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What does an economist need to know about the environment ?

Approaches to accounting for the environment in statistical informations systems

Jan Scherp*

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European Commission
Directorate-General for Economic and Financial Affairs
200, rue de la Loi
1049 Brussels, Belgium

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Jan Scherp*

* The author is economist in the Directorate 'Economic Service' of Directorate General II of the European Commission.

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Résumé

Decision makers in business, public administrations and, to a certain degree, private households have an increasing need for statistical information about the interface between economy and the environment. Integrating an environmental dimension into economic policy objectives, cost/benefit analyses and assessing the long-term sustainability of our development pattern require data the current System of National Accounts can, at best, only provide to a very limited degree. This paper sketches the importance of the factors shaping statistical information systems that take the environment into account: the functional objectives, the definition of sustainable development and the valuation method. Two major conceptual approaches to provide such an information system are identified: the environmental indicator/index approach and the ('green') national accounting approach. Under these headings, the relevant information systems currently under discussion are surveyed and tentatively assessed. The survey suggests that both approaches are complementary and that future work in the field of environmental-economic accounting should take this complementarity into account. Furthermore, the paper describes the evolution of major thinking and activities in environmental accounting at the European Community level and proposes some elements of a Community approach.

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EXECUTIVE SUMMARY

The quest for an integrated environmental-economic statistical information system

In recent times, the 'environment' in a broad sense (the (non)availability of environmental services and efforts to maintain a certain level of such services) has been identified as an increasingly important factor for decision makers, in business, public administrations or in private households. The quest for 'sustainable' policies (there is a multitude of attempts to define sustainability; one of them being policies that lead at least to a maintenance of our level of wealth without jeopardising prospects of future generations) implies that we dispose of a **statistical tool that allows for the monitoring and evaluation of the sustainability of our development pattern.** Such a statistical information system should fulfil **two basic functions**: supporting a microeconomic/sectoral analysis of the economic efficiency of specific development projects and/or environmental policy measures placing emphasis on simultaneously integrating economic and environmental aspects, and a macroeconomic assessment of the long-term welfare effects and sustainability of the current development pattern. Such an information system does not yet exist and is far from being established.

The **existing System of National Accounts (SNA)**, although very useful and indispensable for short-term economic management, cannot fulfil this task. It is, in fact, characterised by three shortcomings concerning the environment/economy interface: 1) despite some first attempts in the recent revision of the SNA, depletion of natural resources is not comprehensively recorded, 2) the SNA largely disregards the environmental damage caused by production and consumption activities, and 3) defensive expenditures for environmental clean-up are, in the absence of environmental damage accounting, considered as increasing income, although they serve only to maintain the level of quality of life. To overcome these shortcomings, we must look for a statistical information system that is as comprehensive and flexible as possible to fulfil the above-mentioned functions.

Factors shaping statistical information systems which take the environment into account

The **specification of the information system we are seeking is conditioned by a number of factors.** Important influencing factors seem to be the functional objectives pursued, the definition of sustainability and the desired degree of environmental data aggregation as well as the chosen technique. Among the **functional objectives** are the provision of a coherent framework for presenting basic data on the environment, an economic assessment of environmental policies and their effects, and the generation of an improved measure of sustainable income and growth. The **definition of sustainable development** can be based on two concepts, the capital stock approach and the environmental functions/services approach. A broader version of the capital stock concept postulates that the total stock of all forms of wealth must not diminish over time thus allowing for a substitution between natural and man-made capital. A stricter definition, keeping natural capital constant, excludes such substitution. A third, alternative variant defines sustainability as the preservation of the functions of the environment for future generations.

The valuation/aggregation method is of decisive importance for the design of the statistical information system, i.e. the way data on the environment in different media or sectors are aggregated to make them comparable through a weighting procedure across media or sectors, to synthesise the main trends of environmental asset evolution and to link them with standard economic accounts. The desired level of aggregation depends on the specific needs users of the information systems have. Valuation of natural resources and environmental services by market values is not possible as they are often public goods or generate externalities. If market valuation is possible as in the case of marketable natural resources (e.g., timber), valuation does not include non-use values of the assets (e.g. the importance of forests for the climate) and can be very erratic due to its high sensitivity to fluctuations of world market prices for natural resources. Therefore, other monetary valuation methods (e.g., travel cost technique, hedonic pricing, avoidance/restoration cost methods, contingent valuation technique) have to be considered. All of them have advantages and shortcomings. Most need refinement and a better scientific underpinning. Alternatively, physical aggregation methods for an aggregation by environmental theme (e.g., Global Warming Potentials) and aggregation, based on expert assessments, are available.

Accounting for the environment: two approaches

Against the background of the various functional objectives environmental accounting can pursue, **two broad approaches have been developed: 1)** the 'environmental indicators' approach, established mainly by policy makers in the environment field, providing physical and (to a limited degree) monetary information on pressures on the environment caused by economic actors, the state of the environment and measures of society responding to changes of environmental quality, and 2), the 'national accounting' approach which attempts to relate information on the environment to macroeconomic statistical information systems like the System of National Accounts (SNA) and its aggregates such as GDP.

The indicators/index approach

The **indicators/index approach** comprises information systems such as the pressure/state/response model, the sustainability indicator and environmental (pressure) indices. The indicators developed within the first model try to answer the questions, to what extent do economic activities and policies exert pressures on the environment, how will they influence the state of the environment, and how does society react to possible environmental degradation? The sustainability indicator aims at providing, at a glance, an indication of whether the macroeconomic development pattern complies with certain sustainability criteria, for instance based on national saving and estimates of depreciation of natural and man-made capital. An environmental index can be calculated through the aggregation (and weighting) of environmental indicators, and thereby provides relevant information on the environmental themes the index attempts to cover. Although indices could be developed for the state of the environment or impacts, for practical policy making reasons most constructed indices are environmental pressure indices. Environmental indicators/indices address different groups of users according to the desired degree of detail or comprehensiveness of the information. Whereas sectoral experts are likely to more often use indicators, politicians are probably more interested in indices.

Assessing the indicator/indices approach: it can be concluded that environmental indicators provide very detailed information in the form of physical data on changes and states of environmental assets. These are useful as a basic input for environmental cost/benefit analysis, modelling of environmental impacts of economic activity and for setting up environmental satellite accounts. They cannot, however, substitute for the functions of environmental-economic national accounts. Sustainability indicators are peculiar as they have a rather specific functional objective and are therefore somewhat selective, concentrated in areas that are considered vital for sustainability. Linking environmental indicators to the economic sphere is feasible, for instance, to establish cost-effectiveness indicators. However, the indicators cannot always reflect a good cause-effect relationship between economic activities, it is environmental pressures and the consequent socio-economic impacts that lead to welfare changes.

Environmental indices can be a powerful analytic tool for policy making if an appropriate aggregation method can be found. Aggregation based on objectives of environmental policy or on sustainability criteria have the disadvantage that the time consistency of index series suffers from the revision of underlying political objectives, or that sustainability criteria can simply not be quantified. Aggregation based on surveys, be it among the general public or experts, seems to have theoretical advantages and to be feasible within a short time horizon. It must be ensured though, that the surveyed public is well informed on the issue in question.

The national accounting approach

The national accounting approach distinguishes itself from the indicator approach by attempting to link the environmental sphere (be it data on changes in the state of the environment or data on societal efforts to halt environmental degradation or to restore environmental functions/services) to the economic national accounts. The aim of this is to provide a statistical tool that allows for the assessment of what impacts environmental policy measures would have on society, business sector and households, and how certain macroeconomic aggregates are affected by resource depletion and environmental degradation.

Three different sets of approaches have been reviewed in this paper. The first are the **systems of physical satellite accounts** that aim at providing information on stocks and flows of environmental and natural resource assets in physical terms. Work in this area has been undertaken in Norway and France. An extension of physical resource accounting is the approach of **Repetto,** who developed a simple methodological framework to account for the depreciation of marketed natural resources and to adjust GDP accordingly. The third set of approaches comprises both **integrated environmental-economic and as satellite accounts with monetary valuation:** 1) The systems of Hueting and Peskin allow the valuation of environmental functions or services outside the market boundary of the SNA and can be used for the generation of an environmentally adjusted GDP. 2) The United Nations Statistical Office has proposed a statistical information system (SEEA) that links satellite accounts on the environment and natural resources to the SNA, and foresees a valuation of natural assets with the maintenance/restoration cost method and, hence, attempts to calculate an Environmentally adjusted net Domestic Product (EDP).

The **discussion of the approaches** has made it clear that the information on natural assets, both man-made and non-man-made, that would become available through physical natural resource accounting systems, and the SEEA, thanks to its extensive assets use accounts, would be more comprehensive and detailed than in the Repetto system and in the integrated systems of Hueting and Peskin. The survey also suggests that information systems under the national accounting approach with valuation are potentially more appropriate for the monitoring and assessment of simultaneous integration of economic and environmental objectives in policy making as well as the assessment of long-term sustainability.

Peskin's proposal for an integrated environmental-economic information system appears to be particularly interesting as it allows, in addition to an estimation of sustainable income, for a rough evaluation of the relative efficiency of environmental policy measures. Such an analysis becomes possible thanks to a separate valuation of environmental damages, on the one side, and pollution (waste) disposal services of the environment, on the other.

The Satellite system for integrated Environmental and Economic Accounting (SEEA) of the UN Statistical Office has the advantage of proposing a flexible system in modular format that allows more ambitious functional objectives to be achieved in a step by step process in line with data availability and applicability of necessary accounting techniques. The SEEA being a satellite accounting system linked to the core of traditional SNA permits the maintenance of the original functions of the SNA and the time continuity of its data series.

Linking the two approaches

Linking both the indicator/indices approach and the national accounting approach the conclusion emerges, when evaluating the functions both approaches can probably comply with, that they are not mutually exclusive but complementary. In fact, the survey suggests that the indicators approach is potentially more appropriate for monitoring trends of environmental problems, identifying the relative importance of environmental problems and perhaps for valuing the efficiency of environmental policy measures. National accounts, on the other hand, seem to be the potentially more suitable statistical-analytical framework for assessing the economic effects of environmental policy measures, the assessment of simultaneous integration of economic and environmental objectives in policy making and, potentially, the generation of a welfare indicator for sustainable development ('green GDP'). However, for the proper performance of both approaches an appropriate aggregation/valuation method is crucial. Although a number of such methods have been developed for specific applications, they are not yet satisfactory and need further refinement.

Environmental accounting in the European Community

Environmental accounting in the European Community was, for a long time, synonymous with compiling environmental statistics and indicators. The reporting requirements of Community environmental legislation provided the first generation of environmental indicators. The programme CORINE was the first attempt to collect, on a systematic basis, local data on the state of the environment as well as certain environmental pressures. Since the eighties, methodological work and, partly, practical collection of data for the pressure/state/response indicator model as well as data on environmental expenditure (SERIEE), as part of environmental satellite accounts, have been undertaken. In 1993, a Commission inter-service working group started to work out proposals for a further integration of economic and environmental information systems in the Community. Since then, EUROSTAT has made a first step to launch future works on environmental national accounts and proposed a study project on environmental pressure indices.

Elements of a Community approach to environmental-economic accounting

Three principal elements of a Community approach to integrated environmental and economic accounting can be identified: 1) reinforced co-operation and co-ordination of Commission institutions and other international organisations in the collection of basic environmental indicators; 2) the promotion of research in the scientific underpinning of environmental indicators and into appropriate aggregation/valuation techniques, and 3), conceptual and practical work of national accountants at EUROSTAT to prepare for the implementation of the System of integrated Environmental-Economic Accounting (SEEA) of the UN Statistical Office on a European level.

1. Introduction: why do we need integrated environmental-economic information systems?

Looking back to how the economies of Western European countries have developed since the second world war it will be recalled that there was a considerable increase in industrial production compared with the pre-war period and a breath-taking rise in material wealth. At the same time there was also a proliferation of environmental problems and, more recently, a partial deterioration of non-material living conditions. These observations support the idea that the pattern of growth and wealth generation has been based on the progressive exploitation of natural resources and other environmental assets. Of course efforts have been made to cut back on pollution. Recent environmental clean-up efforts are becoming increasingly expensive and underline the fact that the environment in a broad sense has become a constraining production factor. A clean environment is often an indispensable production factor, e.g. clean, fresh water for beer brewing, pure air for the production of computer chips and a healthy environment to attract and maintain efficient labour.

However, political and economic decision makers do not know what degree of resource depletion and environmental degradation is sustainable and tolerable without jeopardising prospects of future generations to maintain the present level of wealth. What is clearly needed is a measure of such sustainable policies. Policy makers need to know how to develop an environmental policy that places a minimum burden on production, but that is nonetheless effective. Statistical inputs for cost/benefit analysis and cost-effectiveness analysis should be sought. Furthermore, we would like to know what effects environmental policies have on the economy. What are the costs for different sectors, what are the business opportunities generated, what will be the structural change implied and what would be the effect on employment? To answer all these questions, decision makers need an appropriate statistical tool, an appropriate statistical information system that is not yet available in the European Community.

Since the recognition by the World Commission on Environment and Development in 1987[1] of the need for environmentally sustainable development in order to reconcile development and environmental concerns, the necessity to improve the statistical tools capable of monitoring and evaluating the integration of economy and environment was expressed in several international conventions. The Agenda 21 agreed at the World Summit in Rio de Janeiro in June 1992 which sketches the policy initiatives necessary to attain sustainable development, stipulates an improvement of the environmental data bases for decision making and the establishing of systems for integrated environmental and economic accounting[2]. The 5th Environmental Action Programme for the European Community[3] outlining the broad policy lines of future environmental policy making, also calls for better environmental data and for environmentally adjusted national accounts

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[1] World Commission on Environment and Development (1987), Our Common Future, Oxford, New York,

[2] UNCED (1992), Agenda 21, chapters 8 and 40

[3]'Commission of the European Communities (1992), Towards Sustainability', A European Community Programme of Policy and Action in relation to the Environment and Sustainable Development, March. A resolution on the Programme was officially adopted by the Council of Ministers on 1 February 1993 (OJ C138 of 17 May 1993).

which should be available on a pilot basis from 1995 onwards for all Community countries, with a view to formal adoption by the end of the decade.

In order to evaluate the sustainability of various policy options, policy makers should possess, among other things, an information system that provides them with pertinent information on the effects certain economic policy options have on environmental assets and which impacts environmental policy options have on economic variables like production cost and employment. We can distinguish *two basic functions of an information system that integrates economic and environmental aspects*: supporting a microeconomic/sectoral analysis of the economic efficiency of specific development projects, or environmental policy measures which place special emphasis on simultaneously integrating economic and environmental aspects, and, secondly, a macroeconomic assessment of the long-term welfare effects and sustainability of the current development pattern. The former analysis is often carried out with techniques like cost/benefit analysis, cost-effectiveness analysis or multi-criteria analysis. For the latter, the macroeconomic sustainability analysis, the only appropriate statistical framework appears to be the System of National Accounts (SNA). Unfortunately, however, the current SNA cannot comply with this task.

The existing system of national income accounting is a very useful tool for economic analysis and policy making. It can indicate the level of economic activity, its variations from year to year, the size of savings and investment, factor productivity, industrial structure, and many other things. Economists, development planners and politicians make frequent use of national income measures like gross national product (GNP) and gross domestic product (GDP). They are essentially short term measures of total economic activity for which exchange occurs on markets in monetary terms within a given year and they are particularly useful for demand management and stabilisation policies.

GDP as calculated today, however, is not very useful for gauging long-term sustainable growth, partly because natural resource depletion and degradation are ignored. Furthermore, GDP is often used inappropriately as an indicator of 'welfare', without mentioning its shortcomings. The concept of welfare is much broader than the monetary measure of income. It covers many dimensions of subjective well-being, other than those that involve market transactions, e.g. enjoying a healthy and clean environment.

The *main shortcomings of the current System of National Accounts concerning the environment* are:

- In the old SNA, the depletion of natural resources was not recorded in GDP nor in NDP (Net Domestic Product, taking account of the depreciation of man-made capital). In the new SNA[4], asset accounting includes, in principle, the use of some natural assets (e.g. subsoil assets and biota) and takes account of the positive or negative value changes in the volume of the assets held, for instance, as a result of the discovery of a subsoil asset or the destruction of an asset as a result of a war or a natural disaster. Additionally, value changes accruing during the accounting

[4] A revised version of the SNA was adopted by the United Nations Statistical Commission in February 1993.

period resulting from a change in the price of the asset are allowed for. However, natural resources that are not capable of bringing economic benefits to their owners or that are not subject to ownership rights are outside the scope of assets in the SNA. Thus the off-take of, for example, wild biota in a tropical rain forest, which could potentially be of great value (genetic reservoir) for future generations would not be accounted for. The consequence of not taking the reduction of a country's natural resources comprehensively into account, is that national (net) income is overestimated.

- National accounts are also criticised for disregarding the environmental damage caused by production and consumption activities. A degradation of environmental quality through pollution constitutes a loss of welfare and can result in a reduction of income if the underlying economic activity is dependent on a certain degree of environmental quality (for example, fish need a certain water quality to survive).

- The system of national accounts conveys a misleading picture of what ought to be regarded as costs to society and what must be deemed a contribution to the income of society. This is the case with (defensive) expenditures for environmental purposes. Defensive expenditures are, in common terminology, the money spent on protecting society against undesirable phenomena. In present-day national accounts, defensive expenditures executed by the public sector and by households, such as military defence, the police and environmental protection are included in final demand and, thus, increase GDP[5]. This, however, is only justified if the accounts have taken account of prior environmental degradations, as these expenditures serve only to preserve existing levels of welfare.

Awareness of the shortcomings of the current System of National Accounts for gauging sustainability gives rise to the question of how to conceive a suitable Statistical Information System. An optimal statistical information system should be as comprehensive and flexible as possible to fulfil a broad range of functions. It should also be able to cope with the difficult issue of properly valuing environmental assets or services. Two general approaches have been developed with quite different objectives, answering quite different questions: 1) the 'environmental indicators' approach, providing physical and (to a limited degree) monetary information on pressures on the environment caused by economic actors, the state of the environment and measures of society responding to changes of environmental quality and 2) the 'green national accounting' approach which attempts to relate information on the environment to macroeconomic statistical information systems like the System of National Accounts and its aggregates such as Gross Domestic Product.

In this paper, the two approaches will be considered because both are indispensable parts of a comprehensive statistical information system, however the main emphasis will be on the green national accounting approach. Economists are tempted to believe that an

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5 There should be an increase in GDP at least in tendency. It could, of course, be argued that such defensive expenditure mainly have an impact on the structure of GDP and not so much on its volume. For instance, (additional) spending on military defence is likely to crowd-out economic activity in other sectors by binding human resources (soldiers) that could, otherwise, be productive in the private sector.

environmental-economic national accounting system would potentially be the most efficient statistical tool to assess environmental and economic integration issues, and to monitor and evaluate long-term macroeconomic sustainable development. The survey of the various approaches is preceded by an attempt to identify the factors and issues which have a determining influence on the choice of a particular approach. Such 'shaping factors' seem to be the particular definition of sustainable development that is underlying the philosophy of the approach, the functional objectives that the statistical information system pursues and the issue to what degree and how data on the environment are aggregated in the accounting approach.

Chapter 3 presents in survey form the main approaches to environmental accounting characterising their basic features such as objectives, structure and, as far as possible, experiences of practical implementation. Chapter 4 provides an overview of thinking on environmental accounting in the European Community and highlights major EC initiatives in this field. Finally, an attempt is made to examine the future by sketching some elements of a Community approach to environmental accounting.

2. Factors shaping statistical information systems which take the environment into account

Various statistical institutions and researchers have developed statistical information systems that account for the environment and sustainability of development in one way or another. The approaches proposed and/or implemented so far are very diverse. It is interesting to ask which factors condition the specification of a particular information system and in what manner. Major shaping factors seem to be the functional objectives pursued, the definition of sustainability and the desired degree of environmental data aggregation as well as the technique chosen.

- **functional objectives**

Integrating an environmental dimension into statistical information systems can pursue various objectives. The choice of the functional objective(s) codetermines the shape of the statistical information system. The least ambitious goal is the *provision of a coherent framework for presenting basic data on the environment*. They are usually expressed in physical units and presented in the form of information on the state of the environment, the pressures economic activities exert on the environment and which responses economic actors undertake to changes in the former two indicators.[6] Intertemporal and international comparisons of data require a minimum of coherence in the methodology and the presentational format of the environmental indicator.

The *economic assessment of environmental policies and their effects* requires information on the environment at a fairly disaggregated level. Environmental data in physical or monetary form is used to evaluate the costs and benefits or the cost-effectiveness of environmental policy measures, e.g. through a link of data on the cost of environmental policy measures to data on the environmental effects (the potential benefits of such policy measures). An example would be an assessment of the effect of a charge on virgin paper fibres on economic welfare: on the one hand there would be the adaptation cost to new processes and products by industrialists and to new consumption pattern by consumers; on the other hand, the benefits could lie in reduced waste generation and increased economic efficiency in the production process. Environmental data can also be used as an *input for sectoral or macro modelling*, for instance to model the economic consequences of CO_2 abatement policies.

Environmental data can be used for a *national natural resource assessment*, e.g. to trace the interactions between the trend of a specific form of industrial production and the stock of natural assets like fossil fuels, ores, timber and fish. Natural resource accounting is one statistical framework within which such natural resource assessments can be carried out. This technique usually requires resource data in physical units at a generally low level of aggregation.

Finally, an environmentally enhanced statistical information system can aim at *generating an improved measure of sustainable income and growth*. This objective can require either the completion of standard national accounts (the 'core accounts') by satellite

[6]More detail on environmental indicators will be given in chapter 3.1.

accounts, accounts that provide additional information on resource depletion and environmental quality in physical or in monetary units if a valuation technique has been applied (to aggregate the physical data in order to make them comparable with the monetary data of the economic accounts). Alternatively, the SNA has to be completely revised in order to comprehensively integrate and evaluate changes in natural assets and environmental quality in core accounts. This reform could, of course, have major implications for the temporal continuity of SNA aggregates and the (in)consistency of the valuation approach which is market-based in the SNA. This leads us to the aggregation/valuation issue that will be raised later in this chapter.

- **the definition of sustainable development**

In the case that our functional objective is to monitor the sustainability of our economic development path and to calculate a measure of long-term sustainable national income, the choice of the methodology is closely related to the question of which definition of sustainability to adopt. As usual in national accounting the definition of sustainability can be based on stock or flow accounts. Both, of course, are linked as the flows (income) can be transferred into stocks through capitalisation of discounted income.

Looking at the *capital stock approach*, there are, grosso modo, *two main schools of thought*, one representing a broad interpretation of sustainability, the other a narrow definition based on the conservation of natural resources[7].

The first school of thought postulates that the *total stock of all forms of wealth* must not diminish. Under this broad view of sustainability the two basic forms of capital - man-made and natural - are *substitutes* for each other. Sustainable development is guaranteed as long as man-made capital is substituted for run-down environmental wealth and as long as the trade-off is fully informed in terms of the correct prices for the two forms of capital. In accounting terms, sustainability could be measured by deducting the depreciation of natural capital stocks depleted as a consequence of production and subtracting some measure for the depreciation of the 'environmental quality stock' (e.g., defensive expenditures for environmental clean-up, avoidance cost, etc.) from Net Domestic Product (GDP adjusted for the depreciation of man-made capital).

A second school of thought advocates a *narrower 'conservation of natural capital' approach* to sustainable development, and stipulates that the total stock of environmental assets should not decline over time. This narrow definition is backed by the argument that many non-renewable natural assets do not have man-made substitutes. For instance, the hole in the ozone layer cannot feasibly be plugged. *Non-substitutability* should lead us to be more cautious about running down environmental capital. A further variation

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7 Of course, it should not be forgotten that theoretical contributions from economists such as Dasgupta and Solow claim that it is not necessary to adjust the SNA to take account of sustainability but that it suffices to reinterpret the concept of Net National Product (GDP corrected for capital depreciation). Treating environmental quality as a stock, a kind of capital that is 'depreciated' by the addition of pollutants and 'invested in' by abatement activities, Solow considers that Net National Product measures the maximum current level of consumer satisfaction that can be sustained forever. It can, therefore, be seen as a measure of sustainable income given the state of the economy - capital, resources, and so on - at that very instant. (see for instance: Robert Solow (1993), An almost practical step toward sustainability, in: Resources Policy, Vol. 19, No. 3, September)

on non-substitutability is that an extinct species cannot be replaced. Much environmental capital has the feature of being *irreversible*: once lost it cannot be regained. Thirdly, our understanding of how natural environments function is very limited. Thus, in the face of such *uncertainty*, running down the natural capital stock would seem to be a risky strategy, particularly where irreversibility is involved. In accounting terms, sustainability on the basis of the 'keep natural capital constant' approach (or: "sustainability is if things are not getting worse") could be monitored through a comprehensive set of skilfully chosen "sustainability indicators"[8].

The narrow definition of sustainability still contains some margin for trade-offs. Since the depletion of exhaustible resources as a part of total natural resources is currently indispensable for economic development (e.g., the use of crude oil and other fossil fuels as an energy source) two trade-offs can be allowed for: a) substitutability between exhaustible and renewable natural resources (e.g., the substitution of fossil fuel by solar, wind tidal and wave energy sources) and b) increased efficiency of resource use through technological improvements[9].

The 'keeping capital intact' definition of sustainability has been criticised by some ecological economists. Nordhaus[10], for instance, claims that while it might be "useful for individuals, it is an inappropriate definition of social income except in a stationary economy"[11]. He advocates a definition of sustainability in the context of larger substitution possibilities, including human and 'knowledge' capital. He proposes a *sustainable income variant* that is based on Hicks' income definition: "...maximum amount of money which can be spend during a period if there is to be an expectation of maintaining intact the capital value of prospective returns...; it equals consumption plus capital accumulation."[12] Then sustainable income could be calculated by taking consumption, adding capital accumulation and subtracting an estimate of resource and environmental degradation.[13] In this case, accounting of sustainable development is entirely based on flow variables.

A third, alternative variant of the sustainability definition is based on the introduction of the *concept of environmental functions or services*. If these functions are rival, i.e. mutually exclusive (e.g., the aesthetic function of a beautiful landscape is reduced if the same strip of land has to serve as a waste dump) such rivalry environmental functions satisfy the definition of scarcity and can thus be considered as economic goods and linked to the system of economic accounts. From this perspective, sustainability can be

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[8] For an example of such sustainability indicators see D. Pearce, G. Atkinson (1993), Measuring sustainable development, in: D. Bromley (ed.), Handbook of Environmental Economics, Basil Blackwell, forthcoming. For more detail see chapter 3.1.

[9] This trade-off applies naturally also to the broader definition of sustainability.

[10] William D. Nordhaus (1992), Is growth sustainable? Reflections of the concept of sustainable economic growth, paper prepared for the International Economic Association, Varenne, Italy, October

[11] dito, p.36

[12] J.R. Hicks (1939),Value and Capital, 2nd edition, Oxford, Cavendon Press, p.173, 178; quoted according to Nordhaus (1992)

[13] see Herman E. Daly and John B. Cobb, Jr. (1989), The Common Good, Boston, Beacon Press, quoted from Nordhaus (1992)

defined as the preservation of possible uses or functions of the environment for future generations.[14] Although it is tempting to assume that sustainability of environmental functions is equivalent to sustainability of income and growth, it is theoretically possible for a society to achieve long-term, sustainable income levels while permitting the loss of one or more environmental functions. The underlying presumption is the believe that not all environmental functions are necessary to support human existence.

- **valuation/aggregation method**

The valuation method (i.e. the way data on the environment in different media or sectors are aggregated to make them comparable through a weighing procedure across media or sectors, to synthesise the main trends of environmental asset evolution and to link them with standard economic accounts) is of decisive importance for the design of the statistical information system. In standard national accounting, valuation uses a common numéraire – money. The market values goods and services under consideration when it clears. Market prices are thus the basic reference for valuation in the System of National Accounts[15]. Environmental services and some natural assets do not fall within the market boundary of the SNA. Natural resources and environmental services are often public goods as property rights are not properly defined. Damage to natural and man-made assets are market externalities and in most cases, the polluter (the 'environmental market actor') cannot be identified.

Attempts have been made to estimate environment related changes of asset values by *assigning to natural resources their market values*. From an ecological and even from a comprehensive economic point of view, this could give rise to misleading data: Tropical forests, for instance, might have a market value because of the high market prices of tropical wood. But other functions of these forests which could have non-market values are not taken into account. Among other things, forests have an important role as a carbon sink for the global climate. Their use as a habitat may have a great value for indigenous people whose way of living is adapted to this natural environment. An integrated environmental and economic accounting system should comprise not only the market aspects of national accounts, but also should, as far as possible, include specific ecological aspects. Additionally, the valuation of marketable natural and environmental resources based on their market prices could become under unfavourable conditions highly erratic. World market prices of certain raw materials can undergo extremely high fluctuations that would lead to asset stock valuations in the SNA that are inconsistent with actual volume changes.

The restriction to market transactions has the advantage that statistical work can be based on observable data. Valuation outside the market transaction boundary is often connected with more or less restrictive assumptions. A number of different valuation methods are available such as the travel cost method; the hedonic price method, the restoration or avoidance cost method and the contingent valuation method. The first

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[14] R. Hueting, P. Bosch, B. de Boer (1992), Methodology for the calculation of sustainable national income, Centraal Bureau voor de Statistiek, Statistical essays M44, p.12

[15] There are however some exceptions to that rule. Government services are usually not traded on the market and, therefore, are valued at factor cost. Market valuation inconsistencies arise also if the value of production is paid for only in part by market sales and in part by government subsidies.

three valuation methods are based on the assumption that environmental qualities are arguments in people's utility functions. Since people are assumed to base their market behaviour on these functions, the economic value of environmental goods will be embedded in this behaviour. In other words, these methods depend on a relationship between a market good and an environmental good.

The *travel cost technique* uses information on the amount of money and time people spend in getting to a recreational site to estimate the value (benefits) of a change in the environmental qualities of that site. The model underlying the travel cost method assumes that people will make repeated trips to a site until the marginal value of the last trip is just worth what they have to pay to get there. The demand curve for the recreation site is then estimated by using the travel costs as a proxy for the price of (the number of visits made to) the site.

The *hedonic price method* assumes that market goods provide buyers with a variety of services, some of which are environmental qualities. Houses, for instance, are associated with air qualities and noise levels buyers will have to accept as complements. If people perceive such complementary environmental characteristics, it is assumed that they will pay more for a house located in an area with high environmental quality than for an identical house located in an area with poor quality. Given that people are able to make such voluntary choices - i.e. that they can buy exactly the set of housing characteristics they want - and that the market is transparent the economic value of the surrounding environmental quality will be incorporated in the price for houses.

The *maintenance or restoration cost methods* are based on the opportunity cost concept. They estimate the value of environmental quality on the basis of the expenditures made to prevent the adverse effects of pollution or to restore the pre-pollution level of environmental quality. Examples are the installation of end-of pipe devices that prevent the emission of certain air pollutants or the cleaning-up of the soil of industrial sites that have been contaminated. In order to implement this method it is assumed that people perceive changes in the environmental determinants of their well-being and that they are aware of substitute goods that can reduce the effects of pollution.

The *contingent valuation technique* asks respondents through questionnaires to express their maximum willingness to pay to obtain a clearly defined environmental good or what they are willing to accept to tolerate an environmental nuisance. The main assumption underlying this method is that people have preferences for all kinds of environmental goods and that they can accurately transform into an economic value. It is further assumed that these values can be revealed through the creation of a hypothetical market and that they correspond to those that would emerge on real markets, given that real markets could be implemented for environmental goods.

With these valuation techniques a reasonably comprehensive coverage of environmental problems appears to be possible. However, the credibility of some of the estimates generated to date is very low[16]. The endeavour to use monetary valuation techniques for

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[16] see A. Markandya, Monetary valuation and "green accounting"(1993), note prepared for internal EC discussions, May, p. 14

accounting purposes in the European Community would be hampered by a number of problems and gaps in knowledge. Assigning a monetary value to certain natural assets, such as biological diversity and human health, is still not possible due to gaps in the scientific foundation. The question of generalisation of values from one study to other applications has not yet exhaustively been answered. Valuation exercises are characterised by a high degree of uncertainty due to a relative fuzziness of knowledge about the underlying damage relationships. Furthermore, if an environmental issue has an inter temporal aspect, the choice of an appropriate discount rate is very important to the valuation. In all of these areas and beyond, further research is needed.

The *issue of what valuation method to choose* is closely related to the decision of what the functional objective of the information system should be. Basic statistical series on certain characteristics of the environment can be produced in their respective physical unit of measure. If one wants a more aggregated indicator of the evolution in environmental quality, for instance as an input for economic modelling, the individual series must be synthesised including weights for the relative importance of the individual environmental variable in determining environmental quality. In addition to monetary valuation of changes of natural resource stocks and of the quality of environmental assets there are *alternative non-monetary aggregation methods* available for specific functions.

Physical aggregation methods based on scientific criteria can be used to a limited degree, for instance, if physical environmental indicators can be allocated to environmental themes like global warming, depletion of the ozone layer, acidification, eutrophication and waste generation. For example, an aggregation of data on greenhouse gas emissions (CO_2, CH_4, N_2O, CFCs, etc.) to CO_2-equivalents is possible with the help of Global Warming Potentials (GWP)[17]. Data on important agents leading to acidification (NO_x, SO_2 and NH_3) can be aggregated by looking at the potential contribution to acidification of each of these substances expressed by Potential Acid Equivalents (PAE).[18] Similar procedures are possible for the data aggregation under other themes.

Aggregation based on expert assessments can be used to establish a set of weighting coefficients for a list of environmental problems/themes. Expert systems based on multi-stage Delphi questioning techniques have been designed to aggregate individual environmental indicators to synthesised indicators, so-called indices, for a limited number of environmental themes. These environmental indices can provide valuable information on the direction in which environmental quality moves or the relative importance of environmental problems.[19]

Figure 1 summarises the principal features of the shaping factors of environmental-economic information systems.

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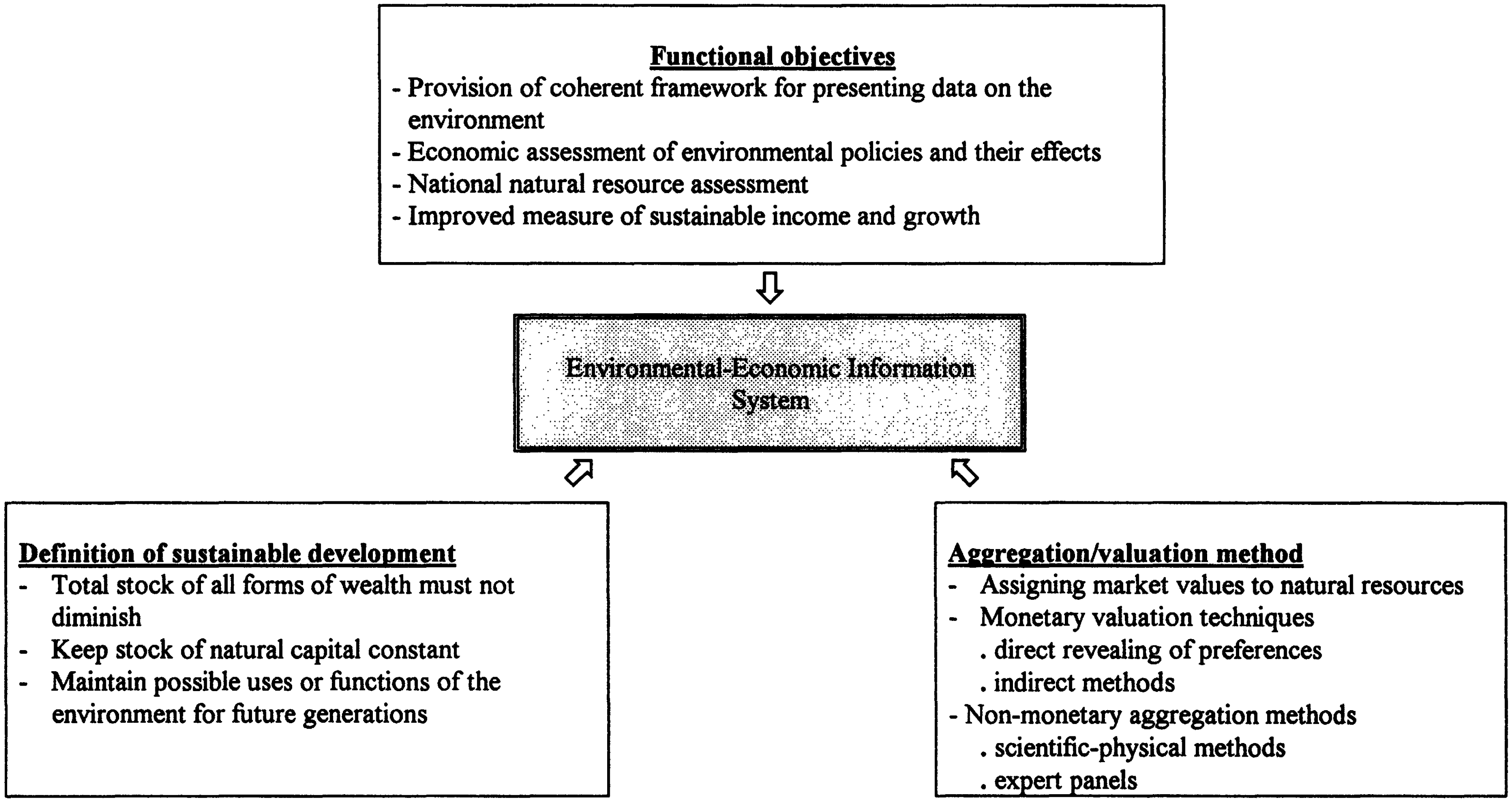
[17] The GWP expresses the CO_2 concentration that would have about the same effect on the radiative properties of the atmosphere as the concentration of the greenhouse gas concerned.

[18] The PAE reflect the amount of an agent that is necessary to form an acid with a certain amount of H^+-ions.

[19] For more detail see chapter 3.1.

Figure 1: Shaping factors of environmental-economic information systems



3. Accounting for the environment: two approaches

Two broad approaches have been developed as regards the functional objectives environmental accounting can pursue: 1) the 'environmental indicators' approach, set up mainly by policy makers in the field of environment, providing physical and (to a limited degree) monetary information on pressures on the environment caused by economic actors, the state of the environment and measures of society responding to changes of environmental quality, and 2) the 'national accounting' approach which attempts to relate information on the environment to macroeconomic statistical information systems like the System of National Accounts and its aggregates such as GDP.

This chapter presents in survey form the main approaches to environmental-economic accounting characterising their basic features like objectives, structure and, as far as possible, experience with practical implementations. A tentative assessment of the various approaches will be attempted based on criteria such as the scope of the information system, the coverage of features in the environmental and economic sphere, the requirements in terms of aggregation/valuation to comply with the functional objectives and the feasibility given the tight time horizon imposed by policy needs.

3.1 Environmental indicators and indices

An indicator is data on the environment that describe a physical or economic phenomenon in numerical terms in a defined and comparable way. According to Adriaanse[20] an indicator has a significance extending beyond that what is directly obtained from observations. He identifies three main functions of indicators: simplification, quantification and communication. Indicators generally simplify in order to make complex phenomena quantifiable in such a way that communication is either enabled or promoted.

Traditionally, environmental indicators are measured in physical units, e.g. indicating concentrations of CO_2 in the atmosphere at given intervals. More recently, environment related indicators in monetary terms are increasingly available, e.g. expenditures of city administrations for cleaning sewage. The request for developing environmental indicators comes from environment related policy makers who would like to have an illustration, often from a sectoral point of view, of how societies' activities affect the environment, i.e. to what extent policies and economic activities exert pressures on the environment, how they will influence the state of the environment, and how society reacts to possible environmental degradation. In particular specifications, indicators can also support assessing the environmental sustainability of economic and sectoral policies.

[20] A. Adriaanse (1993), Environmental policy performance indicators, Den Haag; April, p. 7

3.1.1 types of environmental indicators

A commonly used classification of environmental indicators is the 'pressure/state/response' model[21]:

- *Pressure indicators* attempt to answer the question, what are the actual pressures (or "stresses") on the environment that lead to changes in the state of the environment and which actors (sectors) cause the problems? Pressure indicators may be sub-divided into background indicators (i.e. indicators that illustrate trends that may cause pressures, e.g. population, GDP, traffic growth) and indicators in a more narrow sense. The latter are more directly linked to environmental quality such as amount of greenhouse gases released into the atmosphere.

- *State of the environment indicators* try to answer the question of what the actual condition of the environment is at a given geographical location at a given time, e.g. air pollutant concentrations, water quality, acidification of soils. Very closely related to state of the environment indicators are *impact indicators* that reflect the socio-economic impacts of changes of the state of the environment, e.g. low pH levels of soils (state) lead to forest damages (impact) and high concentration of water pollutants (state) cause a reduction of fish population (impact). Sometimes, the distinction between state and impact indicators is not clear nor is it always useful.

- *Response indicators* attempt to show the efforts of society, to mitigate or to solve environmental problems. The efforts could, for instance, be financial expenditures to fight pollution and environmental degradation, fuel prices or environmental taxes. In a very wide sense, a description of environmental legislation and international commitments would also indicate efforts to solve environmental problems. Response indicators are especially useful for policy evaluation and formulation if the indicator can be conceived in a way that a clear causal relationship is established between the policy action (response) and the target variable, either an environmental quality or impact indicator. In this case, the response indicator could be used as an *cost-effectiveness indicator*.

Table 1 provides examples of the three kinds of indicators (pressure, state, and response) for a number of environmental problems identified by the 5th Environmental Action Programme for the European Community.

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[21] This indicator model goes back to work of Anthony Friend from Canada. It has been adopted in the meantime by the OECD.

Table 1 Examples of possible indicators for a number of environmental problems identified by the Fifth Environmental Action Programme for the European Community

Environmental problem	Pressure Indicator	State Indicator	Response Indicator
	Who causes the problem ?	*What is the actual state of the environment?*	*What is done to solve the problem?*
Climate change	*GNP, energy cons.,* greenhouse gas emission	CO_2 concentr., global/national temperatures, storm damages	expenditures for alternative energy research, energy prices
Ozone layer depletion	*CFC production*, CFC halon, etc. emissions	ozone layer thickness, UV radiation skin cancer incid.	legislation and international commitments, e.g. Montreal Protocol
Loss of Biodiversity	*agri. prod.*, land use changes, fertiliser. and pesticide use	number endangered species, popul. and distribution data	expenditures for protection, new protected areas
Resource Depletion	*GNP*, energy production, metal consumption	life expectancy of known reserves, fish density, forest area	recycling rates, resource prices, reforestation
Dissipation of Toxic Chemicals	*GNP, production of chemicals*, dioxin emissions, pesticide use	concentrations of dioxins in soil & bird eggs	legislation, research expenditures
Waste	*GNP, population*, waste amounts, treatment	landfill area, ground water quality	expenditures for treatment, recycling rates
Air Pollution & Acidification (excluding. Climate Change & Ozone)	*GNP, traffic, energy consumpt.*, emissions of NO_x, SO_2, VOC, partic.	pH levels in soil and lakes, forest damages, urban air quality	abatement, expenditures, legislation
Marine Environment and Coastal Zones	*oil transports, marine tourism*, accidents, popul./industry sewage	quality of marine ecosystems (e.g. coral reefs)	MARPOL and other international commitments
Water Pollution & Water Resources	*population, agric. & industry production*, water use, emissions	concentrations of nitrates and phosphates in rivers and lakes, ground water levels	legislation, % of population with/ expenditures for sewage treatment
Urban Problems, Noise & Odours	*popul. density, urban traffic*, emissions of cars & trucks	noise exposure, no. of smog days, concentrations of ozone, NO_2 etc.	legislation, expenditures for noise & odours protection

<u>Source</u>: Eurostat

A different type of environmental indicator, the *sustainability indicator*, aims at providing at a glance an indication of whether the macroeconomic development pattern complies with certain sustainability criteria. Sustainability indicators are also used in some national accounting systems that incorporate a correction of their aggregates for resource use and environmental degradation valued in money terms. In the Hueting approach and the SEEA, the environmental satellite accounting approach of the UN Statistical Office[22], sustainability standards (or indicators) are taken as a benchmark for the restoration cost approach to valuing environmental damages. This method uses the cost of returning the environment to the level of quality that is deemed sustainable as a proxy for damages to the environment.

Pearce and Atkinson[23] estimated empirical values of a sustainability indicator, which is based on national saving and estimates of depreciation of natural and man-made capital stock in 22 countries. The indicator definition allows for substitution between natural and man-made capital. The sustainability indicator (Z) takes the form:

$$Z = \frac{S}{Y} - \frac{\delta_M \cdot K_M}{Y} - \frac{\delta_N \cdot K_N}{Y}$$

where δ_M, δ_N indicate depreciation of man-made and of natural capital stock and S gross national savings. The value of Z must be either zero or positive to ensure sustainability. Natural resource depreciation is interpreted as a scarcity rent, arising from depleting or degrading the environmental asset in question. For non-renewable resources, depletion is approximated through the estimation of the total Hotelling rent (equivalent to the market price of the resource minus the marginal costs of extraction, the sum multiplied by the units of resource extracted). For renewable resources, exploitation is corrected through an allowance for natural regeneration. For the estimation of environmental degradation the authors suggest various valuation techniques such as contingent valuation or indirect methods like restoration cost or environmental defensive expenditures.

Table 2 presenting the results of the calculations shows that, in total, 8 of the 22 countries covered fail to satisfy the sustainability condition. The indicator is essentially static, it does not consider technological changes, i.e. changes in the quality of capital stock, nor does it take account of international trade in resources. The estimation of the savings and depreciation values seems to be characterised by various shortcomings.

22 More details on the Hueting approach and the SEEA can be found in chapter 3.2.

23 D. Pearce, G. Atkinson (1993), Measuring sustainable development, in: D. Bromley (ed.), Handbook of Environmental Economics, Basil Blackwell, forthcoming

Table 2 Testing for sustainable development : The sustainability indicator Z

An economy is sustainable if it saves more than
the depreciation on its man-made and natural capital

SUSTAINABLE ECONOMIES	S/Y	- $\delta_M.K_M/Y$ -	$\delta_N.K_N/Y$	= Z
Brazil	20	7	10	+ 3
Costa Rica	26	3	8	+15
Czechoslovakia	30	10	7	+13
Finland	28	15	2	+11
Germany (pre-unif)	26	12	4	+10
Hungary	26	10	5	+11
Japan	33	14	2	+17
Netherlands	25	10	1	+14
Poland	30	11	3	+16
USA	18	12	3	+ 3
Zimbabwe	24	10	5	+ 9
MARGINALLY SUSTAINABLE				
Mexico	24	12	12	0
Philippines	15	11	4	0
United Kingdom	18	12	6	0
UNSUSTAINABLE				
Burkina Faso	2	1	10	- 9
Ethiopia	3	1	9	- 7
Indonesia	20	5	17	- 2
Madagascar	8	1	16	- 9
Malawi	8	7	4	- 3
Mali	- 4	4	6	-14
Nigeria	15	3	17	- 5
Papua New Guinea	15	9	7	- 1

Source: Pearce/Atkinson (1993)

3.1.2 environmental indices

An environmental index arises through the aggregation (and weighting) of environmental indicators comprising the relevant parameters for the environmental theme captured by the index. Although the parameters can theoretically be related to emissions (pressures), to pollutant concentrations in the atmosphere, soil and water (state) and to effects on ecosystems and health (impacts), only for pressure and response indicators is it useful to aggregate them to indices since only for these can a direct causal relationship with human activities be established. They are, thus, the only ones, for the time being, that have an economic dimension. Environmental indices can provide information on the relative importance of environmental problems (themes) and the direction of the development trend of an environmental problem. In the ideal case where the weighting coefficients are based on marginal damage to the environment (i.e., for instance, an additional unit of water pollutant emissions would lead to a pressure on the environment equal to that of an additional unit of greenhouse gas emissions), a cost-effectiveness analysis can be supported of the type 'what is the most efficient public expenditures pattern for environmental protection?'

Environmental indices have been established on the basis of scientific weighting procedures for a limited number of environmental themes in combination with politically set targets or 'sustainability standards' for the themes and through expert valuation panels. In the *Netherlands*, attempts have been made to construct an overall environmental pressure index that comprises the environmental themes of climate change, acidification, eutrophication dispersion (of toxics), (waste) disposal and disturbance (through noise in urban areas)[24]. For each of these themes 'Environmental Pressure equivalents' (EPeq) are calculated based on scientific theme-related aggregation methods like 'Global Warming Potentials' and 'Potential Acid Equivalents'[25]. The 'EPeq' are dimensionless and can thus be added up.

Adriaanse (1993) presents two overall indices, one based on political targets and the other on sustainability levels, reflecting different views of how the weights of the various themes to the overall pressure could be defined. In fact, for a given year the contributions of environmental themes to the overall index can vary considerably according to the weighting procedure. Adriaanse describes the procedure as follows: "The weighting itself is realised by dividing the present values, expressed in theme equivalents, by the corresponding target values for the year 2000, expressed in the same measure. This renders a dimensionless parameter which expresses the distance to target for each theme ... . The ... parameters ... can be summarised ... in one single yearly environmental indicator that represents the total environmental pressure."[26]

The theme equivalents (i.e. the weights) based on political targets are derived from official sources like governmental policy programmes and international environmental conventions. The weights based on 'sustainability levels' come from various sources. The problem with weights based on policy targets is that they are likely to vary over time due

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[24] A. Adriaanse (1993), Environmental policy performance indicators, Den Haag; April

[25] Compare chapter 2 on non-monetary aggregation methods.

[26] Adriaanse (1993), p.74f

to changing perceptions of different governments, thus jeopardising the time continuity of index series. Weights based on 'sustainability levels' seem to be more appealing, however, nobody can claim to know the 'true' sustainability levels. In any case, both procedures are unsatisfactory proxies, as targets should always be the result of an evaluation process and not be an input itself to the evaluation process.

The Dutch Statistical Office (CBS) has experimented with a different accounting frame: NAMEA (National Accounting Matrix including Environmental Accounts)[27]. NAMEA complements the existing national accounts in matrix format with accounts in physical units. First of all, for each economic activity an overview is given of the emission of polluting substances such as CO_2, CFCs, phosphorus and waste. These substances are then grouped by a number of environmental problems that they cause. Based on the contribution by each substance to the problem concerned, the emission weights are converted into problem-related environmental stress equivalent units. Lastly, the results for each problem are further processed taking into account the policy standards for the year 2000 similar to the methodology of Adriaanse (1993). This results in five summary environmental indicators. The advantage of this system approach is that changes in the environment can be analysed in relation to economic developments.

Jesinghaus[28] has proposed a system of environmental indices that is based on EXTASY (EXpert Topic Assessment SYstem) a method to measure the relative weight and importance of environmental problems, based on a survey among environmental experts. The main goals are to provide an early warning system, to get reference data for decision makers, to enable efficiency measurements and to support the supply of monetary values for national environmental accounting purposes.

His proposal is based on a two-step procedure to establish of a set of environmental pressure indices (greenhouse effect, air pollution, noise, etc.) which are ranked according to their relative importance through the judgement of an expert panel which allocates "environmental stress points". This expert panel could be composed of representatives of science, politics, industry, media, public administrations and environmental pressure groups. In a second step a further expert panel composed of specialists for a specific problem field would generate a weighting of the underlying components for each problem field (e.g. emissions of CO_2, CFCs, N_2O, methane which contribute to the greenhouse effect). This element of the approach is of particular statistical importance as it provides the link with physical indicators reflecting environmental problem fields.

Theoretically, EXTASY could be used for monetary valuation of environmental damages. As the relative weightings of the experts correspond to the perceived importance of environmental problems for society they can be interpreted to be proportional to the monetary damages caused by these problems. Multiplied by a coefficient ('numéraire'), the expert points become a monetary value of environmental damages. This 'numéraire' can be calculated with conventional methods (contingent valuation, etc.).

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[27] M. De Haan, S.J. Keuning and P.R. Bosch (1993), Integrating Indicators in a National Accounting Matrix including Environmental Accounts (NAMEA); an application to the Netherlands. National Accounts Occasional Paper No. NA-060, Statistics Netherlands, Voorburg

[28] J. Jesinghaus (1992), UNSO-EDP or EXTASY? Or both?, Internal Eurostat discussion paper

Table 3: Characteristics of environmental indicators/indices approaches

	Functional objectives	Coverage	Level and type of aggregation
Pressure / state / response	- Environmental trends - Documenting links between economy / environment - Assessment of efficiency of environmental policy	environment; some link with the economy possible (input/output tables)	low (physical units)
Sustainability	- Assessment of sustainability (e.g. difference between national saving and the depreciation of different forms of capital)	environment (summary); economy	high (monetary valuation of natural capital stock depreciation)
Indices based on: - political objectives - sustainability criteria - assessments of experts or general public	- Ranking of environment. problems - Assessment of efficiency of environmental policy - Supporting monetary valuation	environment, link with economy possible (e.g. "National Accounting Matrix including Environmental Accounts" (NAMEA))	medium, for environmental theme indices (scientific-physical aggregation methods) high, for overall index (non-monetary aggregation techniques)

3.1.3 tentative assessment

Table 3 summarises the main characteristics of environmental indicators/indices approaches. Environmental indicators provide very detailed information in the form of physical data on the state and changes to environmental assets. These are useful as a basic input for environmental cost/benefit analysis, modelling of the environmental impacts of economic activity and for setting up environmental satellite accounts. Sustainability indicators are peculiar as they have a rather specific functional objective, and are therefore somewhat selective in areas that are considered vital for sustainability. A link of environmental indicators to the economic sphere is feasible, for instance, to establish cost-effectiveness indicators. However, the indicators cannot always reflect a good cause-effect relationship between economic activities, consequent environmental pressures and consequent socio-economic impacts that lead to welfare changes.

Environmental indices can be a powerful analytic tool for policy making if an appropriate aggregation method can be found. Aggregation based on objectives of environmental policy or on sustainability criteria have the disadvantage that the time consistency of index series suffers from the revision of underlying political objectives and that the sustainability criteria can simply not be quantified. Aggregation based on surveys, be it among the public or experts, seems to have theoretical advantages and be administratively feasible. It must be ensured, however, that the surveyed public is well informed on the issue in question.

3.2 The national accounting approach

The national accounting approach distinguishes itself from the indicator approach by attempting to link the environmental sphere (be it data on changes in the state of the environment or data on societal efforts to halt environmental degradation or to restore environmental functions/services) to the economic national accounts. The aim is to provide a statistical tool that allows for the assessment of what impact environmental policy measures would have on society, business sector and households, and how certain macroeconomic aggregates are affected by resource depletion and environmental degradation. From an economic policy viewpoint, the ultimate goal should be the generation of a measure of the welfare effects of environment-related policy measures. Not all of the approaches presented in this section aim to realise all of the above mentioned objectives; some strive only for a subset of them.

Three broad sets of information systems providing additional information on environmental and resource depletion effects of economic activities beyond the scope of the traditional SNA can be distinguished.

The first set of information systems are the systems of physical satellite accounts[29] which aim at providing information on stocks and flows of environmental and natural resource assets in physical terms. Work in this area has been undertaken in Norway, France, Canada and Austria.

An extension of physical resource accounting is the approach of Robert Repetto who developed a simple methodological framework to account for the depreciation of marketed natural resources and to adjust GDP accordingly.

Finally, a third set of approaches that foresee a monetary valuation of the environment is presented. Two subsets can be distinguished: 1) attempts to conceive systems of integrated accounts that allow the valuation of environmental assets and services or changes of environmental services outside the market boundary of the SNA and that can be used for the generation of an environmentally adjusted GDP (for instance, the systems of Roefie Hueting and Henry Peskin), 2) the approach of the United Nations Statistical Office that has proposed a statistical information system linking satellite accounts on the environment and natural resources to the SNA; it foresees a valuation of physical variables and, hence, attempts to calculate an Environmentally adjusted net Domestic Product (EDP).

3.2.1 Physical resource accounting

One way of extending the scope of conventional economic national accounts is to develop separate accounts (satellite accounts) which describe the flow of resources, materials (including pollutants), and energy that underlie any economic activity. These accounts could display material input-output balances which are necessary consequences of physical conservation laws. Theoretically, such accounts could not only show the depletion of natural resources and additions to the resource base through discovery and natural growth, but also their transformation into products and materials of which some part could be channelled back to the environment in form of pollutants (material-balances). These resource accounts could be linked to conventional economic accounts through the use of ratios (or input-output coefficients) that represent the use of energy or raw material per unit of production.

Generally, there seem to be *two types of physical accounts*, a stock and a flow account, both of which are found in the most prominent examples of current applications of physical resource accounts, the Norwegian Natural Resource Accounting system and the French 'Natural Patrimony Accounts'.

The first type of account compares an opening stock to which additions, either through discoveries or growth, or any subtraction due to exploitation or natural destruction, have been made with a closing stock. Typically, this type of account is applied to exhaustible resources like minerals or renewable resources like forests. The second concerns the flows of pollutants, usually describing air and water pollution generated by different

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[29] Satellite systems aim at providing additional statistical information for specific policy making purposes which lies beyond the scope of the SNA. Satellite systems provide (often) non-monetary flow and stock data. Contrary to the SNA, their presentation need not to be based on a circular model. Satellite systems present also tables on expenditure streams (for instance, in input/output-form), financing and consumption of goods and services.

sources. Although some efforts have been made to trace the flow to final deposition (where the socio-economic impact arises), often the tables only provide some measures of resulting ambient environmental quality (e.g., concentration of ambient air pollution, etc.).

- **The system of the Central Bureau of Statistics of Norway**

The Norwegian system of resource accounting[30] limits itself to physical accounting, but allows for a theoretical link to economic activity. Two types of natural resources are distinguished: material resources and environmental resources. The former encompasses mineral resources, biotic resources, "inflowing" resources (i.e., any resources immediately arising from the flux of solar energy and the Earth's gravitational field), and energy. Environmental resources are environmental assets which provide non-marketed environmental services. Land and water, for instance, provide waste disposal services but also generate recreation opportunities, species life-support, etc.. In contrast to these inclusive definitions the system's coverage of material and environmental resources in practice is more modest.

The general format of the material resource accounts is divided into three parts: the resource reserve accounts, the extraction, conversion; and thirdly trade accounts and the consumption accounts. In parts II and III, the link to economic activity can be established. The sectoral classification permits the construction of physical input/output tables which, in principle can be formally linked to the input/output-tables underlying the Norwegian national accounting framework. In practice, however, such tables are difficult to establish as all resource flows need to be measured in the same common units.

The *environmental resource accounts* do not have a standard structure. They only aim at describing attributes of the resource, like land use or emission levels and concentrations.

- **The system of the French statistical office (INSEE)**

The French "*Comptes du Patrimoine Naturel*"[31] are probably the most ambitious resource and environmental accounting system from a conceptual point of view which has, however, not yet practically been implemented. The French system may be described as ambitious because of two principal features: the broad coverage of environmental and resource assets on the one hand and the large coverage of functions of the natural environment on the other hand. Concerning the *coverage of natural assets*, the entire "natural patrimony" is taken into account excluding, however, those parts of the natural environment which cannot be transformed or appropriated by man and the so-called "artificial patrimony" (i.e. man-made materials, buildings, etc.) which has no cultural significance or which is not closely related to natural systems.

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[30] K.H. Alfsen, T. Bye and L. Lorentsen (1987), Natural Resource Accounting and Analysis, The Norwegian Experience 1978-1986, Central Bureau of Statistics

[31] Institut National de la Statistique et des Etudes Economiques (INSEE) (1986), Les Comptes du Patrimoine Naturel, N° 535-536 des Collections de l'INSEE, série D, N° 137-138, December and J. Theys (1989), Environmental in Development Policy: The French Experience, in: Y.J. Ahmad, S. El Serafy, E. Lutz (ed.) (1989), Environmental Accounting for Sustainable Development, A UNEP-World Bank Symposium, Washington

The second reason why the French approach is so ambitious is that it intends to describe and analyse each element of the natural environment in terms of its *three basic functions*: economic, ecological and social. This broad descriptive coverage reflects the ambition of the natural patrimony accounts to be part of a large environmental data system. This system has a hierarchical structure of different levels, ranging from non-specific data (level I) over statistical breakdowns by air, water and other environmental sectors (level II), statistical summaries such as state of the environment reports (level III), Patrimony Accounts (level IV) to the development and use of forecasting and simulation models (level V, only partly implemented), and eventually to the development of aggregate welfare indicators and a modified GNP (level VI, not implemented).

The Patrimony Accounts are meant to support both environmental and economic models. In order to achieve this, they consist of a number of separate sub-accounts, which rely on a consistent data base and can thereby be related to each other. These sub-accounts comprise of three groups: physical accounts (comptes d'éléments), geographical accounts (comptes d'écozones) and "agent" accounts. *Physical accounts* are organised as a double entry system, presenting sources on one side of the account (the growing stock of a commercial forest, for instance) and uses on the other (mortality, windfall and commercial felling in our example).

The *geographical accounts* collect data which are related either to ecosystems (e.g., forests, wetlands) or to some other area definitions like geographical regions (e.g., mountain regions) or political territories (e.g., provinces). The *"agent" accounts* cover activities which relate human activity to the natural environment. The characterising feature of agent accounts which comprise stock and flow accounts is the identification of human owners and users. Some accounts (e.g., water use accounts, pollution emission accounts) are expressed only in physical terms, other accounts (e.g., value of different categories of land) may include monetary values.

A *disadvantage of natural resource accounts* is that no common unit of measure exists for the different accounts as an aggregation is not attempted. The need to use a variety of units make the accounting system more complex. The greater the complexity, the less attractive this statistical tool becomes for political decision making.

3.2.2 Accounting for the depreciation of marketed natural resources

The resource accounting approach of *Robert Repetto* from the World Resources Institute[32] goes beyond purely physical resource accounting, as it foresees a monetarisation of physical quantities. It has, however, a rather limited scope: it attempts to account for the value of the depletion of those natural resources that generate marketable output. By adjusting conventionally-measured income for depletion, it is intended to obtain a *better approximation of sustainable net income*. No rectification is made for pollution or environmental degradation, and neither is GNP corrected for any defensive environmental expenditures.

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[32] R. Repetto, W. Magrath, M. Wells, C. Beer, F. Rossini (1989), Wasting Assets: Natural Resources in the National Income Accounts, World Resources Institute

It is important to underline that Repetto's approach focuses primarily on resources which either generate a marketable product directly through harvesting or mining (e.g., timber, coal, etc.) or gain their economic value by contributing to the production of marketed products (as, for instance, top soil). Environmental assets which generate non-marketable environmental services (e.g., habitat, recreation) are not covered.

The *depreciation method* applied in order to estimate natural resource depletion is quite simple. Estimates of the physical change in the resource stock, through use, discovery and natural growth over the accounting period is multiplied by the average net unit value of the resource. The net unit value is defined as the average unit sales price minus the extraction/production cost, thus approximating economic rent. This method is only an approximation to true economic depreciation, namely the change in asset value over the accounting period, where the asset value equals the present value of the future stream of benefits.

Concentrating on the estimation of natural resource depreciation seems to be a *valuable option for developing countries* whose economies are based on natural resources and where resource depletion might have a higher importance than environmental problems such as industrial pollution. Probably due to the modest objectives and the simplicity of the implementation approach, Repetto's resource depreciation approach has already been implemented successfully in some developing countries like Indonesia, the Philippines and Costa Rica and is under study in others.

Repetto's approach has, however, been *criticised conceptually* by other resource accountants. Firstly, the definition of net income as the difference between gross income and depreciation has been criticised. It is alleged that depletions of physical resources may not be welfare decreasing if some of the earnings are re-invested in such a way as to substitute a new asset of equal value for the eventually depleted physical resource. This new asset could well be the generator of wealth when the original resource has been entirely depleted. In this sense, the calculated net income is too pessimistic in that it underestimates true sustainable income.

Secondly, a natural asset being depleted (e.g., a physically smaller forest) instead of depreciating, could show an increase in economic value, i.e. it might undergo a negative depreciation or "capital gain". This anomalous situation can be explained by - among other things - the event that the demand for the output from a smaller natural capital stock could rapidly increase over time. If so, its economic value could grow while its physical size diminishes.

Furthermore, the Repetto approach assumes the existence of economic rent which can be attributed to the scarce natural resource. It has been claimed that such a rent would not be observed if there is uncontrolled access to the resource as in the case of natural "commons". Massive exploitation of the resource could drive the market value of resource rents to zero.

3.2.3 Environmental and natural resource accounting with valuation

Going a step further than accounting physical stocks and flows or depreciating natural resource assets, some environmental accountants have conceived systems which aim at placing monetary values on all physical entries and adjusting conventional national accounts for environmental effects. Three approaches are briefly discussed: the Hueting approach, the Peskin framework and the United Nations Statistical Office system. Although all three approaches aim at monetary valuation, there are differences in concept, coverage and valuation methods.

- **The approach of Hueting and his colleagues from the Netherlands Central Bureau of Statistics**

The Hueting approach[33] is currently being investigated within the framework of the Calculation of Sustainable National Income project of the Netherlands Central Bureau of Statistics which started on 1 February 1991. The aim is to devise an indicator of the loss of environmental quality and natural resources in money terms that is matchable with national income.

The *central idea* of the Hueting approach is that there are various "functions" of the natural environment and that there is competition for these functions by various agents in the economic and environmental systems (e.g., an enterprise which uses the air as an atmospheric discharge medium competes with residents wishing to breath fresh air). This competition may lead to a "loss of function" as perceived by competing agents. This loss is valued by the estimation of shadow prices which requires the construction of supply and demand curves for the possible uses of the environment.

Supply functions would be based on cost data concerning technical and structural measures for the restoration and preservation of environmental functions in the form of a cost-effectiveness curve. Demand functions would be represented by environmental quality standards ("concentrations": e.g., noise intensity, concentration of substances, intensity of ultraviolet and radioactive radiation), as complete demand curves cannot be determined according to Hueting. He found he was not in a position to construct environmental demand curves that would be consistent with individual preferences for environmental functions. The standards may be regarded as consistent with sustainability goals as expressed by politicians and societal organisations. The standards for a sustainable use of the environment could be derived from properties of the ecosystems, like self-purifying capacity, buffer capacity and regenerative capacity.

Conventional NDP will be corrected by subtracting the value of environmental damages as measured by the costs of technical measures and the reduction in activities necessary to avoid damages or to restore environmental functions. The environmental functions themselves are not valued in the Hueting approach.

Essentially, the Dutch approach estimates the loss of environmental functions which is to be deducted from NDP by the *costs of restoring the functions* to a level consistent with pre-set environmental standards. This is a pragmatic procedure and maybe justified in the belief that true environmental damage calculation is difficult or impossible. It raises,

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[33] R. Hueting (1980), New Scarcety and Economic Growth: More Welfare through less Production?, Amsterdam and R. Hueing, P. Bosch, B. de Boer (1992), Methodology for the Calculation of Sustainable National Income, statistical essays M44, 's Gravenhage

however, the *problem* of how to set the standards adequately. Hueting proposes to set standards in a way that emissions do not exceed the natural buffering capacity of environmental media.

Beside the difficulty in defining such natural buffering capacities, the characteristic way of the Hueting approach to set environmental standards is at odds with the conventional economic approach. One should have expected the optimal standard to be the outcome of an analysis based on environmental accounting data and not an input variable to the accounting system.

- **Peskin's proposal for an environmental accounts framework**

The accounting framework of Henry M. Peskin[34] was developed as part of a research programme of the American National Bureau of Economic Research. The aim of the programme was to develop improved measures of economic and social performance. The proposed system adds a new sector, nature, to the traditional sectors (industry, government, households). Additional accounting entries reflecting environmental services, environmental damages and environmental depreciation appear with conventional accounting entries in a double-entry account. A *basic feature of Peskin's approach* is that it treats services of environmental and resource capital as if these services were marketed. These services are considered as intermediate consumption if they are consumed by the production sector and as final consumption if they are consumed by the final demand sector (e.g., households).

The *consumption of environmental services* can lead to environmental damages due to externalities associated with the consumption or, in analogy to Hueting's approach, to the denial of such services in the case of rival use (e.g., disposal services of the environment leads to pollution). The value of these damages or dis-benefits is counted as negative final consumption.

In this accounting framework *all assets are depreciated*, including the natural resource assets. As depreciation of marketed assets, environmental depreciation is subtracted from GDP to calculate an adjusted Net Domestic Product. GDP itself is not affected by depreciation, but may be affected by the negative and positive values of non-marketed environmental services. Peskin does not say how GDP should be adjusted. In fact, he demonstrates that several possible adjustments are consistent with the accounting framework.

An interesting feature of Peskin's system is that the consolidated accounting framework allows for dual valuation, on the input side (disposal services of the environment) and on the output side (environmental damages). To maintain accounting balance, there is a balancing entry equal to the arithmetic difference between these two values. The size of this balancing entry can be interpreted as being proportional to the amount of economically inefficient allocation of environmental assets. Thus, an evaluation of the

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[34] H.M. Peskin (1989), A Proposed Environmental Accounts Framework, in: Y.J. Ahmad, S. El Serafy, E. Lutz (ed.) (1989), Environmental Accounting for Sustainable Development, A UNEP-World Bank Symposium, Washington

relative efficiency of environmental policies can be carried out within the Peskin accounting framework.

The *valuation* of the different environmental entries is based on various valuation techniques (eclectic approach). The value of environmental services is based on the willingness to pay for these services. Environmental damage (thus the denial of environmental services) is estimated by the willingness to pay to avoid this damage.

The US Environmental Protection Agency has initiated an environmental accounting effort for the Chesapeake Bay region (USA) on the basis of the Peskin approach.[35] The exercise attempted to provide a view of the costs and benefits of environmental protection. The study presents both air and water pollution problems in the environmental accounts and compares in economic terms both the relative magnitudes of their seriousness and their changes over time. A comparison of waste disposal service values and corresponding damages suggest that water protection policy would appear to have a better payoff than air pollution policy in that region.

- **The approach of the United Nations Statistical Office (UNSO)**

As part of the recent revision of the System of National Accounts, the Statistical Office of the United Nations has developed methodologies for a satellite System of integrated Environmental-Economic Accounting (SEEA)[36], in cooperation with the World Bank. In order to maintain the continuity of the functions of the traditional SNA and due to still prevailing methodological problems, especially related to the valuation of non-market transactions, the Statistical Commission of the United Nations considered it premature and inappropriate to change radically the established System of National Accounts. Rather than modifying the core system of the SNA itself, the UNSO elaborated a SNA satellite system for 'integrated environmental and economic accounting'.

The SEEA produces accounts which are *closely linked to the SNA* and follows as far as possible the principles and rules established in the SNA. The *objectives* are relatively ambitious, in contrast to the Norwegian approach and more like the French approach, and can be broadly defined as follows:

- Segregation and elaboration of all environment-related flows and stocks of traditional accounts. One aim is the estimation of total expenditures for the protection or restoration of the environment compensating the negative impacts of economic growth ('defensive expenditures');

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[35] Results of this accounting excercise are quoted from A.E. Grambsch, R.G. Michaels (1993), Taking Stock of Nature: Environmental Accounting for Chesapeake Bay, in: E. Lutz (ed.) (1993), Toward improved accounting for the environment, an UNSTAT-World Bank Sypmosium, Washington DC

[36] see United Nations, Department of Economic and Social Development, Statistical Division (1992), Handbook of National Accounting - Integrated Environmental and Economic Accounting, New York, May 1992 and P. Bartelmus, C. Stahmer, J. van Tongeren (1993), Integrated Environmental and Economic Accounting - A Framework for an SNA Satellite System, in: E. Lutz (ed.), Toward Improved Accounting for the Environment, An UNSTAT - World Bank Symposium

- Linkage of physical resource accounts with monetary environmental accounting and economic balance sheets;

- Assessment of environmental costs and benefits. The system is envisaged to expand and to complement the conventional SNA with regard to two major issues: the 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 the one hand, and environmental protection and enhancement, on the other;

- Calculation of modified macro-economic aggregates, notably an Environmentally adjusted net Domestic Product (EDP).

The accounting framework is intended to be *flexible,* so that it can incorporate or link up with other methods of integrated environmental-economic accounting and analysis. The SEEA attempts only to describe the major interrelationships between the environment and the economy. Limited to the production boundary of the SNA, phenomena that take place wholly within the environment, i.e. outside the economic system, are excluded. Also, welfare effects from environmental degradation that affect 'human capital', i.e. human health and welfare, are only tentatively discussed in the proposed system.

The *Environmentally adjusted net Domestic Product (EDP)* is established by subtracting from GDP the depreciation of conventional fixed capital (to arrive at NDP), by deducting the value of depleted natural assets and the value of environmental protection activities.

The SEEA has the *merit* of providing the possibility to trace inter-industry effects of environmental change. The SEEA does not view reductions in natural resource capital in isolation, but clearly displays any offsetting increases in non-environmental capital. This is possible thanks to a comprehensive and widely disaggregated table of accumulation of tangible assets distinguishing between produced (biological and non-biological) assets as well as non-produced assets. Of particular interest among the consolidated accounts is the "use" table with its breakdown of environmental protection expenditures by consuming sector and "environmental costs" (i.e. essentially, environmental degradation and resource depletion) by sector of origin.

However, the UNSO framework is also characterised by *some shortcomings*. It fails for instance, as does the Hueting approach, to distinguish between services provided to economic sectors by the environment and damages (or "costs") to the environment by these sectors. The fact that "environmental cost" is the only entry implies that both values are considered identical. Moreover, as the damages are to be valued either in terms of their maintenance cost (avoidence cost) or their restoration cost, this implies that the opportunity cost of environmental policy equals exactly the policy benefits. Hence, an "assessment of environmental costs and benefits", a stated objective of the SEEA, does not seems to be feasible. The concept of sustainability underlying the valuation method of "environmental cost" is cost-oriented rather than welfare-oriented. The authors justify this choice because of measurement problems and difficulties in establishing ties between particular pollutants and damage to health and welfare.

The underlying philosophy of the environmental adjustment of value added is inspired by the "strong" sustainability concept that implies no substitution possibility between man-made and natural capital. In fact, "the 'environmental costs' are the costs that would be required to maintain the natural assets at the same level during the reporting period".[37] This choice has been justified with the "uncertainty surrounding the long-term impacts of economic activities on the natural environment and the increasing knowledge that irreversible damage can be done to natural balances, for example, in the areas of climate change or ozone layer depletion". The adequacy of the strong sustainability concept is, however, strongly debated, especially in the case of subsoil resources where it is felt that this concept would impose an unreasonable development constraint as it discourages the use of exhaustible resources. The SEEA partially admits this inappropriateness, and suggests a weaker sustainability concept (partial substitution possibilities) in the case of subsoil assets[38].

Practical experience with the UNSO approach has been acquired through pilot studies in Mexico, Papua New Guinea and Thailand. In the case of *Mexico*, the standard analysis of the Mexican SNA which derives the GDP was expanded to include produced and natural asset balances[39]. By deducting from Net Domestic Product (NDP) the valued (net) depletion of natural resources (e.g., oil, forests and ground water) as well as the valued degradation of natural assets (air, water, soil erosion, deposit of solid wastes) and the valued impacts of land use (deforestation) two environmentally adjusted net Domestic Products (EDPs) are calculated. EDP1 is derived by deducting from NDP the environmental uses related to depletion, deforestation and land use; it is estimated to be about 94% of the traditional NDP. EDP2 is obtained by further deducting the cost of degradation, and is estimated to be roughly 87% of NDP.

According to the UNSO, the SEEA has to be seen as *one element of an integrative data system* which encompasses economic data, environmental as well as social and demographic statistics. In order to include the "natural" sector (expand the balance sheets of natural capital in the SEEA beyond the economic asset boundary), some sort of natural resource accounts could be added. The UNSO argues[40] that there are no generally accepted models of the dynamics of economic impacts on, nor repercussions from, the natural environment. The difficulties of identifying unequivocally functional relationships between economic and environmental variables are the main reasons why the United Nation's Framework for the development of Environmental Statistics (FDES) opted simply to list environmental and related economic variables under major information categories, without attempting to specify further connections among them.

3.2.4 tentative assessment

Table 4 provides an overview of the main characteristics of the surveyed information systems under the national accounting approach. It becomes clear that the information on natural assets, both man-made and non-man-made, that would become available through

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[37] Bartelmus, Stahmer, van Tongeren (1993), p.52

[38] Ibid, p.53

[39] J. van Tongeren, S. Schweinefest, E. Lutz, M. Gomez Luna, F. Guillen Martin (1991), Integrated Environmental and Economic Accounting - A case study for Mexico, Environment Working Paper No. 50, The World Bank, December

[40] see P. Bartelmus (1992), Environmental Accounting and Statistics, Natural Resource Forum, February

physical natural resource accounting systems and the SEEA (thanks to its extensive assets use accounts) would be more comprehensive and detailed than in the Repetto system and in the integrated systems. The survey also suggests that the information systems under the national accounting approach are more appropriate for the monitoring and assessment of simultaneous integration of economic and environmental objectives in policy making as well as the assessment of long-term sustainability[41].

When accounting for the depreciation of marketed natural resources, the Repetto proposal appears to be an appropriate approach to assess the sustainability of the development pattern of developing countries as their economies are strongly resource based, however, this is less appropriate for industrialised countries. In these countries, changes to environmental quality becomes the important wealth influencing factor. Also, in developed countries, more sophisticated valuation methods closer to individual preference revelation, such as contingent valuation, are feasible due to a number of factors, one of which is better information on the importance of environmental changes for personal and societal well-being.

Peskin's proposal for an integrated environmental-economic information system appears to be particularly interesting as it allows an estimation of sustainable income and also a rough evaluation of the relative efficiency of environmental policy measures. Such an analysis becomes possible thanks to a separate valuation of environmental damages and pollution (waste) disposal services of the environment.

[41] The physical natural resource accounting systems and also to a certain degree the Repetto approach are less appropriate for these functions as the level of aggregation is lower or the coverage of economy-environment interactions is more restricted.

Table 4: Characteristics of national accounting approaches to the environment

Type of accounting approach	Functional objectives	Accounts type	Coverage	Underlying Sustainability definition	Level and type of aggregation (valuation)
Physical resource accounting					
* Norway	Tool for natural resource management	physical resource accounts	environment (very detailed)	------	low to medium, no valuation
* France	Tools for "natural patrimony" management; Description of econom., ecological and social functions of "natural patrimony"; Support of environmental/economic modelling	physical/monetary satellite accounts	environment (very detailed)	-------	low to medium , no valuation
Accounting for the depreciation of marketed natural resources					
* Repetto	National natural resource assessment; Estimation of sustainable income	monetary resource accounts	economy, environment (restricted to marketed natural assets)	constant natural capital stock	high; monetary valuation through simple depreciation method

Table 4: Characteristics of national accounting approaches to the environment (continued)

Type of accounting approach	Functional objectives	Accounts type	Coverage	Underlying Sustainability definition	Level and type of aggregation (valuation)
Environmental and natural resource accounting with valuation					
* Hueting	Estimation of loss of environ. functions; Estimation of sustainable income	integrated economic-environmental accounts	economy, environment (summary)	maintaining environmental functions	high; valuation through restoration cost
* Peskin	Measures of economic and social performance (several proposals for GDP adjustment); Measure of efficiency of environ. policies	integrated economic-environmental accounts	economy, environment (summary)	constant overall capital stock	high; monetary valuation with various techniques (mainly WTA/WTP); different valuation of envir. services and damages to the environment
* SEEA (UNSO)	Assessment of the envir. and natural resources; Assessment of linkages between environment and econ. sectors; Calculation of an Environmentally adjusted net Domestic Product	satellite accounts with valuation	economy, environment (detailed)	constant natural capital stock with some exceptions for subsoil assets	high; valuation mainly through restoration and maintenance cost approach

The Satellite system for integrated Environmental and Economic Accounting (SEEA) of the UN Statistical Office has the advantage of proposing a flexible system in modular format that allows the achievement of more ambitious functional objectives in a step by step process, depending on data availability and applicability of necessary accounting techniques. The SEEA being a satellite accounting system linked to the core of traditional SNA, permits the maintenance of the original functions of the SNA and the time continuity of its data series.

3.3 Linking the indicators approach to the national accounting approach

The survey of the different information systems proposed under the headings indicator approach and national accounting approach has highlighted the diversity of functional objectives underlying definitions of sustainability and differences in aggregation/valuation methods. However, evaluating the functions both approaches can probably comply with, the conclusion emerges that the indicator approach and the national accounting approach are not mutually exclusive but complementary. In fact, table 5 shows that the indicators approach is potentially more appropriate for monitoring trends of environmental problems, identifying the relative importance of environmental problems and perhaps for valuing the efficiency of environmental policy measures. National accounts seem to be the more suitable statistical-analytical framework for assessing the economic effects of environmental policy measures, monitoring and assessment of simultaneous integration of economic and environmental objectives in policy making and potentially also the generation of a comprehensive indicator for sustainable development.

However, a crucial factor in the good performance of both approaches carrying out their respective functions is the use of an appropriate aggregation/valuation method. For instance, the calculation of a meaningful welfare measure for environmentally sustainable development is only possible if the non-market environmental phenomena are captured comprehensively and valued with a method whose philosophy is coherent with market valuation but nevertheless captures a maximum of value categories of environmental assets (actual use value, option value, and existence value).

Table 5: Feasibility of functional objectives for the indicators and the national accounting approach

Functional Objective	Indicator approach	National accounting approach
Monitoring trends of environmental problems	feasible	partly feasible, depends on extent of natural assets account
Identifying the relative importance of environmental problems	feasible	partly feasible
Efficiency valuation of environmental policy	feasible under certain conditions (cost-effectiveness indicators)	partly feasible (Peskin approach)
Assessment of economic effects of environmental policy	-	feasible
Establishment of welfare indicator for sustainable development	- (only tentative attempts with sustainability indices)	feasible only if valuation method for natural assets compatible with market valuation can be identified

From an economic viewpoint a valuation based on the "consumer sovereignty" concept (i.e., e.g. contingent valuation: willingness to pay, willingness to accept techniques) certainly has merits, as it comes close to the preference revealing process of market valuation. Moreover, the contingent valuation methods has the broadest range of application (for instance, it is only with this method that the valuation of preferences for endangered species seems feasible), and these techniques can measure the total economic value of environmental assets, i.e. both use and non-use values. However, the estimation techniques underlying this concept have been criticised for potentially understating societal valuations. Some environmental services might be more socially important than for the individual. Individual willingness-to-pay might therefore understate their societal value. Moreover, preferences of present day consumers might understate the value of environmental assets to future generations (for instance, the long term ecological and economic value of certain animal or plant species). Other methods, such as restoration costs and hedonic pricing (which cannot, however, be applied in all valuation situations) are considered to be more credible by some economists as the resulting benefit measures are based on realised market behaviour. However, in order to overcome the credibility problem of the contingent valuation method specific validity checks can be included in the survey.

It should be mentioned that estimation methods are likely to be improved through practical application. Furthermore, all estimation techniques approximate, per definitionem, the real value of the variable. This is, for instance, also true for methods estimating the depreciation of a plant and its equipment. Direct observation of true economic depreciation is not possible. As conventional techniques for estimating economic depreciation have become widely accepted nowadays, the same could be the case for environmental valuation methods. Nevertheless, a substantial research effort has still to be undertaken in the future.

4. Environmental accounting in the European Community

Environmental accounting in a broad sense does not have a very long tradition in the European Community, although in some member states (France, Netherlands, Germany) a longer experience with environmental accounts and indicators exits. At the Community level, environmental accounting was for a long time synonymous with the compilation of environmental statistics and indicators: 1) environmental statistics closely linked to the environmental legislation, 2) indicators (predominantly) on the state of the environment generated by the CORINE programme (Co-ORdination of InformatioN on the Environment), 3) physical indicators conceived within the pressure/state/response model and monetary data on expenditures on the environment with the SERIEE methodology (Système Européen de Rassemblement de l'Information Economique sur l'Environnment). More recently, work in the field of 'green national accounting' has started at Eurostat.

- **Environmental indicators based on environmental legislation**

The reporting requirements of Community environmental legislation provided the first generation of environmental statistics. The Directorate General for Environment of the Commission of the European Communities created in various environmental directives the basis for the collection of a large number of environmental data (e.g. quality of bathing or waste water, sulphur dioxide emissions, lead concentration, etc.). However, these instructions to member states were not always conceptualised in a way that would have made it possible to use the reported data directly for statistical purposes. Only very selected parts of the data, e.g. on the quality of bathing water has been used for regular reporting. A Community directive has in the meantime been adopted that attempts to improve conditions of reporting so that, in the future, data may be more suitable for statistical use, and the requested reporting updated.

- **Environmental indicators based on CORINE**

Initiatives like CORINE and its predecessors administered by the Directorate General for the Environment of the EC Commission have, since 1975, created a framework for the systematic collection of local data on the state of the environment, as well as on certain environmental pressures.[42] It now constitutes a large data base covering themes like biotopes, soil types, land quality and important resources, soil erosion risk, land cover, air emissions and water resources. The Task Force of the European Environmental Agency has taken over the work of CORINE, but further work has been delayed due to organisational problems. In fact, although the establishment of the Agency was decided by the EC Council since May 1990, the Agency did not formally exist until October 1993 when an agreement on the location of its seat was reached. Since then, a first draft multi-annual work programme has been prepared after discussions with Commission services and high-level experts from member states. One aim of future work will be to relate indicators to each topic and priority of the 5th Environmental Action Programme of the Community and to specify the necessary data that will be needed for constructing the indicators and to show in what format the indicators could be made available to users.

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[42] see Commission of the European Communities (1991), Results of the CORINE Programme, Communication of the Commission to the Council and the European Parliament, SEC(91)958 final

- **Indicators based on the pressure/state/response system**

Indicators of the pressure/state/response system should be adapted to policy-making needs in order to ensure that they develop in a coherent way. In the Community context, more efforts have to be made to establish clear priorities in order to come from presently available indicators to actually useful information. A large quantity of data is available for the construction of these indicators, but often not harmonised in a consistent framework. Table 6 summarises an evaluation of the coverage, quality and comparability of data available provided on a provisional basis by a Eurostat service. It is apparent that there are still large gaps in the coverage and also, partial quality problems. In a systematic way, physical data are collected since the late 80s on the basis of a joint OECD/Eurostat questionnaire and from various other sources such as other Commission services and national statistical offices. The resulting indicators are published by Eurostat in the regular series *Environmental Statistics* since 1989.

- **monetary indicators on environmental expenditures (SERIEE)**

In the eighties, Eurostat started a pilot project with the aim of establishing a European-wide statistical information system that provides indicators on how various societal actors respond to environmental degradation. The main features of SERIEE[43] are the generation of data on environmental protection activities of the various sectors in the economy and the confrontation of physical data on the environment with the monetary data. The functions of SERIEE are, on the one hand, an analysis of the financial circuits of expenditures for environmental protection. SERIEE attempts to answer the following questions: which agents spend how much money on what environmental protection measures? Who finances these environmental protection expenditures? In what form and through what channels are these operations financed? On the other hand, SERIEE strives for an analysis of the absolute cost of environmental protection. The calculation of absolute cost data of environmental protection would allow a comparison of such data on a micro and a macro economic level with general economic indicators (e.g. turnover, investment of industrial branches) in order to gauge relative efforts of countries and sectors for the environment.

[43] Eurostat (1993), Draft Manual (System SERIEE), version of March 1993 (Planistat), internal Eurostat working document

Table 6 Data coverage, quality and comparability for indicators for a number of environmental problems identified by the Fifth Environmental Action Programme of the European Community

Environmental Problem	Background & Pressure Indicators	State & Impact Indicators	Response Indicators
	Who causes the problem ?	*What is the actual state?*	*What is done to solve ?*
Climate change	Cover.: ok Quality: ok Compar. good	Cover.: good Quality: good Compar. good	Cover.: bad Quality: ok Compar. ok
Ozone layer depletion	Cover.: ok Quality: ok Compar. good	Cover.: ok Quality: ok Compar. ok	Cover.: ok Quality: good Compar. good
Loss of Biodiversity	Cover.: ok Quality: bad Compar. bad	Cover.: ok Quality: ok Compar. bad	Cover.: ok Quality: ok Compar. bad
Resource Depletion	Cover.: good Quality: good Compar. ok	Cover.: ok Quality: ok Compar. ok	Cover.: bad Quality: bad Compar. bad
Dissipation of Toxic Chemicals	Cover.: bad Quality: bad Compar. ok	Cover.: bad Quality: bad Compar. ok	Cover.: bad Quality: bad Compar. bad
Waste	Cover.: bad Quality: bad Compar. very bad	Cover.: very bad Quality: bad Compar. very bad	Cover.: very bad Quality: bad Compar. very bad
Air Pollution & Acidification (excl. Climate Change & Ozone)	Cover.: good Quality: good Compar. good	Cover.: good Quality: ok Compar. good	Cover.: ok Quality: ok Compar. ok
Marine Environment and Coastal Zones	Cover.: bad Quality: very bad Compar. bad	Cover.: bad Quality: bad Compar. ok	Cover.: very bad Quality: very bad Compar. ok
Water Pollution & Water Resources	Cover.: ok Quality: bad Compar. bad	Cover.: bad Quality: ok Compar. bad	Cover.: ok Quality: bad Compar. bad
Urban Problems, Noise & Odours	Cover.: good Quality: ok Compar. ok	Cover.: ok Quality: bad Compar. bad	Cover.: ok Quality: bad Compar. bad

Table 6. Coverage, quality and comparability of environmental data for the construction of three types of indicators on the environmental topics of the 5th Environmental Action Programme of the European Community (as evaluated by Eurostat). **Coverage**: How complete is the description of the environmental problem? **Quality**: How good is the precision of the data, e.g. over time?, **Comparability**: How comparable are the data between Member States? Scale: Good, ok (acceptable), bad, very bad. Source: Eurostat

Along with establishing an EC-wide inventory of environmental protection expenditures and analysing the underlying financing streams, SERIEE aims at providing information on the causalities between economic activity and the environment. Therefore, strong emphasis has been laid on the link between monetary data (environmental clean-up expenditures or investments) and physical data (state of the environment, depletion of natural assets).

Currently, a number of pilot projects are being carried out with the aim of testing the feasibility of an application of the SERIEE methodology and collecting experimental data on environmental protection activities and expenditures of industry, public administrations and private households.

Aware of the attempts to integrate environmental aspects into other policy objectives and the consequent necessity to dispose of new policy tools such as integrative environmental and economic information systems, the Commission services felt the need to better co-ordinate the work done in this field by the various Community institutions and to promote a Community environmental-economic information system. Hence the Commission, at Cabinet level, decided in March 1993 to ask the Cellule de Prospective of the EC Commission to chair an inter service group gathering most Directorate Generals of the Commission, Eurostat and the Task Force for the European Environmental Agency working on the subject "Environmental Indicators - Green National Accounting". The two major goals pursued by this group are: 1) a clarification - at the level of Commission services - as to what is already being done and what obstacles and possible ways forward there are; 2) proposals were sought on how a further integration of economic and environmental information systems can be achieved at least at Community level. In July 1993 the working group issued an intermediate report[44] providing an overview of the state of the art, making organisational suggestions for the work in progress on EC level and established a list of issues for further discussion.

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[44] see Commission of the European Communities (1993), Environmental Statistics and Indicators - 'Green' National Accounting,: The need for an integration of economic and environmental information systems, intermediate report by an interservice working group of the Commission of the European Community, July, internal document

5. Elements of a Community approach to integrated environmental and economic accounting

The analysis of the two major approaches taking account of the environment in statistical information systems (the indicator and the national accounting approach) with respect to the feasibility to fulfil certain functional objectives has shown that both approaches should be used complementarily. The implications for designing a Community approach to integrated environmental and economic accounting would be therefore in the light of the existing shortcomings to strengthen the data base and improve the necessary accounting techniques to develop an operational and policy-oriented information system under both approaches, ideally in a way that would allow an eventual integration of both.

The pressure/state/response indicator model has the merit of being conceptually well advanced and based on an already rich experience of data collection. Furthermore, the aggregation of individual indicators to indices to allow macro-oriented policy analysis, for instance on the basis of expert assessments, appears to be possible within a relatively short time span. Further investigation in appropriate aggregation/valuation methods seems to be indispensable. On the other hand, the development of an information system of the national accounting type is appropriate to answer questions concerning the macroeconomic/sectoral effects of environmental policy measures and to generate (eventually) a welfare measure of sustainable development. A reasonable way to approach this task seems to be to conceive an information system with greater flexibility, e.g. a satellite accounting system, so that information from the indicator approach can easily be integrated[45].

Therefore, the Community should take action in the organisational sphere, in research promotion and in the sphere of conceptual and practical work of national accountants.

- **reinforced co-operation and co-ordination in the collection of basic environmental indicators**

In order to enable the establishment of an operational system of pressure/state/response indicators and an environmental satellite accounting system in the European Community, the quality of the physical data base has to be improved. Both approaches are based on the same data basis, although the national accounting approach may not use all the data needed for the indicator approach. Therefore, ***reinforced co-operation and co-ordination in the collection of basic environmental indicators*** has to be initiated at the Community level. Statistical offices, environmental agencies and environmental ministries of the member states have to undertake a substantial effort to fill existing data gaps and solve harmonisation problems. A consistent evaluation of environmental problems can only be carried out on the basis of statistical series that are comparable internationally, with respect to both time and space.

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[45] In principle, accounts of environmental protection expenditure compiled with SERIEE could become part of an environmental satellite accounting system.

- **promotion of research in the scientific underpinnings of environmental indicators and in appropriate aggregation/valuation techniques**

In the same vein, to improve the usefulness of the physical database, our understanding of the natural-biological framework and our knowledge of how pressures on the environment are translated into states of the environment and finally into socio-economic impacts has to be steadily improved. Therefore, the European Community should strengthen its efforts in the *promotion of research on the scientific underpinnings of environmental indicators*. Also, the influence of uncertainty that is related to our understanding of natural systems on the use of a system of environmental indicators has to be explored more fully; how should policy makers act despite the given uncertainties?

The review of both the indicators approach and the national accounting approach, has shown that the *choice of an appropriate aggregation/valuation method* is of vital importance for implementing meaningful analytical functions of an economic-environmental statistical information system. A lot of know-how and expertise has been accumulated in Europe in this field; however, many gaps and open questions remain. Further research on the generalisation of results from one study to other applications, underlying scientific relationships and the appropriate discount rate is necessary. Anil Markandya, an internationally renowned expert in monetary valuation, has identified those areas where *additional support for research* might be warranted in order to make a European-wide valuation exercise more credible[46]. Among these areas are: morbidity health effects, local and transboundary forest damages, use values of water damages (ecological, recreational and fisheries) and establishing a framework for valuing losses of biodiversity and applying that framework to estimate damages. Particular attention should be paid to research on the comparability of monetary and non-monetary valuation methods.

- **conceptual and practical work of national accountants at EUROSTAT**

Finally, the *development of an environmental-economic satellite accounting system* has to be prepared on a European scale. The UN Statistical Office (UNSO) has asked national and regional statistical offices to study the feasibility of implementing the SEEA conceived by UNSO. The issue has been raised at a meeting of the European Community Working Party on National Accounts on 10 and 11 of May 1993. Many participants were interested and prepared to participate in a Task Force on this topic. Eurostat should take the lead in this endeavour.

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[46] see A. Markandya, Monetary valuation and "green accounting"(1993), note prepared for internal EC discussions, May, p. 11

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