.15	0.04	3.70	0.00	0.10	0.09
	Wood, Building Material, Paper, Printing & Publishing	1c														0.00	15.75	0.28	0.05	1.59	0.17	21.97	0.04	11.54	0.59
	Petroleum & Petroleum Products	1d														8.27	0.00	0.38	15.46	4.72	0.04	1.02	0.05	1.09	1.93
	Other Chemical Products	1e														0.00	10.50	1.22	0.03	14.81	0.20	11.25	0.10	2.39	0.07
	Metal and Other Manufacturing Products	1f														0.00	16.44	0.88	0.19	1.15	4.10	30.06	0.44	10.26	0.71
	Transport Equipment	1g														9.74	0.00	0.00	0.00	0.00	0.00	3.28	0.00	0.12	0.93
	Electricity, Gas, Water and Coal	1h														0.00	9.33	1.18	0.16	2.39	1.09	2.86	3.06	0.13	0.39
	Construction	1i														0.00	1.87	0.35	0.06	0.26	0.18	1.05	0.15	15.57	1.04
	Hotel, Restaurant & Repair Services	1j														0.00	20.07	0.03	0.04	0.18	0.02	1.01	0.04	0.64	0.97
	Transport and Storage Services	1k														0.00	5.14	0.00	0.06	0.11	0.01	0.51	0.00	0.29	1.78
	Other Goods and Services	1l														0.00	117.13	1.75	1.30	4.88	1.02	24.20	1.56	4.32	10.11
	Trade and Transport Margins	1m	23.30	9.92	12.48	2.87	11.27	24.03	4.85	0.17	0.00	0.00	0.00	0.00	-88.89										
2. CONSUMPTION	Transport	2a																							
	Other Purposes	2b																							
3. PRODUCTION	Agriculture	3a	39.43	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10										
	Refineries	3b	0.00	0.00	0.00	18.64	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.69	0.00										
	Chemical Industries	3c	0.19	1.58	0.28	0.78	42.27	0.10	0.00	0.11	0.00	0.00	0.00	1.51	0.77										
	Basic Metals	3d	0.00	0.01	0.02	0.06	0.04	10.42	0.01	0.15	0.00	0.00	0.00	0.36	0.05										
	Other Manufacturing	3e	74.32	8.18	41.69	0.70	8.08	49.79	16.43	0.16	2.60	0.00	0.00	11.28	4.05										
	Electricity Generation	3f	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.95	0.00	0.00	0.00	1.51	0.00										
	Construction	3g	0.00	0.00	0.06	0.00	0.00	0.06	0.05	0.00	70.62	0.00	0.20	1.04	0.44										
	Transport	3h	0.01	0.00	0.11	0.00	0.00	0.00	0.44	0.00	0.19	0.27	31.38	1.46	9.67										
	Services and Other Activities	3i	4.12	1.06	7.92	1.39	0.29	3.94	0.24	22.39	1.60	24.98	0.21	300.55	73.81										
4. INCOME GENERATION	Wages and Salaries	4a																1.46	0.54	5.44	1.70	35.39	1.50	13.96	11.76
	Employers' Social Contributions	4b																0.38	0.13	1.35	0.47	9.36	0.29	5.06	3.03
	Operating Surplus (Incl. Other Net Taxes on Production)	4c																13.67	0.56	6.76	1.32	16.70	0.72	5.38	4.20
5. INCOME DISTRIBUTION AND USE	Non-Financial Corporations	5a																							
	Financial Intermediairies	5b																							
	Insurance Corporations and Pension Funds	5c																							
	Government Including Social Security Funds	5d	4.77	3.78	2.83	6.20	1.87	5.39	4.51	1.63	7.26	2.56	-3.07	2.36											
	Households (Including Unincorporated Enterprises)	5e																							
6. CAPITAL		6																2.87	0.77	2.85	0.76	4.97	2.42	1.49	5.65
7. FINANCIAL BALANCE		7																							
8. REST OF THE WORLD	Current	8a	31.72	15.55	20.78	20.80	28.58	72.59	21.87	2.58	0.01			34.27											
	Capital	8b																							
9. EMISSIONS	CO2	9a																							
	N2O	9b																							
	CH4	9c																							
	CFCs and Halons	9d																							
	NOx	9e																							
	SO2	9f																							
	NH3	9g																							
	P	9h																							
	N	9i																							
	Waste	9j																							
10. THEMES	Greenhouse Effect (GWP)	10a																							
	Ozon Depletion (ODP)	10b																							
	Acidification (PAE)	10c																							
	Eutrophication (PEE)	10d																							
	Waste (mln KG)	10e																							
11. DEPOSITIONS	Acidification (PAE)	11																							
TOTAL			177.87	40.23	86.17	51.43	92.39	166.32	48.39	36.19	82.29	27.81	28.73	354.84	0.00	18.01	266.48	39.68	19.37	47.37	11.12	217.29	10.46	72.47	43.53

a) These data are available but not recorded in the NAMEA because the concomitant policy objectives have been formulated for emissions and not for depositions.

-: Data are not available.

	4. INCOME GENERATION			5. DISTRIBUTION AND USE					6. CAPITAL	8. REST OF THE WORLD		9. EMISSIONS (in million kg, CFCs and halons in thousand kg)										10. THEMES					11. DEPOSITIONS	TOTAL
	Primary Income Categories			National Sectors						Current	Capital	CO2	N2O	CH4	CFCs & Halons	NOx	SO2	NH3	P	N	Waste	Green-house GWP	Depletion Ozone layer OPD	Acidification PAE	Eutrophication PEE	Waste mln KG	Acidification PAE	
	4a	4b	4c	5a	5b	5c	5d	5e	6	8a	8b	9a	9b	9c	9d	9e	9f	9g	9h	9i	9j	10a	10b	10c	10d	10e	11	
8.75							0.12		-0.45	55.77																		177.87
1.07							0.00		0.83	11.20																		40.23
15.93							0.00		4.86	13.40																		86.17
2.36							0.00		-0.33	16.42																		51.43
5.46							0.00		1.52	44.85																		92.39
10.88							0.14		30.06	61.02																		166.32
5.08							0.00		15.11	14.14																		48.39
9.83							0.00		0.23	3.54																		36.19
12.02							0.00		48.43	1.31																		82.29
4.82							0.00		0.00	0.00																		27.81
1.60							0.01		0.00	19.21																		28.73
83.99							71.49		8.28	24.83																		354.84
																												0.00
								18.01				12833	0	4	0	132	3	0	0	39	162							18.01
								266.48				19300	2	9	3157	19	1	10	13	64	7064							266.48
												7511	24	393	0	13	1	230	127	1067	962							39.68
												10732	0	1	0	21	70	0	0	6	40							19.37
												19981	0	4	6313	44	27	8	19	25	3167							47.37
												6636	0	0	0	13	15	0	0	4	150							11.12
												13233	0	0	473	44	13	0	6	26	4024							217.29
												38452	1	2	0	78	43	0	0	23	146							10.46
												958	0	0	3157	9	1	0	0	3	3782							72.47
												7876	1	2	789	125	23	0	0	36	2294							43.53
												20507	5	155	1894	78	14	0	1	23	3674							442.50
27.03										1.12																		199.88
34.02																												54.09
86.56																												135.88
			33.10	38.18	6.37	0.82	0.25	1.11		11.67																		141.50
			-9.43	19.30	5.98	0.42	9.31	14.70		31.70																		71.98
			1.48	9.02	10.68	2.61	12.76	3.86		3.57																		43.98
			2.57	28.36	4.46	0.67	101.59	143.86	0.97	10.70																		333.28
	198.62	54.09	58.16	4.06	13.26	37.44	130.00	349.36		2.69																		847.68
33.10				25.33	4.95	1.95	-8.69	48.00	86.01		0.93																	213.36
									15.62		-15.62																	0.00
	1.26			17.25	26.28	0.07	16.29	2.30								109	101	24	a)	a)	-							312.21
									2.22	-16.91																		-14.69
																						158019						158019
																						33						33
																						570						570
																							15783					15783
										504														181				685
										166														146				312
										146														126				272
										a)															166			166
										a)															1316			1316
0728										-																14737		25465
									1.02																			173199
									1.56																			12451
																											15918	15918
									2.83																			298
									2.94																			14737
									1.95																			15918
42.50	199.88	54.09	135.88	141.50	71.98	43.98	333.28	847.68	213.36	213.21	-14.69	158019	33	570	15783	685	312	272	166	1316	25465	173199	12451	15918	298	14737	15918	

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Chapter VI

NATURAL RESOURCE ACCOUNTING - THE NORWEGIAN APPROACH[2]

Hans Viggo Saebø,

The paper gives an overview of the Norwegian natural resource accounting system: principles, structure, use and experiences. The original concepts are used. Examples of accounting tables and of use of the accounts for planning purposes are also included, though the emphasis of this paper is put on the principles and structure of the accounts. Some important references on both the establishment and experiences from the use of these in planning are listed.

Introduction

The World Commission for Environment and Development recommended that accounts of natural resources and the state of the environment be developed and presented in addition to (traditional) national accounts. The United Nations Conference on Environment and Development, Rio de Janeiro, in June 1992, emphasized natural resources and environmental accounting as an important tool in obtaining sustainable development.

Natural resources and environment accounts can be integrated with or linked to national accounts in several ways. A major possibility is to integrate environment accounts with national accounts through so called satellite accounting, with the aim of adjusting gross domestic product (GDP) to account for the depletion of natural resources and the environment. Such an adjustment presupposes evaluations of both natural resources and changes in the state of the environment in monetary terms.

Another way of increasing the emphasis on natural resources and environmental issues in economic policy, is to link physical natural resources accounts to economic planning through models. Such models can be used to show how economic development affects the environment and how activities and measures to improve the environment (e.g. taxes) affect the development of both the environment and the economy. Monetary valuation of natural resources and the environment is also relevant within this approach, but in analyses and not directly within the framework of the natural resources and environmental accounting schemes. In both cases, however, natural resources and environment accounts in physical terms must be used as a basis for valuation and further analyses.

The Norwegian approach is the latter, with physical natural resources accounts linked to national accounts and models based on these accounts. This paper gives a brief overview of this approach.

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[2] Paper to be presented at the UNEP/ECE/UNSTAT Workshop on Environmental and Natural Resource Accounting in Kistova Nova Ves, Slovakia, 21 to 23 March, 1994.

1. History of natural resource accounting in Norway

The work on the Norwegian natural resources accounting system was initiated by the Ministry of Environment in the early 1970s, but since 1978, the system has been developed and operated by Statistics Norway (SN). The first Norwegian natural resources accounts were established for energy, minerals, forest, fish and land use in the early 1980s (SSB, 1981; Alfsen, Bye and Lorentsen, 1987).

The purpose of these accounts was to provide better and more long-term planning of the exploitation of natural resources. Emphasis was put on the resource aspect, though some of the resources and accounting schemes also included some environmental aspects (i.e. land use).

It was envisaged that improved natural resource planning could be obtained by natural resource accounting giving:

- New and better data;
- Better coordination;
- Common presentation of information on different natural resources;
- Integration of natural resource planning and traditional economic planning;
- Integration of national planning and regional (subnational) planning.

Accounting techniques as such lead to the identification of gaps in data, promote coordination and provide a common presentation scheme (i.e. material balances), whereas the integration of planning in Norway is enabled by modelling based on both the national accounts and the resource accounts. Consistency of sector divisions between these types of accounting schemes represents a precondition for such integrated modelling.

During the development of resource accounts in Norway, the aim was to include pressure on the environment from the extraction and use of natural resources, and in some cases changes in environmental status or quality due to this pressure. These parts of the accounting system are denoted environmental accounts. The aim, however, has never been to include all environmental statistics within the framework of resource accounting.

The land use accounts which were developed at the beginning of the eighties were based on point sampling on maps and air photographs. They provide a survey of land use in the whole country and particularly in urban areas (Sæbø, 1983). For urban areas, tables showing changes in land use from 1955 to 1975 were established. Point sampling was very time consuming, though less than complete mapping would have been. The demand for data and statistics, however, was not large enough to justify updating these accounts. Complete land use accounts are, therefore, not draw up in Norway, but reasonable statistics, based on various traditional data sources are available for some important land use types (such as agricultural land).

At the beginning of the eighties, there were attempts to establish resource accounts for water in Norway, but this was also time consuming. One of the results of the work was the establishment of a watercourse register for Norway. Since water is not a scarce resource in general, however, there were no users of complete and comprehensive water resource accounts, so that the work has not been continued.

Resource policy and planning were larger issues in Norway in 1980 than today. Both managerial and public interest has gradually shifted towards environmental issues, such as changes in global climate and the depletion of the ozone layer. As a result, natural resource accounts, in their original form are today only worked out regularly for energy. These annual energy accounts have also been supplemented by tables on emissions of polluting components to air. These emissions are mainly calculated on the basis of energy consumption figures in the energy accounts. The stock part of accounts for fish and forest (wood) are also updated regularly. Energy, however, (in particular, emissions to air) is the only area where resource accounts have been linked to macro-economic models and used regularly in planning.

Much work is being done, however, to establish statistics for other environmental stresses. Examples are discharges of nutrients and *waste statistics*. The extension of these statistics to describe material flows in both society and nature will represent an extension of the work on resource or environmental accounts in Norway.

Allocating the work on natural resource accounting to Statistics Norway has ensured access to statistical expertise and closeness to the primary statistics used in the development of the natural resource accounts. Statistics Norway is also responsible for national accounting and the development and operation of the economic planning models employed by the Ministry of Finance. The resource accounting framework is based on existing economic standards and sector classification schemes, thus ensuring general consistency in the sectoral classification of economic and resource-related data and statistics. Use of a common set of standards and models in the analysis of resource issues, has facilitated communication between ministries responsible for the management of the economy and those involved in the management of the natural resources; e.g. the Ministry of Finance, the Ministry of Environment and the Ministry of Industry and Energy.

Resource accounts are worked out in the economic and environment statistics department of Statistics Norway, whereas economic analysis and modelling on the basis of these accounts is carried out by the research department. Environment statistics in general have been given increased priority within Statistics Norway during the last few years. A development strategy for these statistics has been established in cooperation with important users, such as the Ministry of Environment and the State Pollution Control Authority. Main priority areas within environment statistics in Statistics Norway today are:

- Resource accounts for energy;
- Resource accounts for fish (stocks);
- Resource accounts for forest (stocks);
- Emissions to air;
- Discharges to water (in particular from population and agriculture);
- Waste and recycling;
- Environmental expenditures.

3. Principles and structure of Norwegian resource accounts

Natural resources are classified in two groups:

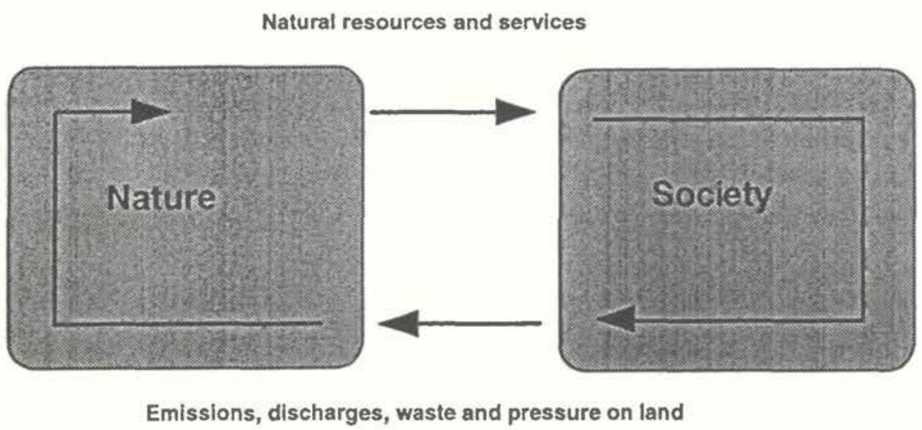
1. *Material resources* - resources which can be extracted or harvested from the nature, denoted *material accounts;*
2. *Environmental resources* - resources on which possibilities for life and production are dependent, denoted *environmental accounts.*

The Norwegian resource accounts are mainly material accounts.

The resource accounts give a coherent survey of stocks (reserves), extraction and use of natural resources. Central economic planning is mainly based on the national accounts, which give a survey of economic stocks and flows in society.

The resource accounts can be seen as an extension of the national accounts to include parts of nature, but the flows between nature and society and inside society are here described in *physical units*. Figure 1 shows such extended national accounts which in very simplified form, consist of only two sectors. The sector "nature" has stocks of natural resources and environmental quality and supplies the economy with goods (natural resources) and services (e.g. recreation services). Nature receives emissions and discharges of pollutants and wastes. Factors like pressure on land also affect nature. The Norwegian resource accounts describe the reserves and extraction of natural resources, the flow of these resources through society and pressures on nature like emissions to air. The flow of pollutants through nature (illustrated by the arrow inside the nature box in figure 1) has so far not been included.

Figure 1. Resource accounts as extended national accounts



Although Norwegian resource accounts are kept in physical units, some calculations of the reserves or the natural capital in monetary units are also carried out, but only for the value of the resource as a natural resource and nòt for its possible value as an environmental asset.

As mentioned, the possibility for integrated economic and natural resource planning by the use of models is an important reason for linking the resource accounts to the national accounts. In practical terms this means that *the resource accounts must be based on the same sectoral divisions as the national accounts* (SNA).

Material accounts

The material accounts comprise accounts for *reserves* in nature and for the *material flow* of resources from extraction through the economy to final usage.

The reserves comprise the known and economically exploitable part of the resources, and the reserve accounts show how the reserves change with in a period by discoveries, revaluations (because of changes in prices and costs and better knowledge) and extraction. Figure 2 illustrates the reserve accounts for a mineral resource.

Reserves of biotic resources are usually called *stocks*. In this case the reserve or stock accounts show how the stocks change due to recruitment (new individuals), growth, revaluation (because of better knowledge), natural death and extraction (catch or harvest), see figure 3.

The material flow in the economy is described as a balance, or a set of tables showing extraction, exports/imports, conversion and use. This part of the resource accounts, with the only difference being that material accounts are in *physical* units, and national accounts are in *monetary* units. Figure 4 gives a simplified sketch of the material accounts.

Figure 2. Reserve accounts for mineral resources

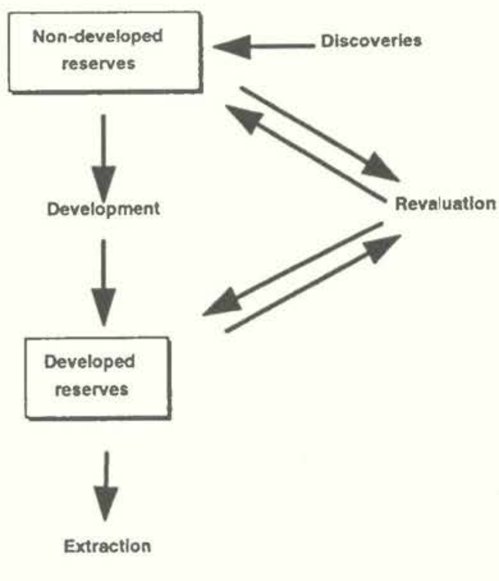


Figure 3. Stock accounts

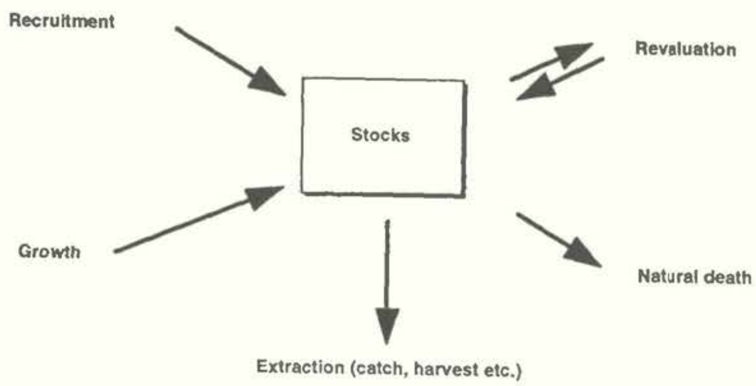
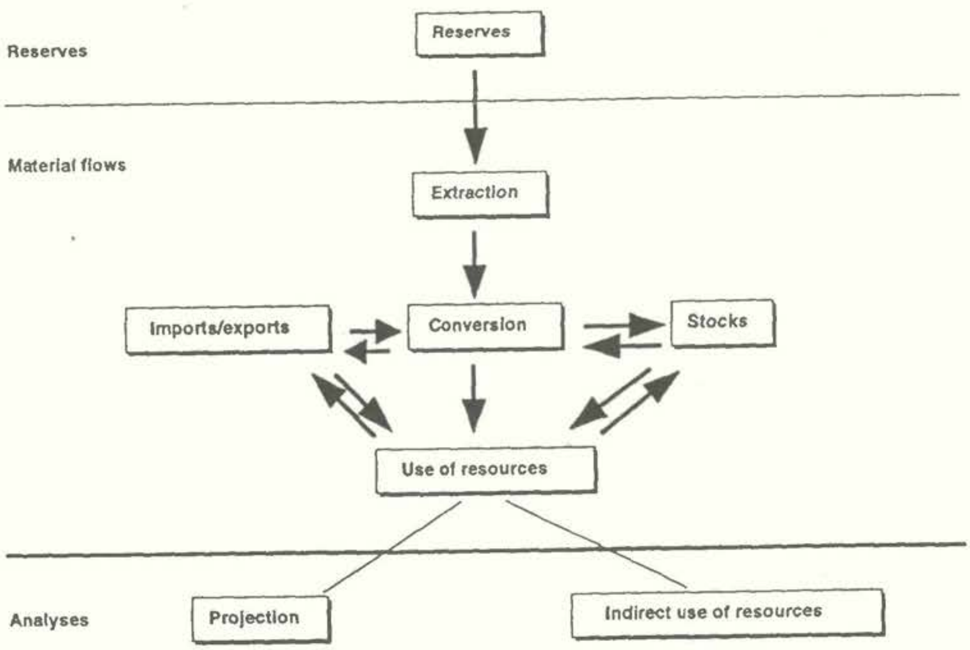


Figure 4. The material accounts



The resource accounts only follow the resource flow through a limited number of goods (raw materials and intermediate products), and usually do not keep track of the end uses of the resource. Resource accounts which are consistent with the national accounts will, however, enable the estimation of the amount of resources used for all goods and services covered by the national accounts. This is done by input-output models. The estimation of so called *indirect energy use* is a type of analysis which has been carried out on the basis of the Norwegian resource accounts.

Other types of analysis project the resource use for every sector included in models based on the national accounts. Macro-economic models have been developed to account for energy use, which have made it possible to study the effect of economic policies on energy use and the effects on the economy of different types of energy policies. The integration of economic planning and resource planning has been one of the main reasons for establishment the Norwegian energy accounts. Recently, similar integration with environmental policies, in the form of agreements setting limits for emissions of pollutants to air, has been important. The energy accounts are the natural basis for the estimation of emission figures. These figures constitute the *emission accounts*, which are the first part of the *environmental accounts*.

Environmental accounts

Environmental accounts in Norway consist of two parts:

* Emission accounts, which survey emissions, discharges and wastes;
* Status accounts, which show a survey of environmental status at a point in time and changes two points in time.

Figure 1 shows the linkages between nature and society. The emission accounts represent the link between human activities and the environment, and in principle can describe all types of environmental stresses such as pressure on land.

Contrary to the material accounts, accounts for environmental status must have a spatial dimension. Environmental resources cannot be moved.

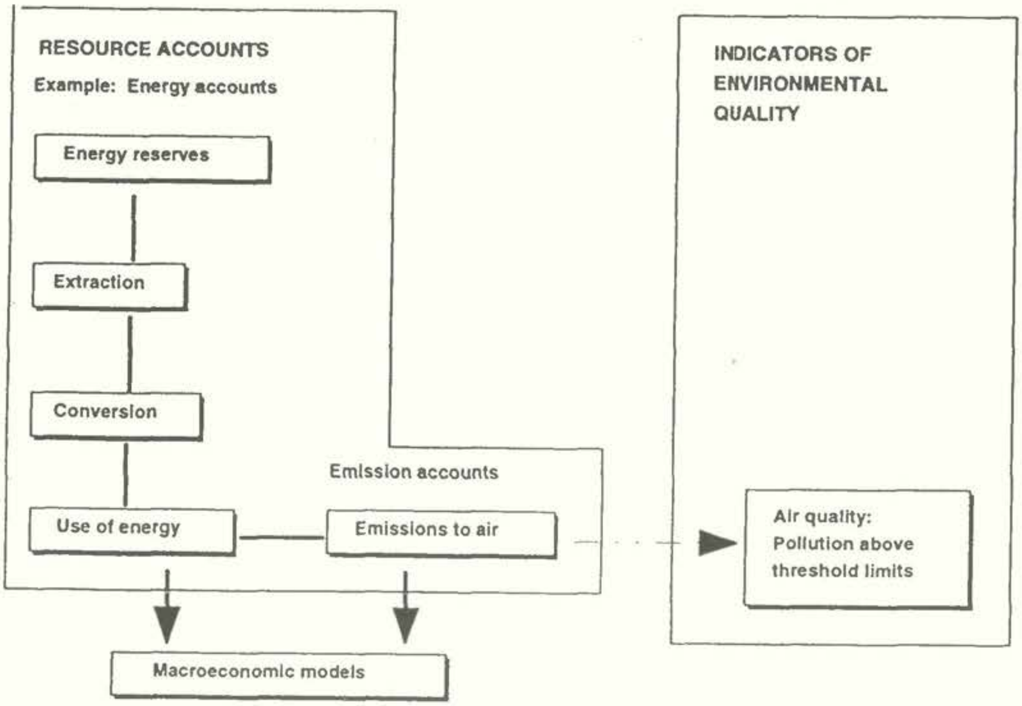
All Norwegian resource accounts, except those for land use, were developed as *material accounts*. The emission accounts for air also describe material flows, but in this case a flow of residuals to nature.

4. Resource accounting and environmental indicators

It is difficult to present status and changes in *environmental quality* within the framework of resource or environmental accounts. An important reason for this is the lack of well established, general, quantitative measures for environmental quality. Another reason is uncertainty and disagreement about the cause/effect chain linking environmental *pressures or stresses* and the *effects* or *environmental status*. The work on *environmental indicators* can be seen as a contribution to solving this problem (Alfsen and Sæbø, 1993). Such indicators both contribute to better presentation of environmental information and provide a better basis for setting priorities and following up on environmental policies.

Figure 5 shows an example of how indicators for environmental quality can supplement and complete the Norwegian resource accounts.

Figure 5. Resource accounting and environmental indicators



5. Resource accounting for analysis and economic planning

Natural resource accounting in Norway is not an aim in itself, but rather a way of providing systematic data for information and analytical purposes, as a basis for both environmental and economic planning. In particular, information based on the energy accounts and associated emission inventories has been integrated into more comprehensive analytical tools, by expanding macro-economic planning models. These extended macro-economic models are now used by government and other administrative bodies on a routine basis. The most recent example is the Government's Long Term Programme 1994-1997.

Several aims are achieved by integrating resource and environmental data with economic models. First, consistency between economic planning, expected growth in energy use and resulting emissions to air is secured in the model-based forecasts. Secondly, by providing output tables covering both economic, energy and environmental variables, the linkage between these policy areas is brought to the attention of the policy makers. Finally, communication among the different branches of the government is enhanced by making a single modelling tool available to both the Ministry of Finance and Ministry of the Environment (among others).

Typically, three types of questions are addressed by the integrated model:

1) What is the likely future economic development, demand for energy and level of emissions to air? Are environmental targets compatible with the economic goals?;

2) How will a change of policy (e.g. introduction of environmentally motivated taxes or regulations) affect the projected development, both with respect to the economy and the environment?;

3) How will future development in the state of the environment and energy resource availability affect economic development?

6. Examples

Tables 1 - 4 are examples from the Norwegian resource accounts showing different aspects of accounting schemes which are of interest in a consistent setup of resource and environmental information. Results of some typical analyses using an integrated economy/resource/emission model are given in the next part of this chapter. For an overview of this model with more detailed examples, see Alfsen, 1993 and 1992.

<u>Accounting tables</u>

Table 1 shows the development of the Norwegian crude oil reserves. It should be noted that both annual revaluations and for most years the increase in reserves due to new fields are comparable in size with the extraction. Thus, the reserves have increased over the last 5 years in spite of high production.

At today's level of production and with known extraction technology, the oil reserves in fields that have been developed or are to be developed will last 10 years. The Norwegian gas reserves, which are even larger than the oil reserves, will last 49 years. If assumed reserves in fields that are not yet licensed are added, the production periods are extended to 15 years for oil and 101 years for gas. Figure 6 shows the trends in the relationship between reserves and production. The decrease in this relationship for oil is due to increased production over recent years.

Table 1. Reserve accounts for crude oil. Developed fields and fields to be developed. 1990 - 1993. Million tonnes

	1990	1991	1992	1993
Reserves per 1/1	982	1111	1112	1222
New fields	103	93	94	4
Revaluation	108	2	122	98
Extraction	-82	-93	-106	-116
Reserves per 31/12	1111	1112	1222	1209

Figure 6. The relationship between Norwegian reserves and production of oil and gas(R/P-rate). Developed fields and fields to be developed. 1979 - 1993

Figure 6. The relationship between Norwegian reserves and production of oil and gas (R/P-rate). Developed fields and fields to be developed. 1979 - 1993

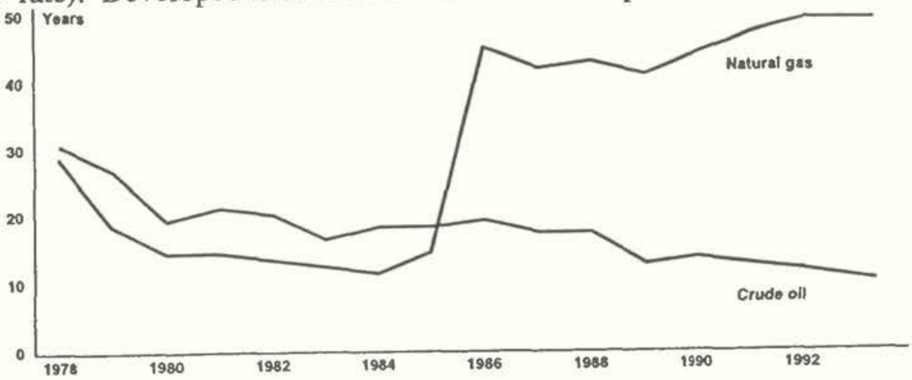


Table 2 illustrates reserve accounts for forest (wood). The forest balance reveals that the volume of wood is increasing in Norway. Annual depletion constitutes about 60 per cent of natural growth. In fact, the volume of Norwegian forests has increased by more than 90 per cent since 1925 (figure 7). Increasing volume of forest is typical for most countries in the Northern hemisphere. This increase leads to greater absorption of the climate gas CO_2, which contributes to slow down the increase of the atmospheric concentration of this gas, an increase which may lead to global warming. The CO_2-content of roundwood has been added to the table. In 1993, net CO_2 binding in Norwegian roundwood of 6.1 mill. tonnes corresponds to 18 per cent of Norwegian (antrophogenic) emissions. If bark, roots and other biomass linked to trees are included, then this figure will probably double.

Table 2. Forest balance for Norway. Mill. m^3 without bark. 1993

	Total	Spruce	Pine	Deciduous	CO_2-content in wood Mill. tonnes
Volume 1/1	588.1	273.7	193.4	120.9	478.3
Roundwood cut	10.3	7.0	2.1	1.1	8.4
Other mortality	2.0	1.0	0.4	0.5	1.6
Gross growth	19.9	10.4	5.3	4.3	16.2
Volume 31/12	595.6	276.0	196.1	123.5	484.4

Figure 7. Cubic mass of forest in Norway. 1925 - 1993. Million m^3

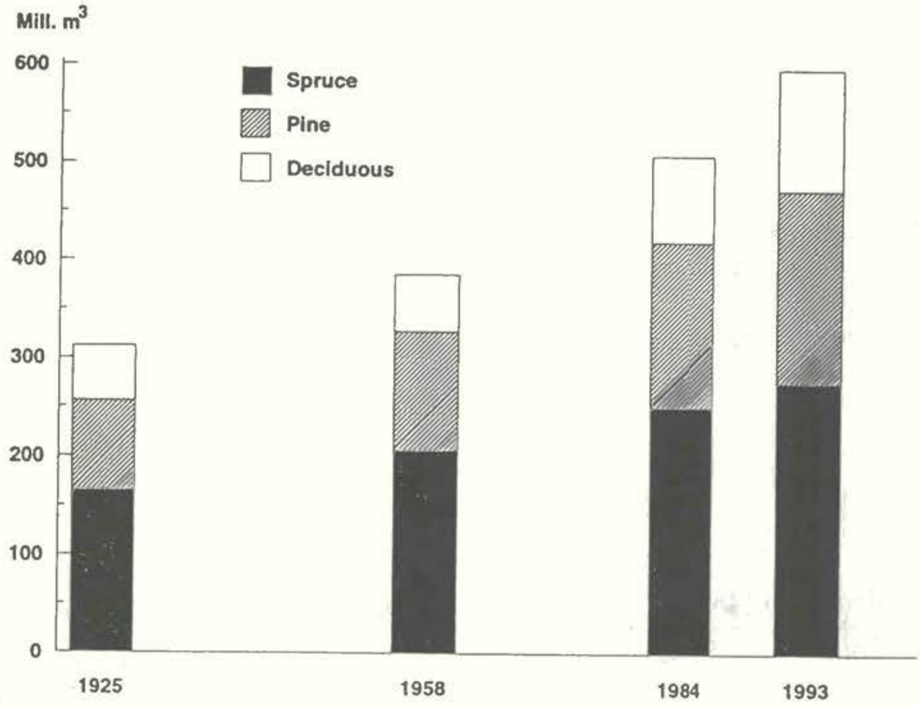


Table 3 shows the flow of energy in Norway with distribution of energy use among main industrial sectors and households. This table is based on a detailed table where energy use is accounted for in more than 100 sectors comparable to sectors in the national accounts system.

Table 3. Extraction, conversion and use of energy in Norway. 1992. PJ

	TOTAL	Coal and coke	Fuel-wood, waste etc.	Crude oil	Natural gas	Petroleum products	Electricity	District heating
Extraction of energy	6194	11	-	4525	1180	57	421	-
Energy use in extraction sectors	-136	-	-	-	-119	-11	-6	-
Imports and Norwegian purchases abroad	518	42	0	48	-	423	5	-
Exports and foreign purchases in Norway	-5510	-9	0	-3980	-1057	-427	-36	-
Stocks	-29	-3	-	-26	-	0	-	-
Primary supply	1038	41	0	567	4	42	384	-
Petroleum refineries	-40	-6	-	-581	-	538	-2	-
Other energy sectors, other supply	51	-1	38	-	-	8	0	6
Losses, statistical errors	-10	0	0	14	-4	6	-25	-2
Use outside energy sectors	1039	46	38	-	-	594	356	4
Ocean transport	312	-	-	-	-	312	-	-
Domestic use	727	46	38	-	-	283	356	4
- Agriculture and fishery	28	0	0	-	-	25	2	0
- Energy intensive manufacturing	192	36	0	-	-	54	102	0
- Other manufacturing and mining	106	10	20	-	-	22	54	1
- Other industries	188	0	0	-	-	107	79	2
- Private households	213	0	18	-	-	75	119	1

Emissions to air of 10 pollutants are calculated on the basis of energy accounts and other activity measures where relevant (e.g. number of cattle in the case of methane). The calculations are done for 132 industrial sectors and time for 30 technical emission sources, such as transportation and industrial processes. For road transport, a detailed sub-model is employed. Emission coefficients are worked out in cooperation with the State Pollution Control Authority which also provides the unmeasured emission figures for companies with major emissions. Consistency is thus ensured both with the National accounts and technical approaches based on classification of emission sources.

Table 4 shows the distribution of emissions by source. Such distributions can be set up for all economic sectors. The emission figures have also been broken down to 19 counties and 439 municipalities. For more information on Norwegian emission accounts, see Rypdal, 1993.

Table 4. Emissions to air by source. 1992. 1000 tonnes unless otherwise specified

	CO_2	CH_4	N_2O	SO_2	NOx	NH_3	NMVOC	CO	Pb	Particles
	Mill. tonnes								Tonnes	
Total	34.3	293.1	13.1	37.5	219.6	39.8	265.2	851.5	150	20.3
Stationary combustion	14.0	13.1	1.4	8.9	41.6	-	10.9	123.8	1	12.8
Petroleum extraction	7.0	2.5	0.1	0.3	27.6	-	1.1	5.2	0	0.1
-- Natural gas	4.2	2.2	0.0	0.0	15.4	-	0.6	4.2	0	0.0
-- Diesel	0.4	0.1	0.0	0.3	7.2	-	0.5	0.5	0	0.1
-- Flaring	0.8	0.2	0.0	0.0	5.0	-	0.0	0.5	0	0.0
Gas terminals and oil refineries	2.3	0.3	0.1	0.1	3.4	-	0.9	0.2	0	0.1
Other industries	2.6	0.4	0.8	6.1	7.0	-	0.7	6.5	0	1.5
Houses, offices etc.	2.0	9.8	0.5	2.0	2.3	-	7.8	111.6	0	11.1
Incineration of waste	0.1	0.1	0.0	0.3	1.2	-	0.3	0.3	1	0.0
Process and evaporation	6.6	277.1	10.6	20.1	6.6	39.4	158.4	46.3	2	..
Oil and gas	0.4	9.2	-	-	-	-	114.7	-	-	..
-- Venting, leaks etc.	0.0	5.2	-	-	-	-	3.6	-	-	..
-- Oil loading	0.3	3.5	-	-	-	-	102.2	-	-	..
-- Gas terminals and oil refineries	0.0	0.4	-	2.5	-	-	8.9	-	-	..
Gasoline distribution	0.0	-	-	-	-	-	8.9	-	-	..
Paper and pulp industry	-	-	-	0.7	-	-	-	-	-	..
Chemical production	1.0	0.8	4.2	5.1	1.0	0.4	0.9	32.3	-	..
Cement and other mineral products	0.6	-	-	0.5	-	-	-	-	-	..
Manufacture of metals	4.2	-	-	11.1	5.6	-	1.3	14.0	2	..
--Ferroalloys	2.4	-	-	7.3	5.0	-	1.3	-	-	..
--Aluminium	1.5	-	-	3.0	0.6	-	-	-	-	..
--Other metals	0.3	-	-	0.8	-	-	-	14.0	-	..
Agriculture	0.2	94.4	6.5	-	-	39.0	-	-	-	..
Waste deposits	0.1	165.6	-	-	-	-	-	-	-	..
Evaporation from solvents	0.1	-	-	-	-	-	31.6	-	-	..
Other processes	0.0	7.0	-	0.3	-	-	0.9	-	-	..
Mobile combustion	13.7	2.9	1.0	8.5	171.4	0.4	95.9	681.4	147	7.5
Road traffic	8.0	1.6	0.6	3.3	79.7	0.4	76.6	638.6	140	4.2
-- Gasoline	5.1	1.6	0.3	1.0	48.9	0.4	72.0	621.4	140	0.7
---- Passenger cars	4.8	1.5	0.3	0.9	44.6	0.4	66.4	574.9	130	0.6
---- Vans	0.3	0.1	0.0	0.1	3.9	0.0	5.0	40.1	9	0.0
---- Heavy vehicles	0.0	0.0	0.0	0.0	0.5	0.0	0.6	6.5	1	0.0
-- Diesel	2.9	0.1	0.3	2.4	30.8	0.0	4.6	17.2	0	3.5
---- Passenger cars	0.3	0.0	0.0	0.2	1.1	0.0	0.3	1.3	0	0.5
---- Vans	0.7	0.1	0.0	0.6	11.3	0.0	1.7	5.9	0	1.4
---- Heavy vehicles	2.2	0.0	0.3	1.8	28.4	0.0	3.8	14.4	0	2.3
Motorbikes, snow scooters	0.1	0.1	0.0	0.0	0.1	0.0	5.3	13.6	2	0.0
Motorized tools	0.7	0.1	0.0	0.6	11.3	0.0	1.7	5.9	0	1.4
Railways	0.1	0.0	0.0	0.1	0.6	0.0	0.1	0.2	0	0.1
Air transport	1.3	0.0	0.1	0.1	3.8	-	0.6	3.2	2	0.2
Ships and boats	3.5	1.0	0.2	4.4	75.8	-	11.7	19.9	3	1.5
-- Coastal traffic, small boats	2.1	0.6	0.1	3.1	44.4	-	10.4	17.2	2	1.0
-- Fishery	1.3	0.4	0.1	1.2	27.7	-	1.0	2.5	0	0.5
-- Mobile oil installations etc.	0.2	0.0	0.0	0.1	3.6	-	0.3	0.3	0	0.1

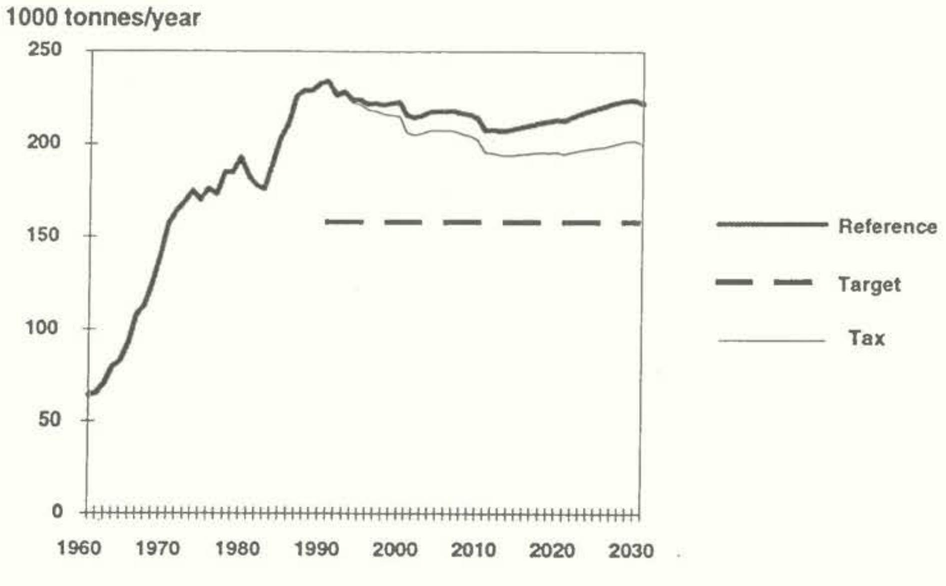
Analyses

Two typical examples of the use of integrated environment-energy-economy models are given. They are taken from Alfsen,1993, who gives a more detailed outline of these and other examples.

Emission forecasts without and with carbon taxes

Figures 8 and 9 show historical development and projected values for the emission of NO_x and CO_2 in Norway to the year 2030. The projections cover one reference alternative and a carbon tax alternative. The assumed tax is relatively high (of the order of US$800/tC (1989-$), corresponding to $93/barrel of oil in year 2030). It is assumed to be part of an international agreement imposing similar taxes in all other industrialized countries. The treaty affects both economic growth in world markets and the price of important commodities like crude oil and natural gas. An important assumption in the calculations is that the trade balance of Norway should be unchanged from the reference alternative. Norway has national emission targets for both NO_x and CO_2. Although specified for different years, the targets are shown as horizontal lines in the figures.

Figure 8. Historical and projected emission level of NO_X in Norway.

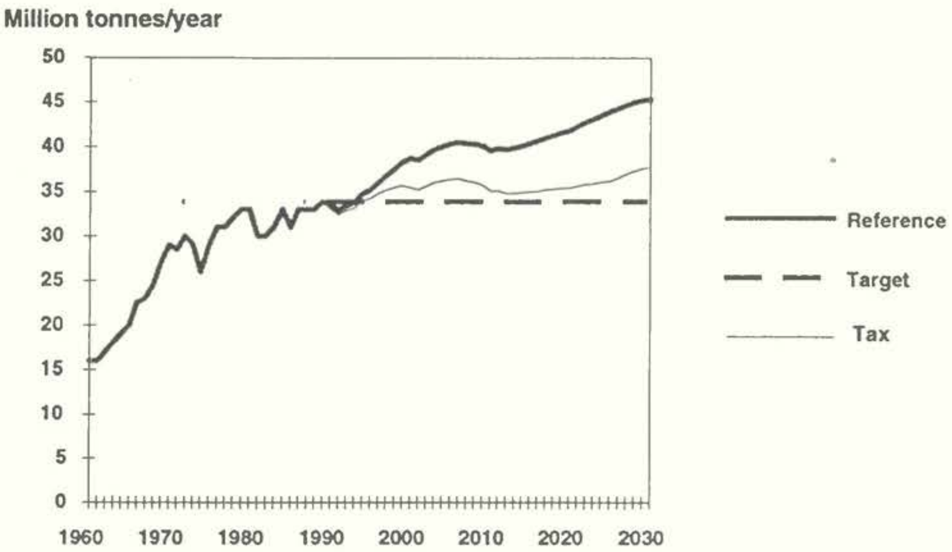


NO_x emissions grew substantially between 1960 and 1990. New control measures, such as catalytic cleaning of automobile exhausts, are expected to eliminate this growth in the future, but this is not enough to achieve national target of a 30 per cent reduction, even with a high carbon tax.

CO_2 emissions also grew over the period from 1960 to 1990, although with a declining rate during the last ten years or so. Further expected growth, however, will make is hard to achieve the national target of stabilization, even with a high carbon tax.

It is obvious from the figures that the main problem for Norway in achieving its targets on air pollution is related to the emission of NO_x.

Figure 9. Historical and projected emission level of CO_2 in Norway.



Costs and benefits of environmental control policies

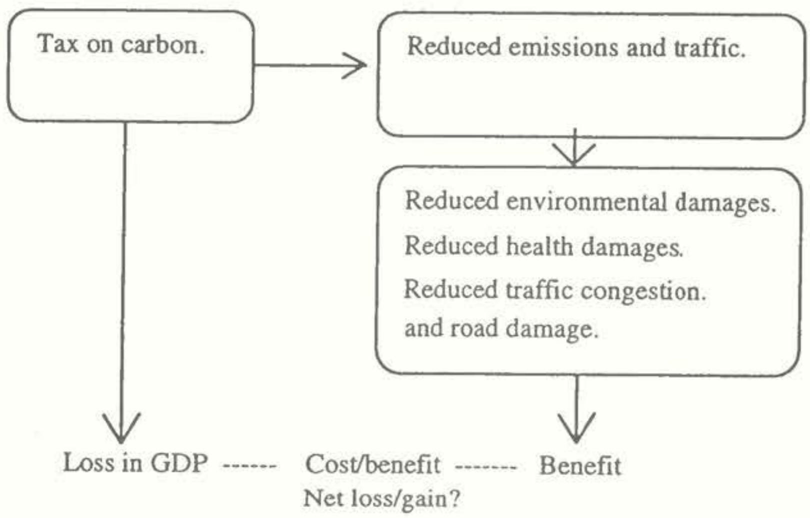
In a pure economic model the effect of environmental taxes usually appears as reduced growth in macro-economic indicators such as GDP and private consumption. By employing a macro-economic model which includes environmental stresses like emissions, and combining it with analyses of environmental quality improvements, it is possible to estimate some of the benefits to society as well.

Environmental taxes such as energy taxes in general or carbon taxes will usually lead to less use of energy and reduced emissions of a series of polluting components. Two types of benefits from reductions in fossil fuel consumption and its associated emissions have been calculated and taken into account. One benefit is related to changes in emission levels of sulphur dioxide (SO_2), nitrogen oxides (NO_x), carbon monoxide (CO) and particulate matter. These are pollutants harmful to human health, forests, fresh water lakes and certain types of capital equipment. In addition, the presence of these compounds reduces the welfare of the population by inflicting aesthetic damage on the natural environment. The other benefit is related to *reduction in road traffic*, and cover aspects such as congestion, accidents, damage to roads and noise from road traffic. For a discussion of data and assumptions, see Alfsen, Brendemoen and Glomsrød, 1992.

Figure 10 shows the structure of this macro-economic cost/benefit analysis.

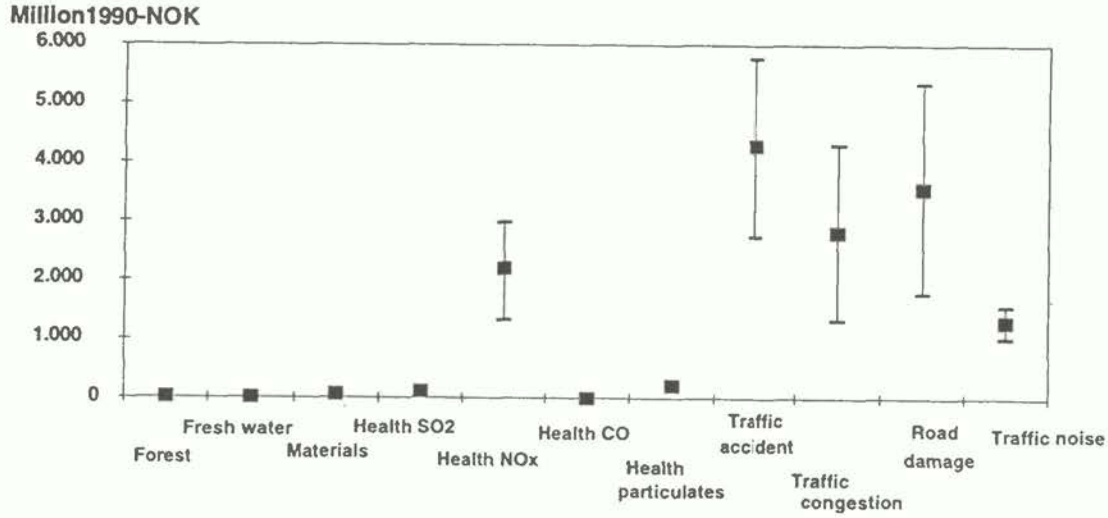
Multiplying the marginal cost of the various damage components with changes in emissions to air of the relevant compounds or with the change in demand for transport, yields a rough estimate of some of the direct benefits of environmental control policy compared to a baseline scenario. It is difficult to measure the economic cost of introducing a control policy correctly, but a rough indicator is the calculated reduction in GDP.

Figure 10. Example: Costs and benefits of environmental control policies



Benefit estimates have been calculated according to the described procedure. They are of course highly uncertain, and for this reason Monte Carlo simulations have been carried out to map the effect of the uncertainty in the marginal cost figures on the final benefit estimate. Figure 11 illustrates the composition of the benefit in the year 2030 of introducing a carbon tax of approximately US$800/tC on all CO_2 emissions in Norway, assuming that similar measures are introduced by Norway's most important trading partners as well. Account is note taken, however, that emission reductions in other European countries are likely to reduce the supply of oxidized sulphur and nitrogen to Norway, a supply that accounts for about 95 per cent of the acidification of Norwegian soil and lakes. As in figure 11 shows, reducing Norwegian emissions alone gives only insignificant benefits with regard to forest, freshwater and materials (acidification).

Figure 11. Some environmental benefits due to reduced emission of local pollutants in the year 2030. Million 1990-NOK. Lower and upper limits correspond to the 25% and the 75% quartiles.



It is worthwhile to note that while the benefit is estimated to be between approximately 10 and 20 thousand million 1990-NOK in year 2030, the calculated reduction in GDP is 34 thousand million NOK in the specific example considered here.

Thus, a sizeable fraction of the economic cost of introducing a carbon tax is recouped by the fact that emissions of local pollutants, like SO_2, NO_x, CO and particulate matter, are also reduced. Also note that *these benefits are in addition to any benefits that may accrue from a reduction in the greenhouse effect;* benefits which must be believed to be the main reason for introducing carbon taxes.

7. Conclusion

In this paper the structure of the Norwegian resource accounts and their historical development has been briefly outlined. Several examples of accounting tables and economy/environment analyses have been presented. Over the years a pragmatic approach has been followed with emphasis on the use of the resource accounts. The analyses mentioned are based on slightly extended versions of disaggregated macro-economic planning models already in use by governmental bodies. This has facilitated the introduction of environmental concerns in the planning process in Norway. The Norwegian resource accounts are kept in physical units, and monetary valuation of natural resources and the environment is performed in analyses based on, but not included in, the accounting schemes.

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