Economic & Social Affairs

ST/ESA/1999/DP.3
DESA Discussion Paper No. 3

Greening the National Accounts: Approach and Policy Use

Prepared by
Peter Bartelmus
January 1999

United Nations

DESA Discussion Paper Series

Peter Bartelmus
The author is a staff member in the Statistics Division of the Department of Economic and Social Affairs. Comments should be addressed to the author, c/o Statistics Division, Department of Economic and Social Affairs, Rm. DC2-1652, United Nations, New York, N.Y. 10017, or by e-mail to bartelmus@un.org. Additional copies of the paper are available from the same address.
This paper was first presented at the *EIIW Conference on "Internationalization of the Economy, Environmental Problems and New Policy Options" (Potsdam, 15-17 October 1998).* Permission to issue the paper as a DESA Discussion Paper by the Conference organizers is gratefully acknowledged.

Authorized for distribution by
Hermann Habermann, Director, Statistics Division.

United Nations
Department of Economic and Social Affairs

Abstract

Green national accounts capture the interaction between environment and economy. The objective is to assess the long-term sustainability of economic performance. The opaque concept of sustainability can be operationalized in terms of produced and non-produced (natural) capital maintenance. Integrated environmental and economic accounts expand therefore the asset boundary of the conventional national accounts. The integrative power of such accounting is based on pricing ‘priceless’ environmental phenomena. Monetary valuation is thus controversial, and alternative physical accounting is also discussed. The main policy applications are (a) the use of environmentally adjusted ‘eco-nomic’ variables in macroeconomic policy and (b) the setting of market instruments of cost internalization according to the environmental cost generated by economic agents.

1. Rationale: accounting for sustainability

1.1 Measuring sustainability – an emerging dichotomy

We all agree: environment and economy interact, and interaction requires integrative policies. Figure 1 describes this interaction in terms of the well-known (re)source and sink (waste disposal) functions provided by the environment to the economy. Environment and economy also affect human welfare through the consumption of goods and services and a deteriorating life-support system. We disagree, though, on how to assess this interaction and on its policy consequences.

Sustainable development was coined in the preparations for the Rio Earth Summit as the integrative paradigm for environment and development. However, the definitions of such development as non-declining welfare (Pezzey, 1989) or the satisfaction of current and future generations' needs (WCED, 1987: 43) are vague. They do not specify the ingredients of welfare or generational needs, nor do they indicate any particular role for the environment. No wonder that hardly comparable indices or indicators of 'true' social progress have proliferated (see Box 1). Nonetheless, sustainable development has shown a – perhaps surprising – staying power, insinuating itself even into the policy agenda of industrialized nations.[1]

Obviously, the elusive concept of sustainability needs to be operationalized in a more systematic manner. The protagonists of the environment and development discussion, i.e. environmental and economic scientists, thus looked into their respective analytical toolboxes so as to apply them to the other field. In doing so they imposed their own particular values on the counterpart field. An unfortunate dichotomy between the 'environmentalist' and 'economic' worldview of the environment-economy interface has been the result.[2]

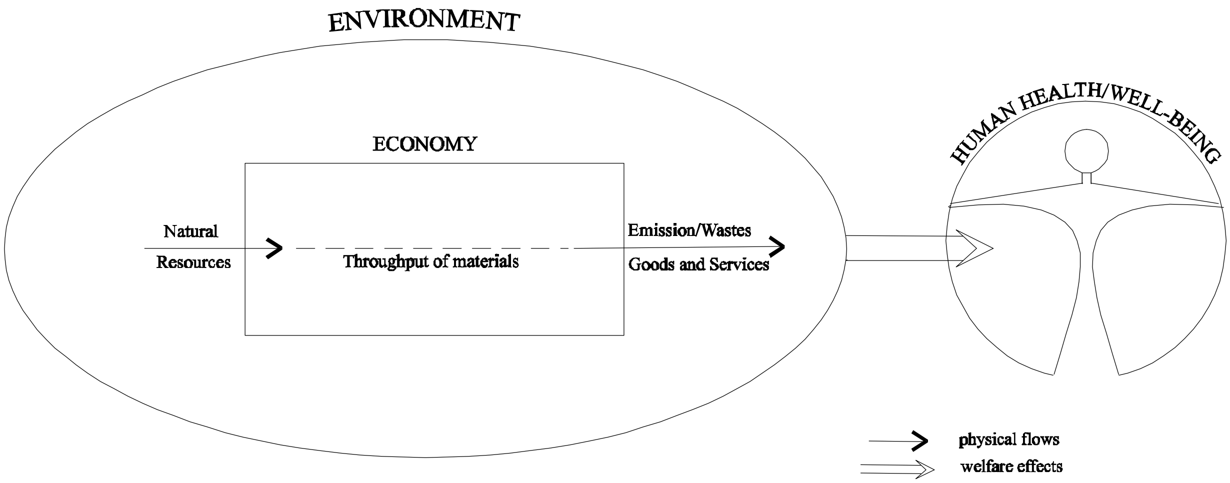
Environmental economists attempt to put a monetary value on the loss or impairment of environmental services as a first step towards 'internalizing' these 'externalities' into the budgets of enterprises and households. Environmentalists repudiate the commodification and pricing of the environment. In their view, the value of the environment cannot be expressed in money, and physical indicators of sustainable development, carrying capacity, or material throughput are advanced. Calls for dematerializing economic activity (Hinterberger, Luks and Schmidt-Bleek, 1997: 8) and/or compliance with social norms and standards (see below, sections 3.3 and 4) are the policy responses of the environmentalist worldview.

There are some advantages to the economic approach. For one, the use of a common *numϑraire* permits direct comparison of conventional economic aggregates with environmentally adjusted ones through simple summation or deduction. Second, some key economic indicators such as income already have a built-in notion of sustainability. Thirdly, a worldwide-adopted System of National Accounts

Box 1: Indicators of social progress

A Genuine Progress Indicator (GPI) claims that America is "down" by 45% since 1970, while GDP is "up" by 50% at the same time (Cobb, Halstead and Rowe, 1995). Nature's *annual services* are given a value of $ 33 trillion by one team of scholars (Costanza *et al.*,1997) while a similar value ($ 35 trillion) is assigned to nature's capital *stock* by another (World Bank, 1997). Total material flows of 45 to 85 tons per capita are considered to be "staggering" by a group of research institutes (World Resources Institute *et al*., 1997). UNDP's (1997) Human Development Index drives Switzerland from its 4th place in terms of per-capita GDP (real, in purchasing power parities) down to 16th, while a "pollution-adjusted GNP" (Rodenburg, Tunstall and van Bolhuis, 1995) lowers the country to number 31.

Figure 1. Environment-economy interaction and effects



(SNA) (CEC *et al*., 1993) provides standard concepts and definitions for international comparison of these indicators. As shown below, the System of integrated Environmental and Economic Accounting (SEEA), advanced by the United Nations (1993), makes use of these advantages.

In contrast, large indicator lists face difficult aggregation (weighting) problems. Moreover, their policy relevance is limited unless they can be linked to sustainability standards or other targets and thresholds, which are difficult to agree upon. As discussed in the concluding section, some indicators do have the capability of capturing social and welfare concerns represented as the health/well-being circle in Figure 1. Also, one should not hide the fact that monetary valuation has its own limitations, especially when it is extended beyond market transactions (see section 2.3).

1.2 Capital maintenance – the door to environmental accounting

Conventional national accounts measure capital consumption, i.e. the 'wear and tear' of fixed assets such as buildings or machinery, as a cost of production. The idea of reserving funds from revenue generated in production for the replacement of run-down capital can be seen as a sustainability criterion built into the fundamental economic concepts of production and income. The view of capital as the source of a continuous flow of output and income can be traced back to Adam Smith's "neat revenue" (quoted in El Serafy, 1989: 11) which was revived much later, among others, by Fisher (1906, reprinted 1965) and Hicks (1946). Capital consumption is thus a useful starting point for operationalizing a broader concept of sustainability and incorporating it into an extended accounting system.

New scarcities in formerly abundant natural resources of water, soil, mineral deposits, forests or endangered species, and in nature's capacities of waste absorption, are the basic reason for introducing these natural assets into the realm of economics and economic accounting. As these assets were not created in an economic production process their incorporation would change the conventional accounting concepts of capital, and capital formation and consumption. The reason is that non-produced natural assets did not enter the economic system by means of a 'transaction' between institutional units (households, government, corporations, non-profit institutions). This transaction criterion defines the scope and coverage of production and income generation in the national accounts (CEC *et al*., 1993: para. 1.12). The use of non-produced assets can therefore not be recorded as a re-allocation of previously produced capital to intermediate or capital consumption, i.e. as production *cost*.

The costing of natural resource depletion and environmental degradation in production and income accounts and the deduction of these costs from output and value added (income generated) have therefore to be justified by introducing an extrinsic objective. This new objective is the desire of society to take care of the environment and account for its depletion and degradation as a 'social cost'. This is radically different from the conventional accounting objective of duplication-free, transaction-based measurement of economic performance. In operational (accounting) terms, the caretaker objective of social cost accounting can be expressed as the need to maintain the non-produced natural asset base of production and income generation. In other words, *sustainability* criteria of natural capital and/or corresponding production/income generation have to be explicitly and additionally introduced to justify the incorporation of environmental cost in integrated environmental and economic accounting.

Hicks (1946: 172) defines income as maximum consumption during a period of time, while making sure to be as well off at the end of the period as at the beginning. The definition has been the model for the national accounts distinction between 'net worth' (the state of being 'well off') and 'disposable income'. [3] This income concept seems to support the extension of wealth (or net worth) maintenance into scarce natural assets. Aggregating the microeconomic income definition to the national level calls for a measure which ensures that 'society' is at least as well off at the end as at the beginning of the accounting period. This is achieved by making an allowance – as production cost – for using up national wealth, whether produced or non-produced. As a consequence, new indicators of net saving, net capital accumulation and 'more' sustainable income are generated.

The term 'more' refers to the fact that comprehensive assessments of sustainability would have to consider, further types of capital, notably human and institutional capital. The values of functioning or decaying institutions of law and order and of increasing or decreasing quality (productivity) of labour are difficult to assess. Only tentative attempts have been undertaken to incorporate human capital in the national accounts (van Tongeren and Becker, 1995). Also, *ex-ante* analysis of sustainability would have to take further effects of technological progress, changes in consumption patterns (lifestyles), discovery and imports of natural resources, and substitution among production factors into account (Bartelmus, 1994a: 70). The roles of human and institutional capital, technological progress, substitution and change in lifestyle in sustaining growth and development is a rich field for further research – an issue beyond this paper on the *measurement* of environment-economy interaction.

The extension of Hicksian individual income sustainability to national income, in terms of produced and non-produced natural capital maintenance, avoids the quite fruitless discussion of sustainability as non-declining welfare. Economic welfare has been typically operationalized in terms of final consumption and, in the field of environment, of demand for natural amenities. The SEEA focuses on the easier-to-measure supply and maintenance of environmental services to the economy. Figure 1 illustrates the demand for welfare generating goods and services from the economy and the environment in the right-hand circle. The supply of environmental services is reflected in the source and sink functions at the *immediate* interface between the economy and the environment. This is a further advantage of environmental accounting, since environmental effects can be directly associated in this manner with causing economic activities - an important requirement for targeted policy responses.[4]

2. Approach: extending the system boundaries

2.1 Asset, production and consumption boundaries

The preceding section showed how sustainability criteria open up the self-contained, market-transaction-based accounting system for the incorporation of natural assets. Expanding the asset boundaries of national accounts for the sake of obtaining measures of more sustainable economic performance is thus a logical way of accounting for the environmental impacts of economic activity.

There are, however, other boundaries in national accounting whose extension was proposed for purposes of environmental accounting. The most important is the production boundary as it determines also the consumption boundary for household activities. The production boundary is based on the fundamental principle of accounting for market transactions. Reference is made to the use of labour and capital inputs in transforming goods and services into outputs, "destined for markets, whether for sale or barter" (CEC *et al*., 1993: para. 1.20). Excluded from this definition are domestic services for own consumption by households, and natural processes, which are not under the managerial control of institutional units such as growth of fish in the ocean, precipitation, geological build-up of minerals and decomposition of pollutants.

There has been a suggestion for introducing an additional "nature production account" which measures environmental damage as input into the production of environmental services (Peskin, 1989). Household production/consumption and its environmental cost, and nature's production of environmental services are also discussed in the SEEA for "opening a window on further analytical applications" (United Nations, 1993: para. 85). However, these extensions were never implemented in actual country studies of the SEEA. Another example of a partial extension of the production boundary is the US study of integrated environmental and economic accounting (Bureau of Economic Analysis, 1994). The study treats the discovery of mineral deposits as capital formation and considers mineral resources as a produced asset.

The problem with modifying the concept of production is that it destroys the fundamental accounting identity between the value of income generated, value added, and income used for purchases of capital and consumption goods and services. Measures of income and its distribution, (un)employment, inflation and market equilibrium are blurred by changing the transaction-based production boundary in national accounts (CEC *et al*., 1993: paras 1.21,22).

The pragmatic approach to SEEA implementation as reflected in its operational manual (United Nations, in prep.) is therefore to extend the asset boundary only. The production and consumption boundaries are maintained while allowing for the introduction of natural assets and asset changes in both the asset and production accounts. This is achieved through the following steps:

- the transfer of assets from the environment to the economy – accounted for as 'other change in volume' in the asset accounts: production and income accounts are not affected;
- costing permanent, i.e. non-sustainable, depletion or degradation of 'economic' (in the SNA sense, see Box 2) assets: the values of depletion and degradation are shifted from 'other changes in volume' of the conventional asset accounts to the production and income accounts as natural capital consumption;
- accounting for 'non-economic' or 'environmental' asset stocks in physical terms only, but applying a maintenance cost valuation to permanent, i.e. non-sustainable, losses of environmental functions of waste absorption and other environmental services.

> **Box 2: Asset definition**
>
> The *economic asset* definition of the SNA includes already all natural assets "over which ownership rights are enforced by institutional units, individually or collectively, and from which economic benefits may be derived" (CEC *et al*., 1993: para. 10.2). These natural assets can be produced such as agricultural products or non-produced such as land, mineral deposits or forests in the wilderness. Changes in the availability of economic, non-produced assets, resulting from depletion or degradation, are accounted in the SNA as "other changes in volume". The SEEA shifts the value of depletion and degradation as "cost" into the production and income generation accounts.
>
> Implicitly, *environmental assets* are all those non-produced natural assets that do not function as providers of natural resource inputs into production. They supply environmental services of waste absorption, ecological functions such as habitat or flood and climate control, and other amenities such as health or aesthetic values.

The distinction between economic and environmental assets is at the heart of environmental accounting. It determines the additional information on the environment to be incorporated in the extended accounts. Box 2 describes how environmental assets can be defined as non-economic natural assets, using the SNA definition of economic assets.

Figure 2 shows in a simplified manner how the SEEA is developed as an expansion of conventional stock (asset) and flow (supply and use) accounts. Environmental components are added by incorporating environmental assets and asset changes in the shaded vertical column of the asset accounts. At the same time, natural resource depletion and environmental quality degradation are reflected as additional environmental costs in the use accounts (as indicated in the shaded row of natural asset use). Environmental costs reflect the consumption of natural capital and are therefore recorded in both the asset and flow accounts. Expenditures for environmental protection are a social response to environmental impacts. They are shown as 'thereof' elements of conventional aggregates.

2.2 Accounting identities and environmentally adjusted aggregates

The inclusion of natural assets and asset changes in national accounts permits the compilation of environmentally modified aggregates. Summing up the rows and columns of Figure 2 obtains most of these aggregates, as shown in Figure 3. The aggregates can thus be presented as the sum totals and elements of the following accounting identities:

- supply-use identity:

  $$O + M = (IC + EC) + C + (CF – EC) + X$$

  indicating that the supply of goods and services produced (O) and imported (M) equals their use in intermediate (IC) and final consumption (C), capital formation (CF) and export (X). Note that environmental costs (EC) are added to intermediate consumption (IC) as additional cost and deducted from environmentally adjusted capital formation, thus maintaining the supply-use identity;

- value-added (environmentally adjusted) identity for industry i:

  $$EVA_i = O_i - IC_i - CC_i - EC_i = VA_i - EC_i$$

  describing value added generated by an industry i (EVA_i) as the difference of output (O_i) and cost, including intermediate consumption (IC_i), fixed capital consumption (CC_i), and environmental depletion and degradation (EC_i);

- domestic-product (environmentally adjusted) identity for the whole economy:

  $$EDP = 3EVA_i - 3EC_h = NDP - EC$$
  $$= C + CF + X - M - CC - EC$$

  defining Environmentally-adjusted net Domestic Product (EDP) as the sum of environmentally adjusted value added of industries, with a further deduction of environmental costs generated by households (EC_h). Alternatively, EDP can also be calculated as the sum of final uses of consumption (C), environmentally adjusted net capital formation (ECF = CF – CC - EC) and the balance of exports (X) and imports (M). Environmentally-adjusted net Capital Formation (ECF) is an indicator that can be used for demonstrating the non-sustainability of economic performance (see section 3.1, below).

The incorporation of asset balances in Figures 2 and 3 adds another set of identities relating opening and closing stocks. They explain the changes in the value of stocks during the accounting period as produced and natural capital consumption (CC and EC) and other changes in assets.[5] The stocks of economic and environmental assets are measures of wealth, which reflect the endowment of a country with economic and environmental assets at the beginning and end of the accounting period.

Figure 2. SEEA: Flow and Stock Accounts with Environmental Assets

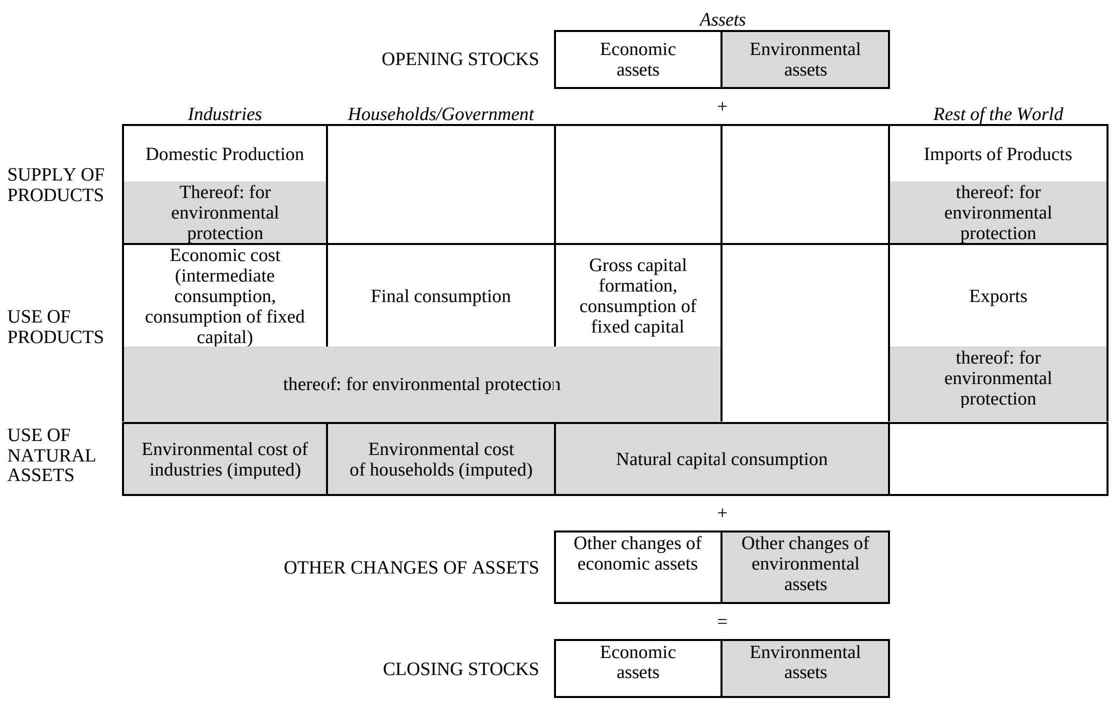


Figure 3. Environmentally adjusted accounting indicators

			OPENING STOCKS: Economic assets	Environmental assets	
			+		
	DOMESTIC PRODUCTION (industries)	FINAL CONSUMPTION (households, government)	CAPITAL FORMATION	CAPITAL ACCUMULATION	REST OF THE WORLD
SUPPLY OF PRODUCTS	Output (O_i)				Imports (M)
USE OF PRODUCTS	Intermediate consumption (IC_i)	Final consumption (C)	Gross capital formation (CF)		Exports (X)
USE OF FIXED CAPITAL	Fixed capital consumption (CC_i)		Fixed capital consumption (-CC)		
Value added (VA), NDP	$VA_i = O_i - IC_i - CC_i$ NDP = 3VA_i				
USE OF NATURAL ASSETS (depletion and degradation)	Environmental cost of industries (EC_i)	Environmental cost of households (EC_h)	Natural capital consumption (-EC)		
Environmentally-adjusted indicators	$EVA_i = VA_i - EC_i$ EDP = 3EVA_i - 3EC_h		ECF = CF - CC - EC		
			+		
			Other changes of economic assets	Other changes of environmental assets	
			=		
			CLOSING STOCKS: Economic assets	Environmental assets	

2.3 Pricing the priceless: methods and limits of monetary valuation

Putting a monetary value on natural assets and asset changes, even if they are not traded in markets, is a prerequisite for establishing most of the above-described accounting identities and indicators. As discussed in section 3.3, physical accounts underlying the monetary ones are an important tool of environmental management but do not possess their aggregative power. Monetary valuation is indeed the only possibility to fully integrate environmental concerns into the economic accounting system while ensuring consistency of ‘green’ with conventional economic indicators. However, the imputation of monetary values, which were not necessarily observed in market transactions, has been criticized not only by environmentalists but also by more conservative national accountants. The following reviews, therefore, briefly the three commonly proposed valuation techniques as to their capability of assessing environmental impacts and repercussions.[6]

Market valuation, as the name suggests, provides values that are closest to prices observed in the market. It is usually applied to economic assets of natural resources though traded pollution permits could also generate a market value for environmental waste absorption capacities. In principle the economic value of natural assets can be derived from the – discounted – sum of net returns obtained from their use in production. It is at this value that a natural asset such as a mineral deposit or a timber tract would be traded if a market existed for the asset. Market valuation techniques are also applied to changes in asset values, caused by depletion, i.e. their non-sustainable use. These value changes represent losses in the income-spinning capacity of an economic asset. Depletion cost allowances reflect thus a weak sustainability concept, calling for their reinvestment in any income-generating activity.

Box 3 indicates how different valuation techniques may reflect different degrees of sustainability of production and income generation.

Given the problems of projecting future net returns, several simplifying valuation techniques were advanced, notably the net price valuation (see e.g. Repetto *et al*., 1989*)* and the user cost calculation (El Serafy, 1989). The net price method makes use of the Hotelling assumption of compensating net price and discount rate increases to dispense with discounting future net returns. The user cost is calculated as a part of the net return from the exploitation of a finite resource, such as a mineral deposit, which through reinvestment would create a perpetual income stream. It can be shown that this allowance is a simplification of the net present value, assuming constant net returns over the lifetime of the resource (Hartwick and Hageman, 1991).

Maintenance valuation permits the costing of losses of environmental functions that are typically not traded in markets. Dealing only with economic assets, which conveniently supply marketed products, would reduce drastically economic analysis concerned with scarce goods and services, whether traded in markets or not. Notably in industrialized countries, environmental externalities of pollution can indeed be of far greater importance than natural resource depletion. The SEEA defines maintenance cost as those that "*would* have been incurred if the environment had been used in such a way as not to have affected its future use" (United Nations, 1993: para. 50).

Maintenance costs refer to the – missed – opportunity costs of avoiding the environmental impacts caused during the accounting period. Of course, these costs are hypothetical since environmental impacts did occur. They are used, however, to weight the environmental impacts in money terms for assessing the social environmental (expenditure) costs generated by different economic agents. Those agents did not 'internalize' these costs into their budgets but *should* have done so from society's social costing point of view. Actual internalization, brought about for instance by means of fiscal disincentives (see section 3.2.2), would of course change production and consumption patterns. The ultimate effects of internalization could be modelled for determining hypothetical aggregates such as an "analytical green GDP" (Vu and van Tongeren, 1995) or an "optimal net domestic product with regard to environmental targets" (Meyer and Ewerhart, 1998). Maintenance costs reflect a 'strong' sustainability concept as they measure the outlays required for the long-term conservation of environmental assets, beyond natural regeneration or replenishment (see Box 3).

Contingent valuation was proposed for green accounting (Peskin, 1989); United Nations, 1993: paras 320-321) but is hardly applicable in the practice of national environmental accounting. Together with other demand-side valuations this technique refers to the ultimate welfare effects (damages) of environmental impacts which are quite impossible to trace back to causing agents and the period of time when the impacts occurred. Contingent valuations are also inconsistent with market prices because of their inclusion of consumer surplus and face well-known problems of free-rider attitudes and consumer ignorance. Mixing these "cost-borne" valuations with "cost-caused" (maintenance cost) valuation creates aggregates which are neither performance nor

Box 3: Sustainability and valuation

Different valuations applied in the SEEA reflect strong and weak sustainability to a differing degree. The commonly applied *net-present-value and net-price methods* assess depletion as the value change in a particular asset from loss in its income-generative capacity. This can be seen as a call for asset maintenance as far as possible within the production line of the particular enterprise – not necessarily a very strong sustainability notion, since diversification of the enterprise through reinvestment in other production processes remains a possibility. The so-called *user cost allowance*, on the other hand, focuses on income maintenance without restriction as far as investment of the user cost in (physical or financial) assets is concerned. It reflects weak sustainability in that it aims at overall income preservation, irrespective of where and how income may be generated. A more conservationist view, i.e. strong sustainability, of environmental waste absorption capacities, is taken by *maintenance costing*, albeit allowing for substitution if alternative production and consumption processes can be found (see Bartelmus, 1998).

welfare measures and quite impossible to interpret (Bartelmus, 1998: 295).

Conventional national accountants and economists, especially in industrialized countries, have been quite recalcitrant in implementing environmental satellite accounts in monetary terms. While some now favour the incorporation of natural resource depletion as cost into the conventional accounts (Hill and Harrison, 1995), many consider the costing of environmental externalities a matter of modelling (e.g. van Dieren, 1995; Vanoli, 1998). ‘Official’ statisticians seem to believe that they might lose some of their long-standing goodwill, if they let in controversial concepts and valuations, even through the backdoor of supplementary ‘satellite’ systems.[7]

As a result, a number of relatively timid approaches of mixed physical and monetary accounting have now been adopted, mostly in Europe. The prototype Dutch NAMEA (de Haan and Keuning, 1995) refrains from monetary valuation of environmental impacts by simply allocating these impacts (mainly emissions) to causing economic sectors and juxtaposing them next to the conventional economic (supply and use) aggregates. While this approach facilitates the allocation of physical impacts to causing agents, it fails in aggregating environmental impacts as cost. Environmental costs and benefits generated during the accounting period can thus not be compared at the national or sectoral levels. To improve on this situation, i.e. to enhance the policy relevance of the physical data, the same authors combined different environmental impacts by means of “environmental policy theme equivalents” (Keuning and de Haan, 1998). However, even these aggregates suffer from limitations in selecting and defining the themes and their equivalent factors which still do not permit inter-theme comparisons.

Other country projects, especially in developing countries, addressed quite successfully both natural resource depletion and environmental degradation (Uno and Bartelmus, 1998). These studies demonstrate the feasibility of environmental accounting for both natural resource depletion and environmental degradation. They might serve as an incentive for similar studies in industrialized countries where pollution is of much greater significance then resource depletion.

Monetary valuation of environmental impacts in a national accounting system can achieve a high degree of data integration. However, with increasing distance of environmental effects from economic activity and output monetary valuation becomes controversial if not meaningless. Effects on human welfare such as health, inter- and intra-generational equity, loss of cultural patrimony, security or political stability are difficult to quantify in physical and quite impossible in monetary terms. The possible use of physical accounts and indicators in assessing the overall sustainability of a broad concept of ‘development’ is briefly discussed in sections 3.3 and 4.

3. Policy uses of green accounting

The worry of national accountants about getting drawn into value/assumption-laden ‘analysis’ is manifest in the generalities of the two-page (out of about 700 pages) discussion of the “uses of the SNA” (CEC *et al*., 1993: 6-8). This may also reflect the difficulty of pinning down concrete policy uses for a multi-purpose statistical system serving a large variety of decision makers. Environmental accountants are no exception, and rare are the cases where data producers and users sat together to share their knowledge about policy needs and new data concepts of green accounting.[8]

Environmental accounts, just as conventional accounts, are to facilitate the diagnosis of past economic performance and the formulation of policies responding to diagnosis. In light of the above-described rationale for environmental accounting, the following focuses on:

- the assessment of the sustainability of a nation’s past economic performance, taking account of environmental impacts and repercussions;
- the use of environmentally adjusted economic indicators in policy analysis and formulation;
- the use of physical accounts in environmental management and policy.

3.1 Diagnosis: is growth sustainable?

Interaction between environment and economy was found to be the cause for non-sustainabilities in growth and development. Measuring the sustainability of economic performance is therefore the main objective of integrated environmental and economic accounting. To this end, the notion of sustainability was operationalized as produced *and* natural capital maintenance for continuing production and income generation. In principle this allows the measurement of sustainable performance and growth, either as non-declining net output or as non-reduced capital input into production, i.e. non-negative capital formation.

Net output (and corresponding income generation) and capital formation play key roles in conventional economic accounting and analysis. A similar significance can be assumed for their environmentally adjusted counterparts, EDP and ECF. However, the analytical road from capital maintenance to income preservation is not without hurdles, including:

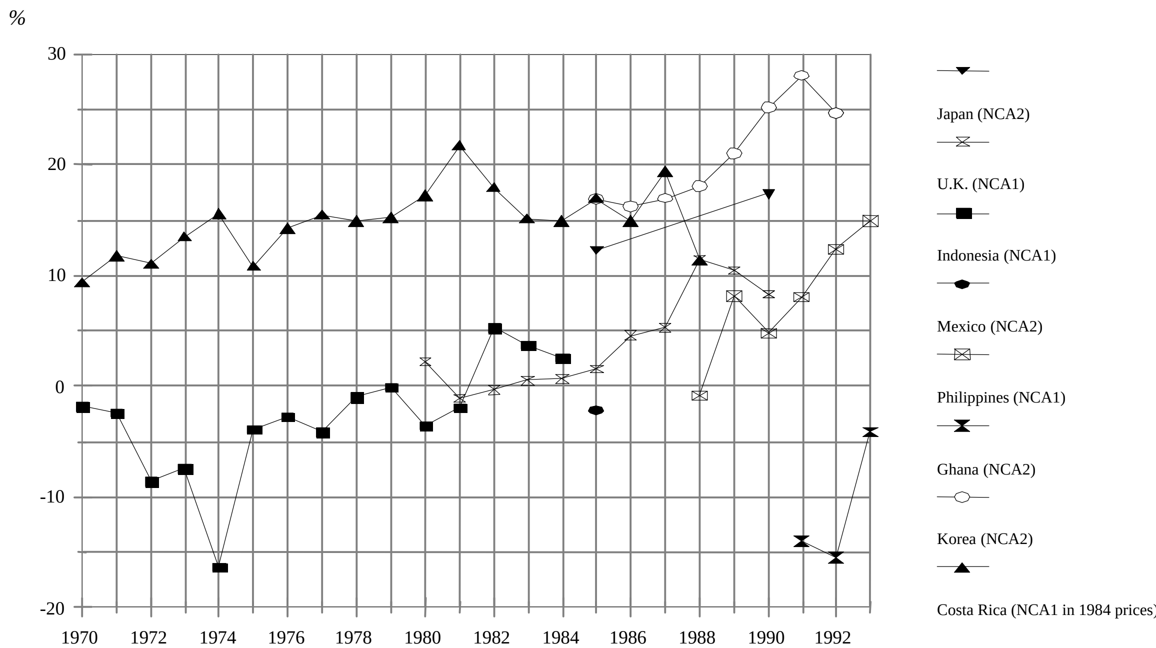
- the possibility of substitution among production factors, giving rise to the distinction between strong (natural capital conserving) and weak (overall capital and income maintaining) sustainability;
- technological progress in capital-saving production processes;
- change in consumption patterns, which may bring about changes in production patterns and corresponding capital use.

Empirical studies mostly neglected possible 'complementarities' in capital use. For instance, the Philippine environmental accounting project (Domingo, 1998) made an allowance for natural capital depreciation which assumes by and large weak sustainability in valuing depletion at net-prices and strong sustainability in maintenance costing of degradation (see Box 3). The project thus found that sustainability of economic growth could not be rejected for the country, at least for the period under consideration (1988-1994): EDP has grown, though moderately, and ECF was positive in each year (except for the first year, see Fig. 4). As mentioned above, positive ECF may hide complementarities that could make growth non-sustainable in the long run.

Figure 4 shows 'confirmed' non-sustainability in the sense of negative ECF only for Indonesia, Ghana and Mexico. Despite some attempt at harmonization, the results reflect the use of different concepts and methods; they also suffer from undercoverage and underestimation (Bartelmus, 1997: 331/332). Rough World Bank (1997) estimates seem to indicate widespread non-sustainability for Africa & in terms of "genuine savings" which is similar to ECF. However, the validity of the World Bank estimates has already been questioned by more detailed studies (Auty, 1997).

Multi-purpose national accounts facilitate of course much broader economic analysis than just the scrutiny of production and capital accumulation. Beyond production and income generation, the accounts provide detailed records of income distribution and use, financial transactions, and asset (stock) accounts and balance sheets. It is beyond this paper to describe in detail all the possible uses of the numerous stock and flow indicators covered in an extended national accounting system. Table 1 lists thus simply some of the monetary stock and flow indicators that seem to be obvious candidates for environmental adjustment. The synoptic illustration of their uses in the assessment of economic and related environmental conditions is to lead us, albeit eclectically, into further discussion of the role of 'green' indicators in policy formulation.

Figure 4. Net Capital Accumulation[a] in per cent of NDP



Source: P. Bartelmus, "Whither economics? From optimality to sustainability?", *Environment and Development Economics* 2 (1997).
Note: [a] Net capital accumulation (NCA) is defined as net capital formation minus environmental cost; NCA1 refers to net capital accumulation covering natural resource depletion costs only; NCA2 covers depletion and degradation costs.

3.2 Policy formulation: steering by 'eco-nomic' variables

National accounts facilitate policy making either through the direct use/interpretation of accounting indicators (as described in Table 1) or indirectly through modelling future developments and policy scenarios. Direct use has the advantage of avoiding the analytical straightjacket of assumptions and simplifications inherent in modelling while fully reflecting the priorities, knowledge and experience of the decision maker. Modelling on the other hand makes use of the accounting indicators as variables and parameters in a more rigorous and transparent format than the intuitive data interpretation by policy makers.

For illustrative purposes, the following focuses on the two salient features of green accounting, natural wealth/capital and environmental cost (see Table 1). Natural capital (CAP_n) and changes in capital stock ($\in CAP_n$) are important macro-policy variables.[9] On the other hand, depletion and degradation costs can be directly related to the microeconomic (production and consumption) behaviour of economic agents.

Table 1. Policy analysis of green accounting aggregates

Environmentally adjusted indicators		**Policy analysis**	
		Macro-analysis	*Micro/meso-analysis*
Stocks and change in stocks	CAP_n = natural capital	Natural wealth categories; comparison with total economic capital and wealth; portfolio analysis of development finance; debt servicing capacities of natural resource dependent countries	Distribution of natural wealth among economic sectors (property rights, equity, distribution policy)
	$\in CAP_n$ = changes in natural capital stock	Causes of stock changes: exploitation, growth, land use, natural disasters etc.; environmental-economic policy trade-offs	Changes in capital stock by causing agents (industries and households)
	$EDP/CAP+CAP_n$ = environmentally adjusted capital productivity	Comparison with conventional measures of (capital) productivity	Comparison of conventional and environmentally adjusted capital productivity; sectoral investment policy
	ED = environmental debt (accumulated environmental cost)	Liability of past to future generations (enhancing inter-generational equity)	
Flows	EDP = environmentally adjusted net domestic product	"More" sustainable indicator of economic performance and growth (per capita, constant prices); score keeping of policy success/failure; comparison of growth rates; ranking of countries	Environmentally-adjusted value added: net (of environmental cost) indicator of economic performance and structure
	Ratios per EDP (budget deficit, trade and trade balance, debt, consumption, environmental protection expenditure etc.)	National and international comparative analysis, and policies of trade, debt, consumption, saving, investment etc.; modelling import and export of sustainability	
	EC = environmental depletion and degradation costs (total EC and as per cent of NDP)	Assessment of social cost that should be incurred to achieve sustainability in economic performance and growth; international comparison; rent capture for reinvestment; modelling 'optimal' EDP.	Costs to be internalized into the budgets of households and industries; initial level of fiscal (dis)incentives for changing production and consumption patterns; scenario modelling
	ECF = environmentally adjusted capital formation	Sustainability of economic growth	Sectoral breakdown of 'truly net' capital formation for reform of investment policy
	S_g = genuine saving	Domestic saving available for capital formation after environmental costing (growth/investment policy)	
	EPE = environmental protection expenditure (current, capital expenditures, green taxes, etc.)	National environmental policy response (by environmental area); employment policy (generation of employment in protection industry)	Environmental responses by economic sectors; green business opportunities; assessment of eco-efficiency of economic performance; competitiveness of industries

3.2.1 Natural wealth maintenance: enhancing the sustainability of economic growth

The availability (stock) of productive wealth denotes the baseline for the long-term growth potential of an economy. A declining capital base would alert to limits of growth nationally, internationally and globally - a topic that has preoccupied environmentalists and environmental economists alike, at least since the Club of Rome study.[10]

Besides alerting to possible transgression of ultimate limits to growth, extended monetary asset accounts assess the relative significance of different economic assets, whether produced (fixed) or non-produced (natural). Long-term plans and policies of economic growth can make use of such assessment for setting priorities for capital formation and regimes of natural capital exploitation. The World Bank (1997: 28) even considers comprehensive wealth assessment as a new model for “development as portfolio management”. Furthermore, productive and financial growth potentials are important indicators for steering technical assistance and public and private capital flows into the most promising channels of international cooperation.

For policy action, beyond priority setting, the asset accounts can be further broken down by industrial activity. This permits productivity analysis “before and after” incorporation of natural capital. At least one empirical study (Mexico: see van Tongeren *et al*., 1991) showed large differences in conventional and green capital productivity, especially for primary production. Clearly this would call for significant changes in sectoral investment policies. The use of fiscal incentives and disincentives for natural-capital-saving or -wasting industries is discussed below as a micro-level policy instrument.

It is doubtful if the above-described uses of asset accounts warrant a paradigmatic shift from flow to (capital) stock analysis as advocated by the World Bank (1997: 19). Static pictures of growth potentials have their uses but are probably less important than examining what a nation has actually done with its wealth during a period of time. As this period happens to be one year in most national accounts, their use has been mostly for short- and medium term-analyses of market equilibrium. Some have argued that short-and medium-term stability is a prerequisite for environmental preservation (Gandhi and McMorran, 1996), implicitly relegating environment-economy interaction to long-term planning. A recipe of business as usual for short-lived administrations?

Green accounts should help to shed light on sweeping policy statements like the above on short- vs. long-term action or inaction. Two scenarios can be conceived. The first is the case of confirmed non-sustainability, reflected in declining EDP and negative ECF; the second is the case of EDP growth and positive ECF.

In the first case we can make use of the accounting capacity for systemic classification. The distinction of different categories of natural and produced capital and the allocation of their consumption to different economic sectors allows to put the blame of non-sustainability on (1) the consumption of fixed or natural capital and their components and (2) on different sectors that did not account for their capital use and/or were unwilling or unable to reinvest depreciation allowances for capital maintenance. In this manner policy pressure points for the encouragement of capital maintenance through regulatory measures or market instruments (see below) can be identified.

As already discussed, positive ECF does not ensure sustainability if significant complementarities in non-produced and non-regenerative natural capital exist. The search for such complementarities can only be successful if, again, we break down capital into different categories and identify the capital users/investors. Once use of non-substitutable natural capital has been identified and measured, regulatory action such as a logging ban or exploitation quotas could ensure its sustainable or socially desirable use. Such use would not exceed nature’s self-restoring capacity (through natural growth or replenishment) unless the government is willing to sacrifice future generations' needs for those of the current one. Alternatively, market instruments could be used to achieve similar goals, possibly in a more efficient manner.

3.2.2 Accounting for accountability: prompting cost internalization

The above discussion of natural 'economic' capital maintenance referred already to allocation of depletion costs to the exploiters of natural resources. This cost allocation could be enforced either by direct regulation ('command and control') or by using so-called 'market instruments' of cost internalization. This applies even more so to non-economic, environmental capital maintenance.[11] Market instruments are deemed to be more efficient in dealing with external effects of production and consumption than top-down market intervention. The reason is that economic agents are given different options of dealing with environmental impacts, adapting production and consumption processes, paying environmental charges and depletion fees, or purchasing pollution permits. Drawbacks of market instruments are their time-lagged efficacy, high monitoring and enforcement costs, shortsightedness of individuals and general resistance to taxation.

Theoretically, internalized degradation costs should reflect the ultimate welfare losses generated by environmental damage (to health and well-being), i.e. the costs *borne* by individuals. Once internalized, an optimal (maximum) and sustainable net national product would be obtained under perfect conditions (Dasgupta and M≅ler, 1991; Hamilton and Atkinson, 1995; Solow, 1974; Hartwick, 1977). As discussed above, such damage costing is not practicable in environmental accounting. Instead, maintenance costing is applied which assesses the cost of hypothetically avoiding actual impacts on the environment. Such costing permits to allocate the macroeconomic social (expenditure) costs generated by the degradation of a public good to those who *caused* the degradation. In other words, polluters can be made "accountable" for their environmental impacts, in line with the popular polluter-pays principle.

Environmental maintenance costs are thus those at which the market instruments should be set, initially and pragmatically. They refer to the best available technical solution which could have prevented environmental impacts or reduced them to acceptable environmental standards. The ultimate effects of possible cost internalization on the economy, i.e. their final incidence onto other market partners, would have to be modelled with the usual assumptions about price elasticities and production and consumption functions. Further assumptions about environmental targets set, for instance, in dynamic input-output models, permit to assess the consequences of internalization policies for the whole economy at different target levels and with different market instruments (see e.g. Meyer and Ewerhart, 1998).

The polluter-pays principle is myopic, however, in that it assigns the responsibility exclusively to those who directly cause environmental impacts. This is an unambiguous approach for cost allocation in environmental accounts. It can be argued however that responsibilities on the supply side should be shared with the demand for goods whose production involves a joint supply of environmental bads. A further analytical use of environmental accounts and input-output tables is therefore to make the connection between the supply of environmentally harmful goods and services and their final uses.

At the international level, exports and imports of natural resources and products made in polluting processes can provide an indication of imports and exports of sustainability by the national economy. Increasing globalization of economic activity ν through trade liberalization Σ calls indeed for full-environmental-cost pricing by everyone to avoid distortions in competitiveness. Comparable environmental cost assessments across countries in a standardized accounting framework are a means of identifying and addressing such distortions.

3.2.3 Monitoring policy response: environmental protection expenditures

The implementation of environmental protection measures, prompted by regulations or market instruments, requires budgetary allocations and expenses by government, non-governmental institutions, enterprises and households. These environmental expenditures are in principle already covered in the conventional accounts.[12] Proposals for deducting them from GDP as "defensive" (Leipert, 1989; Daly, 1989b); see also the Genuine Progress Indicator, (mentioned in Box 1), are to obtain a better measure of economic welfare. They are methodologically questionable.[13]

At first sight the total of environmental expenses seems to be an indicator of the national environmental protection effort, which could be compared to either the total national economic effort, i.e. GDP, or to other countries' environmental efforts. The mixture of current and capital expenditures is, however, not directly comparable to NDP or GDP, requiring the estimate of value added for a hypothetical protection 'industry'. International comparisons, on the other hand, are hampered by differences in 'environmental debt', i.e. the accumulated environmental damage, of countries.

Perhaps more useful are evaluations of the efficiency of environmental activities in different protection fields, comparing expenditures with changes in the state of the environment. This is not an easy task, given the time-lagged reactions of the environment and human health and welfare to particular protection measures. All in all, despite their popularity, the policy use of information on environmental protection expenditures is far from obvious.

3.3 Physical accounting - a tool of environmental management

The above analysis focused on the use of environmentally adjusted monetary aggregates to capture the role of nature in economic policy. Underlying the monetary aggregates are physical stocks and flows. As already mentioned, physical environment statistics were adopted by some national accountants to avoid the controversial valuation of non-market phenomena. Indeed, the organization of physical data in an accounting framework has its own uses, beyond this evasive argument.

Box 4 gives a brief overview of the commonly advanced physical accounting systems. They can be directly related to the simple real-world model of Figure 1, which depicts source and sink functions of, and material throughput through, the environment. Besides these direct interactions between environment and economy, intra-environmental (nutrients, pollutants) flows and health effects of pollution are typically the subject of environmental statistics and indicators organized in their own frameworks.[14]

Owing to their use of different units of measurement, physical accounts do not have the aggregative power of price-weighted monetary indicators. However, policy makers prefer highly aggregated indices to get the picture of the forest rather than being bogged down in looking at trees. Several methods of overcoming this deficiency and making physical indicators more policy relevant have been advanced. The use of equivalent factors (oil, greenhouse gas equivalents etc.) permits aggregation of different, but still somewhat related natural resources and pollutants. For more comprehensive aggregation into compound indices other types of weighting were suggested. Equal weighting is applied, for instance, in the popular Human Development Index (UNDP, 1997) and the sums and balances of material flows, pioneered by the German Wuppertal Institute (Schηtz and Bringezu, 1993; Bringezu, 1995). 'Expertocratic' weights, reflecting the priorities of "those who represent best environmental policy" were proposed for use in the European Environmental Pressure Index Project (Jesinghaus, 1998).

Adding up material flows in tons seems to be less subjective, even if the relative importance of resource losses and different emissions of pollutants cannot be assessed in this manner. The result is a measure of material throughput, weighted by weight. Such throughput can be viewed as:

- a measure of pressure from the economy on the environment; or
- a measure of "scale"of total resource flow and, by extension, economic activity.

Environmental pressure is the result of removing natural resources and accumulating wastes and pollutants. If notions of (non)sustainability, i.e. depletion and degradation, are applied only permanent changes in natural assets should be accounted as discussed above. At the optimal level, scale analysis supposedly takes over allocative economics, since critical (carrying capacity,

Box 4: Physical environmental accounting

Three physical accounting approaches (and variations thereof) have been commonly advanced and applied. They can be categorized as natural resource accounting (NRA), environmental input-output tables (EIOT) and material flow accounts (MFA).

NRA describe the stocks and use of stocks of different natural resources during the accounting period in a fairly aggregate fashion. They were pioneered by Norway (Alfsen, Bye and Lorentsen, 1987) and further developed by France (Theys, 1989). NRA are typically measured in different units of weight, volume, energy equivalent etc. They have been further developed by the SEEA as an integral part of its asset accounts.

It is still an open issue if so-called *land use accounts* are a part of NRA, a separate accounting system or part of environmental statistics (frameworks). The separate consideration of land use accounts is favoured by those that see them as an instrument of detailed assessments of land quality, biodiversity and land use intensity (Radermacher, 1998; Stott and Haines-Young, 1998).

MFA are a physical response to monetary measures of the sustainability of economic activity, focusing on material throughput as a measure of environmental pressure from the economy. They describe the extraction, production, transformation, consumption and accumulation of chemical elements, raw materials or products (Steurer, 1997) and may or may not include hidden "ecological rucksacks" of materials that are not incorporated in a particular economic output (Spangenberg *et al.*, 1997). For aggregation purposes, the flows of materials (and energy) are usually expressed in one physical unit, weight.

Physical *EIOT* and mixed accounts like NAMEA (Keuning and de Haan, 1998) are variations of MFA in an input-output or make-use format. A physical input-output table prepared by German statisticians (Stahmer, Kuhn and Braun, 1997), for instance, provides greater sectoral detail (49 products and 11 residuals for 58 branches and final uses). Focusing on detailed production and consumption processes, beyond sectoral breakdowns of input-output matrices, *material/energy balances* were advanced by the United Nations (1976) but were never implemented owing to considerable data requirements.

sustainability) limits of natural resource capacities and waste absorption are about to be transgressed (Daly, 1989a).

In both cases of environmental pressure and scale measurement, the specification of critical limits is critical for the interpretation of total material flow as a signal for policy response. Such response could take the fairly radical form of "replacing quantitative expansion (growth) with qualitative improvement (development)" (Daly, 1996: 1). More optimistic policies could attempt to supply "more with less", in other words aim at "dematerializing"production and consumption as a "management rule for sustainability" (Hinterberger, Luks and Schmidt-Bleek, 1997). The questions are of course how much dematerialization and where. The "Factor 4" proposal for doubling wealth while halving material input, together with a list of promising examples (Weizs≅cker, Lovins and Hunter Lovins, 1995), is an attempt at answering these questions.

Looking at the trees, i.e. at the physical detail underlying monetary aggregates, has further uses. Monitoring the state of particular ecosystems and the availability of particular natural resources is necessary for m*anagerial* decisions on resource exploitation and pollution control. The presentation of these data in an accounting format permits to link specific environmental impacts to the causing economic activities or sectors. The purpose is to take direct action against the culprits, or to identify potential culprits of environmental damage in different environmental and economic scenarios (see e.g. Keuning and Timmerman, 1995).

4. Outlook: from valuation to evaluation

The preceding section referred to the limited capability of physical accounts and indicator sets to capture the interaction between socioeconomic, cultural and political issues for purposes of integrative policy making. One way to improve the policy relevance of physical indicators is to relate them explicitly to social norms, made operational as standards or targets in all fields of interacting policy.

Introducing standards of living, limits in natural resource and carrying capacities, pollution standards, and distributional, cultural and political standards for economic activities turns the analysis of sustainability of growth into one of the "feasibility" of development (Bartelmus, 1994: 73). Feasibility in this connection means compliance of development programmes with an exogenously set normative framework of minimum and maximum standards and thresholds. Monetary valuation of costs and benefits from economic activities is replaced - at the borderline - by social *evaluation* of feasible development. Within the feasibility space, conventional economic strategies could be played out, ruled by the invisible hand of the market. Outside this space, the invisible hand needs to be replaced by the visible one of the standard setter(s): non-economic values interfere in this case with conventional economic decision making (Bartelmus 1997: 337-340).

The assessment of the limits themselves and the 'distance' of the market economy to these limits, in other words, the size of the feasibility space, is still a disputed matter. Widely differing proposals for indicators "of" and "for" sustainable development have been made, typically without any specification of the limits (see Box 1, above and Bartelmus, 1998).

Consensus building through standardization of measurement and (e)valuation would improve the rational assessment of possible limits to growth and development. Such consensus might also overcome the above-described dichotomy between environmentalists and economists. The difficulty is to foster standardization while not discouraging pluralism in methodological research and experimentation. The current revision of the SEEA under the aegis of the Statistical Commission of the United Nations, in collaboration with the so-called "London Group" of national accountants, is a significant step towards harmonizing environmental accounting methods.

References

Alfsen, K.H., T. Bye and L. Lorentsen (1987). *Natural Resource Accounting and Analysis, the Norwegian Experience 1978-1986*, Oslo: Central Bureau of Statistics.

Auty, R.M. (1997). "Sustaining mineral-driven development: Chile and Jamaica", in R.M. Auty and K. Brown (eds.), *Approaches to Sustainable Development*, London and Washington: Pinter.

Bartelmus, P. (1994a). Environment, Growth and Development - The Concepts and Strategies of Sustainability, London and New York: Routledge.

Bartelmus, P. (1994b). *Towards a Framework for Indicators of Sustainable Development*, DESIPA Working Paper Series No. 7, New York: United Nations.

Bartelmus, P. (1997). "Whither economics? from optimality to sustainability?", *Environment and Development Economics* 2: 323-345.

Bartelmus, P. (1998). "The value of nature - valuation in environmental accounting", *in* K. Uno and P. Bartelmus (1998).

Bartelmus, P. (forthcoming). "Green accounting for a sustainable economy – policy use and analysis of environmental accounts in the Philippines", *Ecological Economics.*

Brown, L.R. (1993). "A new era unfolds", in L. R. Brown *et al.* (eds.), *State of the World 1993 – A Worldwatch Institute Report on Progress Toward a Sustainable Society*, London and New York: Norton.

Bringezu, S. (1998). "Comparison of the material basis of industrial economies", in S. Bringezu, M. *et al*. (eds.), *Analysis for Action: Support for Policy towards Sustainability by Regional and National Material Flow Accounting* (proceedings of the ConAccount conference, Wuppertal, 11-12 September 1997), Wuppertal: Wuppertal Institute.

Bureau of Economic Analysis (U.S.) (1994). "Accounting for mineral resources: issues and BEA's initial estimates." *Survey of Current Business*, Washington, D.C.: BEA.

Cobb, C., T. Halstead and J. Rowe (1995). "If the GDP is up, why is America down?", *The Atlantic Monthly*, October 1995: 59-78.

Commission of the European Communities (CEC), International Monetary Fund (IMF), Organisation for Economic Co-operation and Development (OECD), United Nations and World Bank (1993). *System of National Accounts 1993* (United Nations sales no. E.94.XVII.4).

Costanza, R. *et al.* (1997). "The value of the world's ecosystem services and natural capital", *Nature* 283: 253-260.

Daly, H.E. (1989a). "Steady-state and growth concepts for the next century", in F. Archibugi and P. Nijkamp (eds.), *Economy and Ecology: Towards Sustainable Development*, Dordrecht, Boston and London: Kluwer.

Daly, H.E. (1989b). "Toward a measure of sustainable social net national product", in Y.J. Ahmad, S. El Serafy and E. Lutz (eds.), *Environmental Accounting for Sustainable Development*, Washington, D.C.: The World Bank.

Daly, H.E. (1996). *Beyond Growth, the Economics of Sustainable Development*, Boston: Beacon Press.

Dasgupta, P. and K.-G. Mäler (1991). *The Environment and Emerging Development Issues*, Beijer Reprint Series No. l, Stockholm: Beijer.

De Haan, M. and S.J. Keuning (1995). *Taking the Environment into Account: the Netherlands NAMEA's for 1989, 1990 and 1991*, Occasional Paper No. NA-074, Voorburg: Statistics Netherlands.

Domingo, E.V. (1998). "Philippines: adaptation of the United Nations system of environmental accounting", *in* Uno and Bartelmus (1998).

El Serafy, S. (1989). "The proper calculation of income from depletable natural resources", in Y.J. Ahmad, S. El Serafy and E. Lutz (eds.), *Environmental Accounting for Sustainable Development*, Washington, D.C.: The World Bank.

Eurostat (1994). *SERIEE 1994 Version,* Luxembourg: European Communities.

Fisher, I. (1965). *The Nature of Capital and Income,* New York: Kelley.

Gandhi, V. P. and R. T. McMorran (1996). "How macroeconomic policies affect the environment: what do we know?", in V.P. Gandhi (ed.), *Macroeconomics and the Environment*, Washington, D.C.: IMF.

Hamilton, K. and G. Atkinson (1995). "Valuing air pollution in the national accounts", in *Second Meeting of the London Group on Natural Resource and Environmental Accounting, Conference Papers,* Washington, D.C.: U.S. Government.

Hartwick, J.M. (1977). "Intergenerational equity and the investing of rents from exhaustible resources", *American Economic Review,* 67(3): 972-974.

Hartwick, J. M. and A. P. Hageman (1991). "Economic depreciation of mineral stocks and the contribution of El Serafy" (report for the World Bank, July 1991).

Hicks, J. R. (1946). *Value and Capital*, 2nd ed., Oxford: Oxford University Press.

Hill, P. and A. Harrison (1995). "Accounting for depletion in the 1993 SNA", in *Second Meeting of the London Group on Natural Resource and Environmental Accounting, Conference Papers.* Washington, D.C.: U.S. Government.

Hinterberger, F., F. Luks and F. Schmidt-Bleek (1997). "Material flows vs. 'natural capital' – what makes an economy sustainable?", *Ecological Economics* 23: 1-14.

Hinterberger, F. *et al.* (1998). *Integration von Umwelt-, Wirtschafts- und Sozialpolitik,* _IN/WI Policy Paper No. 1, Wuppertal and Wien, May 1998.

Jesinghaus, J. (1998). "Tools for sustainable development: towards a system of societal performance indicators", paper presented at the Fourth International Workshop on Indicators for Sustainable Development (Prague, Charles University, 19-21 January 1998), mimeographed.

Keuning, S.J. and M. de Haan (1998). "Netherlands: what's in a NAMEA? Recent results", *in* Uno and Bartelmus (1998).

Keuning, S. and Y. Timmerman (1995). "An information system for economic, environmental, and social statistics: integrating environmental data into the SESAME", in *Second Meeting of the London Group on Natural Resource and Environmental Accounting, Conference Papers*. Washington, D.C.: U.S. Government.

Leipert, C. (1989). "National income and economic growth: the conceptual side of defensive expenditures", *Journal of Economic Issues* 23: 843-856.

Meadows, D.H. et al. (1972). *The Limits to Growth,* New York: Universe Books.

Meyer, B. and G. Ewerhart (1998). "Modelling towards eco domestic product" *in* Uno and Bartelmus (1998).

Peskin, H.M. (1989). "A proposed environmental accounts framework", in Y. J. Ahmad, S. El Serafy and E. Lutz (eds.), *Environmental Accounting for Sustainable Development,* Washington, D.C.: The World Bank.

Pezzey, J. (1989). *Economic Analysis of Sustainable Growth and Sustainable Development*, Environmental Working Paper No. 15, Washington, D.C.: The World Bank.

Radermacher, W. (1998). "Land use accounting – pressure indicators for economic activities", *in* Uno and Bartelmus (1998).

Repetto, R. *et al*. (1989). *Wasting Assets, Natural Resources in the National Income Accounts*, Washington, D.C.: World Resources Institute.

Rodenburg, E., D. Tunstall and F. van Bolhuis (1995). *Environmental Indicators for Global Cooperation*, Global Environment Facility Working Paper No. 11.

Sch≅fer, D. and C. Stahmer (1989). "Input-output model for the analysis of environmental protection activities", *Economic Systems Research* 1 (2): 203-228.

Schηtz, H. and S. Bringezu (1993). "Major material flows in Germany", *Fresenius Environmental Bulletin* 2: 443-448.

Solow, R.M. (1974). "Intergenerational equity and exhaustible resources", *Review of Economic Studies*, Symposium: 29-46.

Spangenberg J.H. *et al*. (1997). *Material Flow Based Indicators in Environmental Reporting – A Report for the EEA's Expert Corner*, Wuppertal: Wuppertal Institute.

Stahmer, C., M. Kuhn and N. Braun (1998). *Physical Input-Output Tables for Germany, 1990,* Eurostat Working Paper No. 2/1998/B/1.

Steurer, A. (1997). "Material flow accounting and analysis: where to go at a European level", in Eurostat (ed.), *Material Flow Accounting – Experience of Statistical Institutes in Europe.*

Stott, A. and R. Haines-Young (1998). "Linking land cover, intensity of use and botanical diversity in an accounting framework in the UK", *in* Uno and Bartelmus (1998).

Theys, J. (1989). "Environmental accounting in development policy: the French experience", in Y. J. Ahmad, S. El Serafy and E. Lutz (eds.), *Environmental Accounting for Sustainable Development,* Washington, D.C.: The World Bank.

United Nations (1976). Draft guidelines for statistics on materials/energy balances: report of the Secretary-General (E/CN.3/492).

United Nations (1984). *A Framework for the Development of Environment Statistics* (sales no. E.84.XVII.12).

United Nations (1993). *Integrated Environmental and Economic Accounting* (sales no. E.93.XVII.12).

United Nations (1996). *Indicators of Sustainable Development, Framework and Methodologies* (sales no. E.96.II.A.16).

United Nations (in prep.). *Integrated Environmental and Economic Accounting – An Operational Manual.*

United Nations Development Programme (UNDP) (1997). *Human Development Report 1997,* New York and Oxford: Oxford University Press.

Uno, K. and P. Bartelmus (eds.) (1998). *Environmental Accounting in Theory and Practice*, Dordrecht, Boston and London: Kluwer.

Van Dieren, W. (ed.) (1995). *Taking Nature into Account,* New York: Springer.

Van Tongeren, J. *et al*. (1991). *Integrated Environmental and Economic Accounting – A Case Study for Mexico,* World Bank Environment Working Paper No. 50.

Van Tongeren, J. and B. Becker (1995). *Integrated Satellite Accounting, Socio-economic Concerns and Modelling*, DESIPA Working Paper Series No. 10, New York: United Nations.

Vanoli, A. (1998). "Modelling and accounting work in national and environmental accounts", *in* Uno and Bartelmus (1998).

Von Weizs≅cker, E.U., A.B. Lovins and L. Hunter Lovins (1995). *Factor Four – Doubling Wealth, Halving Resource Use*, Earthscan Publications.

Vu, V. and J. van Tongeren (1995). "An analytical approach to the calculation of 'green GDP' ", in *Second Meeting of the London Group on Natural Resources and Environmental Accounting, Conference Papers,* Washington, D.C.: U.S. Government.

World Bank (1997). *Expanding the Measure of Wealth, Indicators of Environmentally Sustainable Development*, Washington, D.C.: The World Bank.

World Commission on Environment and Development (WCED) (1987). *Our Common Future,* Oxford: Oxford University Press.

World Resources Institute *et al*. (1997). *Resource Flows: The Material Basis of Industrial Economics,* Washington, D.C.: World Resources Institute.

Endnotes

[1] For instance, into the constitution of the European Union, making the transition from the more restrictive sustainability of *growth*, stipulated in the Maastricht treaty, to sustainable *development* in the 1997 Amsterdam treaties (see for a discussion of the policy implications of these treaties, Hinterberger *et al*. (1998).

[2] This crude distinction between holistic views of human activities and their environment, and mainstream (neoclassical) economic approaches to the environment-economy interface is, of course, a simplification of existing schools of thought. For instance, 'ecological economists' can be placed somewhere in between. See for a more detailed discussion of this polarization in tackling sustainable growth and development, Bartelmus (1997).

[3] There are however important differences in the Hicksian and national accounts income concepts. They are founded on differences in the definition of 'saving' and 'changes in net worth'. In the national accounts, the latter includes, in addition to saving, capital transfers, other changes in volume of assets and holding gains/losses. Those additional items would have to be deducted from Hicksian income, defined as the sum of consumption and change in net worth, to obtain the national accounts definition of disposable income as the sum of saving and (final) consumption (cf. CEC *et al*., 1993: para. 8.15). The reason for this difference is to avoid erratic fluctuation in income due to large capital transfers, natural disasters and asset price changes in recurrent national accounting.

[4] Welfare/damage estimates are quite impossible to trace back to their causing production and consumption activities because of time-lagged and synergistic effects, e.g. in the complex pollution process of emission |ambient concentration | exposure |contamination |health effects.

[5] Note that 'other changes of economic assets' includes both other (quantitative and qualitative) 'volume' changes and purely monetary 'holding gains/losses', also termed 'revaluation', due to price changes of the assets.

[6] See for a more elaborate discussion of the pros and cons of different valuations in environmental accounting, e.g. Bartelmus (1998).

[7] Satellite accounts are explicitly introduced in the SNA to enhance its flexibility and analytical capacity without overburdening the central system. They may provide additional information, use alternative or complementary concepts and provide links to physical data sources (CEC *et al*., 1993: para. 21.4).

[8] One noteworthy event of data user-producer dialogue on the results of an integrated environmental-economic accounting project took place in January 1998 in the Philippines (Bartelmus, forthcoming).

[9] Ignoring here difficult-to-assess microeconomic aspects of ownership and land tenure and their distribution.

[10] Since the Meadows *et al*. (1972) report, the discussion on the limits to growth has continued, e.g. with Daly (1989a) warning about the sinking of the overloaded planetary boat, the Worldwatch Institute (Brown *et al*., 1993) predicting the economy's self-destruction as it undermines its environmental support system, or the (new) Club of Rome report (von Weizs≅cker, Lovins and Hunter Lovins, 1995) B on a more positive note regarding technological solutions.

[11] Note that individual corporations might already account for the depletion of the natural assets they own and exploit, costing them as capital depreciation. In this case, the conventional national accounts, which record depletion of natural resources as other volume change in asset accounts only, would overstate the net value added generated by these industries. Green accounts would correct this distortion of the production

evel and structure of the economy by shifting depletion costs to the production/income generation accounts. In the case of environmental degradation (from pollution) it is less likely that these non-economic 'social' costs are already accounted for, though not impossible, as the cases of some U.S. concerns have shown (Monsanto, Du Pont, Cyanamid Cos, costing potential environmental liabilities, see Wall Street Journal of 23 March 1992).

[12] The fact that environmental expenditures are conventional transactions seems to explain their popularity with national accountants. However, the segregation of environmental expenditures as 'thereof' components of accounting aggregates (see Fig. 2) still poses difficult classification problems (see e.g. Eurostat, 1994).

[13] Defensive expenditures, sometimes called 'regrettables', are difficult to distinguish from 'desirables'. Also, simple deduction would not account for the contributions of antecedent industries (e.g. steel or parts for environmental installations). Modelling these indirect contributions could be done by means of input-output analysis (see e.g. Sch≅fer and Stahmer, 1989).

[14] Most physical environmental data have been presented in relatively loose frameworks such as the United Nations (1984) Framework for the Development of Environment Statistics (FDES) or the related frameworks for indicators of sustainable development (FISD) (Bartelmus, 1994b; United Nations, 1996). The more restrictive environmental accounts framework has the advantage of directly linking physical and monetary data, but the disadvantage of narrowing down the scope and coverage of environmental data.