



Peter Bartelmus with
André Vesper

**Green Accounting
and Material Flow
Analysis**
Alternatives
or Complements?

No. 106 • July 2000
ISSN 0949-5266

Wuppertal Papers

Wuppertal Institut für Klima, Umwelt, Energie GmbH
Division for Material Flows and Structural Change
Peter Bartelmus
Döppersberg 19
42103 Wuppertal

Tel.: 0202-2492 -132
Fax: 0202-2492 -138
E-Mail: peter.bartelmus@wupperinst.org
<http://www.wupperinst.org>

Paper originally submitted to the Klausurtagung, Vereinigung für Ökologische Ökonomie e.V. (Weimar 25-27 Oct. 1999). Comments and suggestions by Jochen Luhmann are gratefully acknowledged.

Table of Contents:

1 Introduction: getting physical?	5
2 Physical and monetary accounting: commonalities and differences	7
2.1 Rationale and approaches	7
2.2 (E)valuation: pricing the priceless and weighting by weight	11
2.2.1 Valuation methods	11
2.2.2 Linking physical and monetary approaches	12
3 First results	15
3.1 TMR of some industrialized countries	15
3.2 Green accounts: Germany and selected countries	15
4 Analysis and policy use	19
4.1 Ecological vs. economic sustainability: two sides of the same coin?	19
4.2 Sustainability strategies	20
4.3 Environmental accounts and policy making	22
Annex: SEEA Germany 1990 — First results and evaluation	25
1 Results	25
2 Evaluation	27
Notes	29

Figures and tables:

Figure 1: Environmentally adjusted accounting indicators	9
Figure 2: Material Flow Accounting (MFA)	10
Figure 3: Annual TMR per capita for the USA, Netherlands, Germany, Japan and Poland	17
Figure 4: Environmentally-adjusted net Capital Formation (ECF) in per cent of NDP	17
Table 1: Conventional and environmentally adjusted accounting aggregates: Germany 1990 (preliminary results)	18
Figure 5: Integrated Environmental and Economic Accounts for Germany, 1990	26

1 Introduction: getting physical?

Environment and economy interact. Global warming and depletion of the ozone layer from industrial and household pollution, land degradation from improper agricultural practices, loss of habitat and biodiversity from deforestation, and desertification from extending agriculture and settlements into arid lands are conspicuous examples of the impacts and repercussions between environment and economy. Opinions differ on how to measure this interaction and how to deal with it. This is despite the Rio Summit's consensus on sustainable development which seemed to provide an integrative policy paradigm. The paradigm did not work, though.

The first stumbling block is definition. The popular Brundtland notion of sustainable development as the satisfaction of current and future generations' needs is vague, as are others such as the economists' favourite of non-declining welfare: both fail to specify the ingredients and time frame of welfare or needs; nor do they indicate any particular role for the environment. No wonder, hardly comparable indices or indicators of 'true' social progress such as Human Development, Genuine Progress, Expanded Wealth or Environmental Sustainability proliferate.¹ The second obstacle to agreeing on a common strategy is a prevailing polarization among environmental and economic scientists who impose their own particular values on the counterpart field. This mutual colonization seems to continue unabatedly under the cloak of economics where environmental and ecological economists apply their own cherished tool kits in crossing the boundaries of economic analysis.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 households and enterprises. Green accounting systems are among the more systematic attempts at modifying conventional macro-economic indicators such as GDP or capital formation. Market instruments of environmental charges or tradable pollution permits are to prod enterprises and households into environmentally sound behaviour. Most environmentalists and ecological economists, on the other hand, reject 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, ecological footprints or material throughput are advanced.

Large physical indicator lists do cover a broader set of social values and amenities. They do not have, however, the integrative power of monetary aggregates generated in environmental accounting systems. But policy makers prefer highly aggregated indices to get the picture of the wood (or preferably the forest) rather than being bogged down in looking at trees. Disdaining monetary valuation, more compound indices have therefore been calculated as indicator averages, as for instance by UNDP's Human Development Index³, or by adding up the weight of materials entering the economy.

The following discusses some of the pros and cons of both physical and monetary approaches, with a view to linking or combining them. The answer to the question of getting physical or monetary? will be: both!

2 Physical and monetary accounting: commonalities and differences

2.1 Rationale and approaches

Data comparability and validity are ensured by statistical systems which provide standard concepts, methods and classifications. Rather than contributing to the proliferation of ad hoc indicators we address the physical-monetary dichotomy by focusing on two systemic approaches which appear to become international standards for data development and analysis. They are the physical Material Flow Accounts (MFA), developed by the Wuppertal Institute (WI),⁴ and the physical and monetary System of integrated Environmental and Economic Accounting (SEEA) of the United Nations.⁵ The SEEA is designed as a ‘satellite’ system of the world-wide adopted System of National Accounts (SNA)⁶ with which it maintains greatest possible compatibility. Such compatibility with a standard accounting system has not yet been achieved for the MFA but is currently tackled in our work through link-up with the SNA/SEEA.

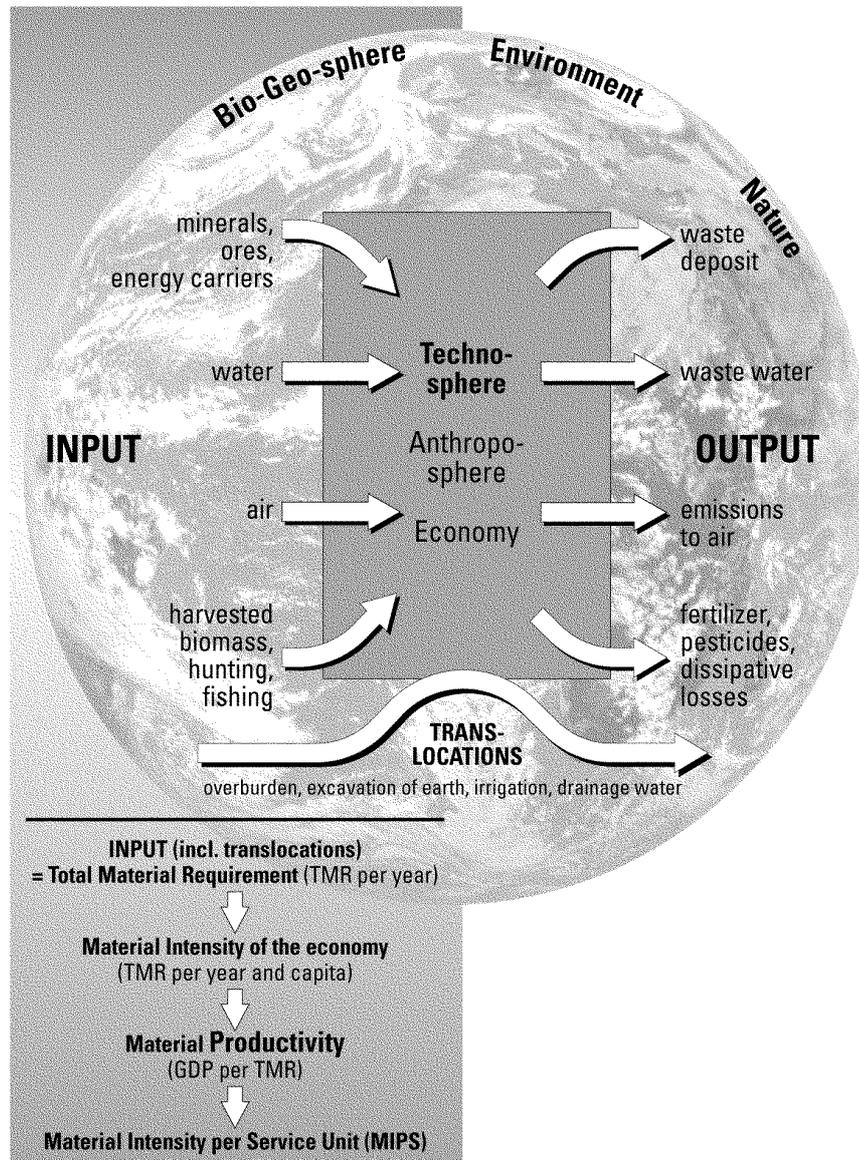
In line with their focus on physical and monetary data, MFA and SEEA also reflect different notions of the sustainability paradigm, which may be more difficult to reconcile. They can be categorized as the needs for *dematerialization* of economic activity and for the *preservation of natural capital*, in addition to produced (fixed) capital assets.

The MFA assess the use and movement of materials by means of Total Material Requirement (TMR) and Material Intensity per Service unit (MIPS) indicators. Both reflect the total use of materials as an index of material throughput through the economy, including hidden flows or ‘ecological rucksacks’⁷. For achieving sustainability of economic performance such throughput should be at a level compatible with the long-term ‘ecological equilibrium’ of the planet. Ecological equilibrium is operationalized by applying the normative notion of available ‘environmental space’, i.e. equal access to energy sources and raw materials. The result is a sustainability standard calling for halving TMR while doubling wealth and welfare: the popular notion of Factor 4.⁸ Under current production and consumption patterns, this can be translated into a Factor 10 for industrialized countries.⁹ It is recognized that such norms, which are based on reducing the total weight of materials used, are ‘unspecific’ in their attempt at reducing overall environmental pressure. On the other hand, all kinds of actual and potential

environmental impacts and welfare effects are to be captured in this manner. In this manner, a precautionary approach is applied which permits anticipating potentially disastrous and largely unknown environmental effects.¹⁰

In contrast, economic accounting does not deal with uncertainty. It is a statistical information system which measures economic performance during a past accounting period. With regard to physical depletion and degradation of natural assets, the SEEA measures only actually occurred and specific impacts of natural resource losses and pollution, generated by different economic activities. The setting of normative standards is thus avoided in principle, since the deduction of the value of natural capital consumption can be seen as compiling simply a 'net' value of production, without double-counting of (depreciation) costs. Even though capital loss was not avoided, *de facto*, the generation of funds by means of a depreciation allowance would permit re-investment of these funds for capital formation. Such accounting for capital maintenance extends the sustainability criterion of allowing for capital consumption, already built into the conventional indicators of national income, product and capital formation, to natural capital. Modified aggregates of Environmentally adjusted net Domestic Product (EDP), Value Added (EVA), Capital Formation (ECF), Cost (EC) and Wealth (in economic and environmental assets) are generated in this manner.

Figure 1 presents the main definitory accounting identities for these indicators in the SEEA format. The vertical view of the asset accounts shows changes in produced and natural wealth, overlapping the flow accounts in the areas of capital formation and capital consumption. The shaded boxes indicate flows and stocks which were conceptually modified for purposes of environmental accounting. The basic MFA concepts are described by Figure 2, in terms of physical inputs of materials and outputs of wastes and residuals; the results are indicators of TMR, material productivity, material intensity and MIPS.



UM-194e-2/93

Figure 2: Material Flow Accounting (MFA)

Source: Wuppertal Institute, (after S. Bringezu, 'Where does the cradle really stand?', in Fresenius Environmental Bulletin 8/93, p. 423, Basel, Boston and Berlin: Birkhäuser, 1993).

2.2 (E)valuation: pricing the priceless and weighting by weight

2.2.1 Valuation methods

Putting a monetary value on natural assets and their changes, even if they are not traded in markets, is a prerequisite for establishing most of the above-mentioned accounting identities and 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.¹¹

Market valuation, as the name suggests, uses prices for natural assets which are observed in the market. It is usually applied to ‘economic’ assets¹² of natural resources, though traded pollution permits could also generate a market value for ‘environmental’ assets of waste absorption capacities. Where market prices for natural resource stocks, such as fish in the ocean or timber in tropical forests, are not available, the economic value of these assets can be derived from the — discounted — sum of net returns, obtained from their potential 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 in particular 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 the reinvestment of environmental cost in any income-generating activity such as capital formation or financial investment.

Maintenance valuation permits the costing of losses of environmental functions that are typically not traded in markets. Dealing only with marketed natural resources would reduce drastically economic analysis concerned with scarce goods and services, whether traded 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”.¹³

Maintenance costs are the missed-opportunity costs of avoiding the environmental impacts caused during the accounting period. They refer to best-available technologies or production processes with which to avoid, mitigate or reduce environmental impacts. Of course, these costs are hypothetical since environmental impacts did occur. They are used, however, to weight actual

environmental impacts, generated during the accounting period by different economic agents. Those agents did not internalize these costs into their budgets but *should* have done so from society's point of view.¹⁴ As with depreciation allowances for the wear and tear of produced capital such costing can be seen as the funds required for re-investing in capital maintenance.

Contingent and related damage *valuations* were also proposed in the SEEA for environmental accounting. These valuation have been applied in cost-benefit analyses of particular projects and programmes but are hardly applicable in practice at the national level. They refer to the ultimate welfare effects (damages) of environmental impacts which are quite impossible to trace back to causing agents.¹⁵

2.2.2 Linking physical and monetary approaches

Conservative national accountants and economists, especially those in industrialized countries, have been quite recalcitrant in implementing environmental satellite accounts in monetary terms. While some now favour the incorporation of the cost of natural resource depletion into the conventional accounts, many consider the costing of environmental externalities a matter of modelling.¹⁶ '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 supplementary satellite systems. The Federal Statistical Office (FSO) of Germany appears to have taken a wait-and-see view of this question. On the one hand, it incorporates the compilation of avoidance costs in its — SEEA-based — environmental accounts; on the other hand, it refutes adding them up as a "*gesamtwirtschaftliche Kostengröße*" (total, economy-wide cost item).¹⁷

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 refrains from monetary valuation of environmental impacts by simply allocating physical measures of these impacts (mainly emissions) to causing economic sectors. This approach facilitates the linkage of physical impacts with their immediate causes; it fails, however, in aggregating these impacts and relating them as capital consumption and accumulation to the balance sheets of natural assets. To improve on this situation, i.e. to enhance the policy relevance of the physical data, the NAMEA authors combined different environmental impacts by means of "environmental policy theme equivalents".¹⁸ However, these aggregates suffer from limitations in selecting and defining the themes and their equivalent factors which still do not permit inter-theme comparisons.

The above-described MFA attempt to resolve the aggregation problem for physical measures by assessing material flows with their 'natural' (mass) unit of

measurement: weight. Such weighting by weight has been criticized as ‘ton ideology’ since counting tons reduces all kinds of environmental hazards caused by one factor, material input, to a simple one-dimensional measure of this factor.¹⁹ As indicated in section 2.1, it can be argued that difficult-to-predict potential environmental impacts are best addressed by an indicator like TMR, which focuses on the origin of these impacts in a highly visible fashion.

What can be done to overcome the physical-monetary dichotomy? Some linkage of physical and monetary accounting can be achieved through physical or mixed physical-monetary NAMEA-type input-output systems. However, these tabulations do not cover the above-mentioned ecological rucksacks of the MFA and do not resolve the aggregation problem. Additional indicator sets will therefore have to cover those sustainability concerns which cannot be assessed by the above-described accounting indicators of EDP, ECF, TMR and MIPS. Those concerns can be considered as ‘development’ issues, beyond economic growth, including the equitable distribution of income and wealth, health effects of environmental degradation, and other cultural and political values.

One way to improve the policy relevance of non-additive 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 targets for economic activities turns the analysis of sustainability of growth into one of the ‘feasibility’ of development.²⁰ 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 the feasibility of development.

3 First results

3.1 TMR of some industrialized countries

Reducing material flows into the economy, as expressed by their sum total, TMR, aims at delinking economic growth from the generation of environmental impacts. TMR per capita seems indeed to be levelling off for selected industrialized countries at 75 to 85 tons per annum, except for Japan at 45 tons, because of its low per-capita energy use (see Fig. 3). The low TMR per capita in Poland reflects the country's comparatively low level of economic development.²¹ Given that GDP per capita is increasing in all countries there is some delinkage, albeit far from the prescriptions of Factors 4 and 10. We have therefore to conclude that current delinkage cannot be equalized with sustainability as specified by these physical/ecological sustainability standards.

In Germany, the latest numbers do indicate an absolute decrease in TMR per capita from about 80 tons in the early 1990s to 72 tons in 1996 according to our own calculations.²² The main reason is the decrease of overburden resulting from the shutdown of unprofitable lignite production in the new states (*Länder*) after unification of Germany. In contrast, the total weight of *direct* material inputs of raw materials and energy (exclusive of ecological rucksacks) has remained constant, according to compilations by the FSO, between 1991 and 1997. This is deemed to reflect a continuing unchanged use of nature's source function in Germany. The same accounts also reveal a distinct reduction in the domestic generation of greenhouse and acidifying gases, on the output side of the MFA.

3.2 Green accounts: Germany and selected countries

Costing natural capital consumption and thus allowing for the possible re-investment of these costs reflects a monetary/economic notion of sustainability as overall capital maintenance.²³ Upward trends of EDP would therefore indicate the sustainability of economic growth. Compilations of EDP in case studies of environmental accounting²⁴ do not indicate a reversal in growth trends, conventionally measured by time series of GDP. This is largely because of the relatively short time series available. Given this data restriction, a more pertinent way of looking into the sustainability of economic performance is to measure a nation's ability to generate new capital after taking produced and natural capital

consumption into account. Figure 4 shows Environmentally-adjusted net Capital Formation (ECF) in in per cent of Net Domestic Product (NDP). Indonesia, Ghana and Mexico (as far as a one-year result can tell) exhibited a non-sustainable pattern of disinvestment. The performance of all other countries seems to have been sustainable, at least for the periods covered, and in terms of produced and natural capital maintenance. Of course, such costing refers to the accounting and economic sustainability principles of keeping capital intact and do not represent welfare effects of, or damages to, the environment. Past overall capital maintenance or increase hide the fact that in the long run complementarities of natural capital might make it impossible to maintain current production and consumption patterns and growth rates. Extending past trends into the future reflects thus a weak sustainability concept: the assumption is that natural capital can be replaced, at least 'at the margin'²⁵ by other production factors. The empirical testing of this assumption should be an important field of sustainability research.

Provisional results of a pilot application of the SEEA in Germany (old States), carried out by the authors, are presented in Table 1. In 1990, overall Environmentally-adjusted net Domestic Product (EDP) amounted to 97% of the conventional NDP aggregate. In other words, the economy generated about DM 59 billion environmental (degradation and depletion) costs during the accounting period. The Annex presents a synopsis and a more detailed description of the SEEA-Germany. As elaborated there, the environmental cost calculation depends to a large extent on the assumption about CO₂ reduction — in this case by 40%. Energy supply is responsible for over 20% of the total environmental costs, consisting mostly of avoidance costs for emissions of CO₂ and NO_x. The largest share of environmental cost (45%) was incurred by 'Others', reflecting mostly emissions by commercial and private transport, which could not be separately assessed. Note also the relatively high share of environmental cost per unit of value added in agriculture, energy supply and (the less important) other mining industries.

Natural resource depletion is of little importance (0.6% of total environmental costs), since the extraction of most mineral resources is subsidized to an extent which renders them non-economic; in this case, they obtain therefore a zero monetary value. Moreover, economic water and forest resources are generally (at the national level) used in a sustainable fashion, and only the catch of some fish species and the extraction of minerals like oil and gas incurred any depletion costs.

For a more assured assessment of the sustainability of economic growth, further studies in constant prices and over longer periods of time would be needed. All one can say at this stage is that the picture of sustainability in Germany is bleak: development does not seem to be ecologically sustainable, and seemingly sustainable economic growth needs further examination as to hidden complementarities of natural capital.

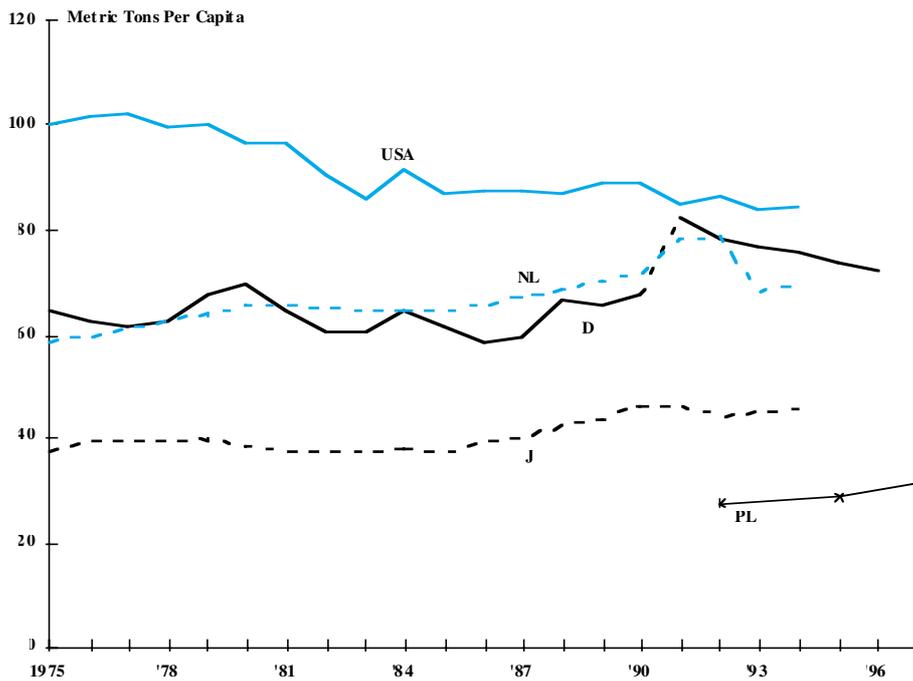
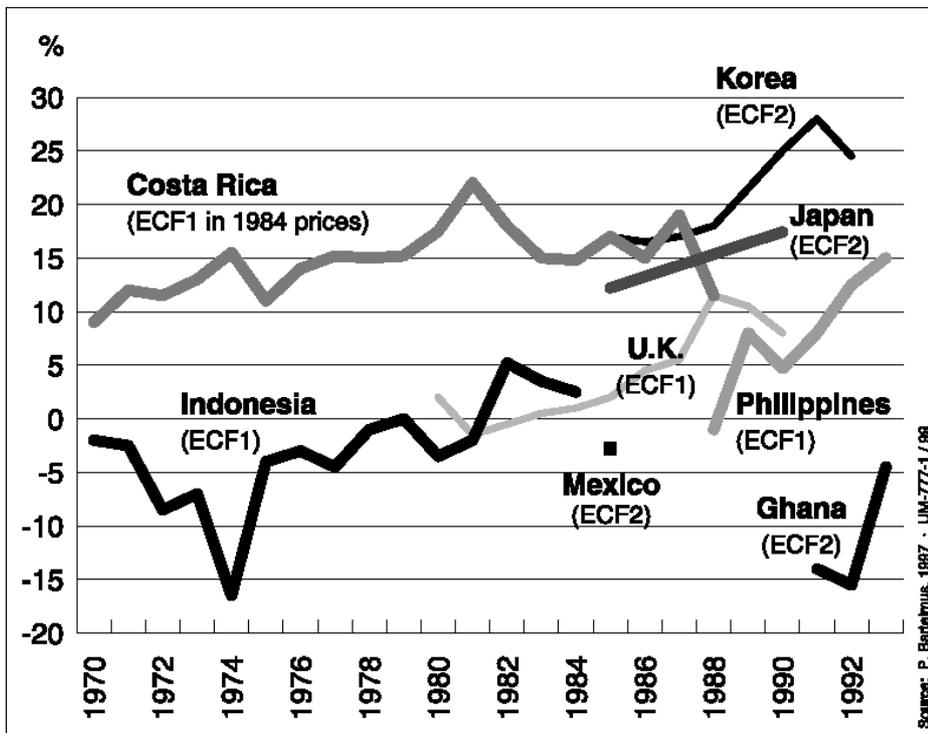


Figure 3: Annual TMR per capita for the USA, Netherlands, Germany, Japan and Poland
 Sources: A. Adriaanse et al., *Resource Flows: The Material Basis of Industrial Economies*, Washington, D.C.: World Resources Institute, 1997; Wuppertal Institute (S. Bringezu, H. Schütz).



Note: ECF 1 covers natural resource depletion only; ECF 2 covers depletion and degradation costs.

Figure 4: Environmentally-adjusted net Capital Formation (ECF) in per cent of NDP
 Source: P. Bartelmus (1997). 'Whither economics? From optimality to sustainability', *Environmental and Development Economics* 2, p.332.

Monetary unit: Million DM	Total	Agriculture	Mining of coal	Other mining	Manufacture of chemicals and chemi- cal products	Manufacture of basic metals	Energy supply	Public administration and defence; compulsory social security	Others
NDP	1,943,040	17,840	5,830	2,010	62,220	14,430	39,590	236,540	1,564,580
EDP	1,883,854	9,668	5,364	1,099	60,265	11,696	26,299	231,531	1,537,932
(NDP-EDP)/NDP (%)	3,05	45,81	7,99	45,32	3,14	18,95	33,57	2,12	1,7
NCF/NDP (%)	11,13								
ECF/NDP (%)	8,14								
ICEP/GDP (%)	1,46		5,53	5,11	4,09	3,57	3,88	5,18	
GCFEP/GDP (%)	0,78								

Explanations:

GDP = Gross Domestic Product

NDP = Net Domestic Product

EDP = Environmentally-adjusted net Domestic Product

NCF = Net Capital Formation

ECF = Environmentally-adjusted net Capital Formation

ICEP = Intermediate Consumption for Environmental Protection

GCFEP = Gross Capital Formation for Environmental Protection

Table 1: Conventional and environmentally adjusted accounting aggregates: Germany 1990 (preliminary results)

4 Analysis and policy use

4.1 Ecological vs. economic sustainability: two sides of the same coin?

Dematerialization, and hence reduction of environmental pressure by a certain factor, can be seen as a notion of *ecological sustainability*. Natural and produced capital preservation, on the other hand, represents the extension of economic prudence contained in the Hicksian income concept²⁶ to natural assets. *Economic sustainability* is thus to ensure continuing income generation through production and economic growth, taking nature's vital services of resource inputs and waste/residual absorption into account. Moving from the assessment of ecological sustainability to economic sustainability could therefore be viewed as moving from the input side of material flows into the economy to the output side of production and environmental impacts — two sides of the same coin?

At the most generic level, the key physical and monetary sustainability measures, TMR/MIPS and EDP/ECF, appear indeed to have a similar, or possibly the same, underlying sustainability notion: viz. the long-term preservation of environmental source and sink functions or, in other words, the maintenance of environmental assets. They differ, however, when looking more closely at the definition, scope and envisaged use of these aggregates:

- Factor 4 assessments link dematerialization with wealth/welfare generation. Human welfare and the similar concept of the 'quality of life' are usually taken as indicators of development, which would make dematerialization a notion of environmentally *sustainable development*.²⁷ Maintaining natural capital for ensuring non-declining income or product, on the other hand, aims at *sustaining economic growth*. This reflects the capacities of national accounts which measure economic performance in terms of production, accumulation and consumption, rather than welfare.
- Extending the notion of capital consumption from produced (economic) to non-produced (natural) capital generates an environmental-economic concept of sustainability which appears to be broader than dematerialization. This is because dematerialization refers, as an environmental pressure index, to environmental assets only.

- The TMR aims at assessing actual and potential environmental impacts in a precautionary approach. In contrast, accounting for natural capital consumption captures only actually occurred and observed environmental impacts.²⁸ Non-sustainability derived from material flows refers thus to an unspecified *risk* of transgressing Factor X standards in dematerialization. Such risk is difficult to compare to actual losses of specific natural assets.
- The controversial monetary valuation of natural resource depletion and emissions reflects in principle the preferences of individual economic agents. The TMR weights different environmental impacts by weight — perhaps even more controversially, but also more graphically.
- Calls for overall dematerialization of economic activity by a given factor ignore, or at least do not acknowledge explicitly, possibilities of substituting natural capital by other, human or produced, production factors. The TMR indicator does allow for substitution among different materials, e.g. non-renewable resources by renewable ones, when reference is made to overall material flow reduction by a certain factor. Such a sustainability principle is still *stronger* than the *weak* sustainability of overall capital maintenance, which ignores ‘complementarities’ in natural capital use.

Dematerialization and capital maintenance: two sides of the same coin? Well, yes, but only as far as the most generic goal of environmental sustainability is concerned. Otherwise, there are important differences in the scope of the sustainability concept, its connection with growth or development, the strength of the underlying sustainability notions, the degree of risk of environmental impacts addressed, and the evaluation (weighting) of environmental impacts. The question is, what do the obviously different notions and assessments tell us for drawing strategic and policy conclusions?

4.2 Sustainability strategies

The basic idea of dematerialization is delinking environmental deterioration, assessed in particular by the environmental pressure indicator TMR, from economic growth. Advocates of the so-called Environmental-Kuznets-Curve (EKC) hypothesis suggested that such delinkage would be an ‘automatic’ feature of growth. No further action would thus be required, once a certain level of economic development is reached. Unfortunately, empirical studies confirm the EKC hypothesis only in selected cases and for particular emissions.²⁹ It is therefore useful to recast dematerialization and capital maintenance in more strategic terms for purposes of policy analysis.

One such term is *resource productivity* which focuses on new technologies to reduce material inputs while generating the same or even better ultimate services from outputs. Such increase in resource productivity is the mirror image of a

decrease in material intensity. It is generally held, however, that technology alone cannot be the saviour from non-sustainability: it needs to be reinforced by more or less voluntary restriction in consumption levels. 'Ecoefficiency' in production needs to be combined with 'sufficiency' in final consumption. Otherwise, efficiency gains could be offset by increased consumption, made possible by the very same efficiency gains.

Some faith in technology is also reflected in *cost internalization* and corresponding full-cost-pricing strategies. Facing effluent charges or fees for excessive uses of environmental resources, producers and consumers have the incentive to search for environmentally benign techniques which replace harmful production and consumption processes. The idea is to combine competitive and fiscal pressures to meet environmental goals in a more efficient manner than by command-and-control strategies of remote bureaucracies. It is interesting to note that, despite the above-described differences in sustainability notions, both strategies of enhancing resource productivity and prompting cost internalization make use of market instruments for their implementation. The former favours, however, material inputs (e.g. by trading material certificates) whereas the latter tackles resource depletion and environmental degradation (e.g. by means of user fees, effluent charges or tradable pollution permits).

In preference of market instruments over regulation, most (neo-classical) environmental economists stress consumer sovereignty which should not be impaired by sufficiency criteria or other sustainability standards such as the above-discussed Factors 4 or 10. Unfettered markets have failed, however, in recognizing restrictions posed on economic activity by environmental, social and other cultural or political goals.³⁰ Relating explicitly the set of social and environmental goals to economic (market) activity could be achieved by means of a normative framework within which economic activities could be played out. This framework would, in fact, delimit the feasibility space of development, referred to above for linking and enhancing physical indicators (see section 2.2.2).

Introducing normative standards explicitly into economic analysis is not easy, though. First, it is difficult to reveal widely accepted policy targets and social norms, hidden under the veil of political exigencies and rhetorics. Second, revealing such policy targets and norms might disclose a necessity of shifting the focus of policy making from individual preferences, expressed in market choices, to society's collective ones: the invisible hand of the market would be replaced, at least in part, by the visible hands of the standard setters.

What then are the limits of market activity? Is a Factor 4 standard enough? Should it be supplemented by other targets or limits of a social, cultural or political nature? In other words, what is the size of the feasibility space for economic activities, in the context of sustainable national development? These are some further questions that need to be addressed for incorporating sustainability criteria in individual and collective decision making.

4.3 Environmental accounts and policy making

National accounts are a multi-purpose statistical system. This property carries over into the SEEA. It is therefore difficult to specify the many possible applications of an extended accounting system, which is even broader in its scope and coverage. The following examples thus point to just a few direct uses of the results of SEEA case studies.

At the *micro/meso-economic level*, the compilation of environmental costs permits the setting of market instruments at a level at which natural capital could be preserved with currently available technologies and market conditions. For instance, such cost calculations could defuse the current, emotionally loaded discussion about eco-taxes in Germany. With environmental costs of air pollution in 1990 of about DM 46 billion and expected annual eco-tax returns in the next few years in the range of 20-30 billion DM³¹, should we not push our ‘pain barrier’ (*Schmerzgrenze*) a bit further to gracefully accept the full cost of our splurging energy consumption?

While being more efficient than top-down regulation, drawbacks in applying these instruments are their time-lagged efficacy, high monitoring and enforcement costs, short-sightedness of economic agents, a general resistance to any kind of taxation and the neglect of ‘environmental debt’, i.e. accumulated environmental effects from previous accounting periods. The comparative advantages of regulatory and incentive measures in different situations and at different levels need further exploration.

At the *macro-economic level*, the comparison of the availability of different categories of produced and non-produced natural capital facilitates the setting of priorities for exploitation or maintenance of natural wealth. Assessing ownership of these stocks allows to make informed decisions about allocating property rights, in the case of common-access resources — in an equitable fashion among individuals, countries and the present and future generations. Such allocation is not only a matter of equity in assessing a tolerable ‘environmental space’ but might also bring about a more caring treatment of this space by its owners.

The availability of productive wealth also determines the long-term growth potential of an economy. A declining (natural) capital base would alert to limits of growth, nationally and globally. The World Bank even considers comprehensive wealth assessments as a new model for ‘development as portfolio management.’³²

Changes in stocks through exploitation, discovery, growth, natural disasters and capital consumption are particularly important for investment decisions, as is capital productivity which includes natural capital. Capital productivity may change and differ (among different economic sectors) considerably after incorporation of natural resource stocks. Altogether different investment, price and growth policies should be the consequence of this information.

Direct policy use of physical *material flows* seems to be less clear, with regard to setting national policy priorities. Physical indicators are most useful at the — managerial — micro-level. Here, particular materials can be easily linked to different production and consumption processes, and their potential impacts become more obvious. Ecoefficiency and material intensities are thus on target when changing production techniques in enterprises. Moving up towards meso- and macro-levels, the non-specificity of material flow aggregates makes it more difficult to base policy decisions on (the weight of) material flows. As a consequence, policy advice is deliberately couched in ‘directionally safe guardrails’, suggesting the reduction of overall material flows by different factors.³³

Given the general failure of *laissez-faire* economics in dealing with the environmental question, there does not seem to be a way around setting standards for desirable facets of sustainable development and thus limiting market activity. The crucial question of the actual and desirable feasibility space generated in this manner cannot be solved by markets which have been responsible for most environmental impacts. Non-economic norms which affect market behaviour need to be established as transparently and democratically as possible. A social compact or alliance between ‘shareholders’, benefiting from economic activity, and ‘stakeholders’, suffering from its environmental impacts, might minimize market interference. The result should be consensus and partnership — the sustained implementation of sustainable development depends on it.

Annex: SEEA Germany 1990 — first results and evaluation*

1 Results

Figure 5 is a synoptic presentation of a pilot SEEA for Germany.³⁴ It includes the supply and use accounts, incorporating environmental costs, and, in principle, the asset accounts, extended for non-produced natural assets. Time and data constraints prevented, however, the compilation of asset stocks, and only stock changes are shown for now in the asset accounts. Both categories of accounts overlap in the areas of capital formation and consumption, covering produced and natural capital.

Total environmental cost generated by the consumption and use of natural capital, i.e. depletion of natural resources and the degradation of environmental sinks, amounted to *DM 59.2 billion or 3% of NDP*. This calculation reflects a reduction of CO₂ emissions by 40% according to available technologies. Alternatively, a 25% reduction standard, with differing marginal reduction costs, decreased total environmental cost to about DM 28 billion or about 1.4 per cent of NDP.

As shown in text Table 1, agriculture, energy supply and other mining incurred the biggest shares of environmental cost per value added. Over 20% of the total environmental costs were caused by the energy sector, followed by agriculture (14%). The largest share (45%) was generated by 'Others', consisting mainly of environmental costs of commercial and private transportation. Lack of data prevented the further breakdown of this sector. Environmental costs are made up largely of maintenance costs for the avoidance of emissions into air of CO₂ (61%) and NO_x (17%), and into water (nitrogen: 21%).

Natural resource depletion in Germany is *negligible* (0.6%) of total environmental cost. There are few mineral resources, and those that are extracted are subsidized to the extent that they do not show a positive economic value (notably coal). Moreover, the use of water and timber resources was found to be sustainable — at the national level — with current production patterns. Depletion

* Contributions and assistance in this pilot study by H.-P. Cornus (Bundesforschungsanstalt für Fischerei, Hamburg), Fichtner (Institut für Industriebetriebslehre und Industrielle Produktion, Universität Karlsruhe), T. Lüllwitz (Bundesanstalt für Gewässerkunde, Koblenz) und W. Riege-Weislo (Statistisches Bundesamt, Wiesbaden) are gratefully acknowledged.

costs were thus only incurred in selected fish stocks (exploited beyond sustainability) and some minerals and metals, especially oil and gas. Since there were no usable market prices for natural resource stocks, the net price, using a 6% rate of normal return to fixed capital,³⁵ was applied as a proxy for the net present value of the resource. *Actual environmental protection expenditures*, made during the accounting period, are already part of conventional accounts and indicators, albeit not always presented separately. In our own calculations, gross capital formation for purposes of environmental protection amounted to 0.8% of GDP. In the 1999 environmental accounts of the Federal Statistical Office, total expenditures (capital *and* current outlays) reached 1.5% of GDP. While not directly comparable with annual environmental cost, such expenditures are sometimes interpreted as a nation's willingness to pay for the environment. Of course, such willingness should not be compared to other countries without some knowledge about their differences in environmental conditions.

2 Evaluation

The overall results depend significantly upon the two CO₂ reduction standards. This is because marginal costs increase considerably with higher reduction targets. Nonetheless, the emission of greenhouse gases can be considered as the most significant environmental cost factor in Germany's economic activities. Considering Germany's commitment to reduce its emissions of greenhouse gases by 25% (from its 1990 level) by the year 2005, we obtain (for 1990) an amount of DM 16 billion or 0.8% of NDP. This is a relatively small expense, compared to the results of case studies in developing countries, but is of the same order as in other industrialized nations.³⁶ It is of course another question whether these avoidance costs should be internalized immediately or distributed over a lengthy period of time — for optimizing economic growth. Modelling, rather than accounting, would have to provide the answer.

When considering the much lower depletion cost of natural resource use (0.02% of NDP) one has to take account of the dependence of the German economy on resource extraction in other countries. In 1990, natural resource imports amounted to about 6% of NDP. Not all of it may reflect non-sustainable natural capital consumption but the number is a first indication of Germany's need to 'import' sustainability.

The above rough estimates are the results of a first attempt at greening the German national accounts, carried out by the authors in the course of two months. They illustrate the feasibility of such accounting, reveal major data gaps and point to the need of improving the data base. Still, the study does provide some insight into the causes, responsible sectors and significance of environmental concerns of natural resource depletion and pollution. It does so in terms of costs which, owing

to the systemic character of the national accounts, can be compared to other costs and to the monetary value (benefits) of output, consumption and capital formation.

Data gaps should preferably be filled by the ‘official’ statistical system. The reluctance of official statisticians to embark on monetary valuation (see section 2.2.2) is an incentive for scientific institutes to tackle this thorny issue by test-applying the UN methodologies. In fact, the Wuppertal Institute is currently designing a major international programme of comparative physical and monetary accounting and accounting.

Much of the — physical — data base underlying the monetary accounts was derived from the Physical Input-Output Table (PIOT) of the Federal Statistical Office. Input-output tables are an integral part of the national accounts, facilitating the linkage of physical and monetary data. PIOTs also cover a large part of Material Flow Accounts, excluding however the hidden flows of ‘ecological rucksacks’ of production and consumption processes. A further important difference is, apart from the physical weighting by weight, that material flows do not distinguish between sustainable and non-sustainable uses of the materials. Including ecological rucksacks of national and international economic activities produces, however, a broad environmental pressure indicator (as elaborated in the main text of this paper). Non-sustainable, i.e. permanent, losses of natural resources and sink capacities are, on the other hand, part of the definitory characteristics of ‘depletion’ and ‘degradation cost’ of the SEEA, in line with the conventional definition of capital consumption. SEEA and MFA can thus be seen as complementary, rather than contradictory, approaches to assessing the (non)sustainability of economic performance.

Notes

- ¹ References: *Human Development Index (HDI)*: UNDP, *Human Development Report 1999*; New York and Oxford: Oxford University Press, 1999; *Genuine Progress Indicator (GPI)*: C. Cobb, T. Halstead and J. Rowe, 'If the GDP is up, why is America down?', *The Atlantic Journal*, Oct. 1995; *Wealth*: The World Bank, *Expanding the Measure of Wealth, Indicators of Environmentally Sustainable Development*, Washington, D.C.: The World Bank, 1997; *Environmental Sustainability Index (ESI)*: Yale University *et al.*, 2000 — see <http://unisci.com/stories/20001/0201006.htm>.
- ² See for a discussion of this polarization P. Bartelmus, 'Sustainable Development — Paradigm or Paranoia?' *International Journal of Sustainable Development*, 3, 2000.
- ³ More exactly an average of index values of one monetary indicator (GDP per capita) and two non-monetary indicators of life expectancy and literacy (UNDP, 1999, *op. cit.*).
- ⁴ J.H. Spangenberg *et al.*, *Material Flow-based Indicators in Environmental Reporting*, Copenhagen: EEA, 1999.
- ⁵ United Nations, *Integrated Environmental and Economic Accounting*, New York: United Nations, 1993. See for a summary description, P. Bartelmus, *Greening the National Accounts: Approach and Policy Use*, DESA Discussion Paper No. 3, New York: United Nations, 1999. The SEEA is currently being revised by the so-called London Group of national accountants and is expected to be re-issued in 2001.
- ⁶ United Nations *et al.*, *System of National Accounts 1993*, New York and others: United Nations and others, 1993.
- ⁷ Ecological rucksacks are defined as "the sum of all materials which are not physically included in the economic output under consideration, but which are necessary for production, use, recycling and disposal" (Spangenberg *et al.* 1999, *op. cit.*, p. 15).
- ⁸ E.U. von Weizsäcker, A. Lovins and H. Lovins, *Factor Four: Doubling Wealth — Halving Resource Use*, London: Earthscan, 1997.
- ⁹ The assumption is that an equal environmental space should be reached by all countries in about 50 years while permitting a limited increase of material use in developing countries; see F. Schmidt-Bleek, *Wieviel Umwelt braucht der Mensch?*, Berlin, Basel und Boston: Birkhäuser, 1994, p. 168.
- ¹⁰ F. Hinterberger, F. Luks and M. Stewen, *Ökologische Wirtschaftspolitik*, Berlin, Basel und Boston: Birkhäuser, 1996.
- ¹¹ See for a more elaborate discussion of the pros and cons of different valuations in environmental accounting, P. Bartelmus, 'The value of nature — valuation and evaluation in environmental accounting', in K. Uno and P. Bartelmus, *Environmental Accounting in Theory and Practice*, Dordrecht, Boston and London: Kluwer Academic Publishers, 1998.
- ¹² In the sense of the SNA which defines 'economic assets' as "entities (a) over which ownership rights are enforced ... and (b) from which economic benefits may be derived by their owners ..." (United Nations *et al.*, 1993 *op. cit.*, para. 10.2). Figure 1 displays therefore part of natural capital consumption under the column of economic assets.
- ¹³ United Nations, 1993, *op. cit.*, para. 50.
- ¹⁴ Actual internalization 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" (V. Vu, and J. van Tongeren, '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, 1995) or an "optimal net domestic product with regard to environmental targets" (B. Meyer and G. Ewerhart, 'Modelling towards eco domestic product', in K. Uno and P. Bartelmus, 1998, *op. cit.*).

- ¹⁵ 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) valuations creates aggregates which are neither performance nor welfare measures and quite impossible to interpret (P. Bartelmus, 1998, *op. cit.*, p. 295).
- ¹⁶ See P. Hill and A. Harrison, 'Accounting for depletion in the 1993 SNA', in *Second Meeting of the London Group, op. cit.*, 1995 for costing natural resource use. Advocates of environmental cost modelling are W. van Dieren (ed.), *Taking Nature into Account*, New York: Springer, 1995; and A. Vanoli, 'Modelling and accounting work in national and environmental accounts', in Uno and Bartelmus, 1998, *op. cit.*
- ¹⁷ Statistisches Bundesamt, 'Umweltökonomische Gesamtrechnungen 1999', Pressemappe, 'Weitere Informationen zu den Umweltökonomischen Gesamtrechnungen 1999', Wiesbaden, 1999, pp. 2 and 3.
- ¹⁸ S. J. Keuning and M. de Haan, 'Netherlands: what's in a NAMEA? Recent results', in Uno and Bartelmus, 1998, *op. cit.*
- ¹⁹ See for a comprehensive critique, E. Gawel, 'Das Elend der Stoffstromökonomie — eine Kritik', *Konjunkturpolitik* 44, 2, 1998, and for a counter-critique, F. Hinterberger, F. Luks and M. Stewen, 'Wie ökonomisch ist die Stoffstromökonomie — eine Gegenkritik', *Konjunkturpolitik*, 45, 4, 1999.
- ²⁰ See for a corresponding definition of sustainable development as "the set of development programmes that meets the targets of human needs satisfaction without violating long-term natural resource capacities and standards of environmental quality and social equity", P. Bartelmus, *Environment, Growth and Development — The Concepts and Strategies of Sustainable Development*, London and New York: Routledge, 1994, p. 73.
- ²¹ This is not necessarily a sign of efficiency in resource use (TMR per GDP) which is about triple the amounts of Germany and the Netherlands.
- ²² Note that a 17% reduction from 1991 to 1997, calculated by the FSO (1999, *op. cit.*), does not cover soil erosion nor, more significantly, the ecological rucksacks of imported and domestic materials.
- ²³ See section 4.1 for a comparison of ecological and economic concepts of sustainability.
- ²⁴ See e.g. K. Uno and P. Bartelmus, 1998, *op. cit.*
- ²⁵ Pointed out by David Pearce at the Second OECD Expert Workshop on 'Frameworks to Measure Sustainable Development' (Paris, 2-3 September 1999), meaning that substitution of total stock is, at least in the short- and medium-run, not necessary as sometimes assumed by critics of the weak sustainability criterion.
- ²⁶ J.R. Hicks, 1946, *Value and Capital*, 2nd edn, Oxford: Oxford University Press, p. 172.
- ²⁷ There is however some ambivalence with regard to the strategy of increasing resource productivity for dematerialization strategies: typically the notion of 'ecoefficiency' and its reciprocal value of 'resource productivity' refer to output or GDP rather than a welfare indicator.
- ²⁸ A certain degree of precaution is reflected in the above-mentioned Hicksian prudence in reserving depreciation costs for maintaining future economic activity, i.e. re-investment in capital maintenance or in avoidance of environmental depletion and degradation.
- ²⁹ C. Perrings, 1998, 'Income, consumption and human development: environmental linkages', in UNDP, *Consumption for Human Development*, New York: UNDP; see also a special edition of *Ecological Economics* 25, 2, 1998.
- ³⁰ Examples of recent criticism of the narrow focus of economics on formalistic models of market behaviour, at the expense of real-world vision, are R. Kuttner, *Everything for Sale*, New York: Knopf, 1997; J. Foster (ed.), *Valuing Nature? Ethics, Economics and the Environment*, London and New York: Routledge, 1997; and R. Heilbroner and W. Milberg, *The Crisis of Vision in Modern Economic Thought*, Cambridge University Press, 1995.
- ³¹ www.bundesfinanzministerium.de/fachveroeff/Abt.I/IA5/Datensammlung/ds27.htm/is.htm/index.htm
- ³² The World Bank, 1997, *op. cit.*, p. 28.
- ³³ F. Hinterberger, 1998, *op. cit.*
- ³⁴ Note that rounding may affect the exact accounting identities.
- ³⁵ The 'net price' is defined as the net return per unit of the resource sold, with 'net return' representing the total sales value minus all costs of resource exploration, development and extraction (see for a detailed formal presentation, P. Bartelmus, 1998, *op. cit.*, pp. 305-307).

- ³⁶ Cf. P. Bartelmus, 'Whither economics? From optimality to sustainability?', *Environment and Development Economics* 2, 1997, p. 331, and the case studies presented in Uno and Bartelmus, 1998, *op. cit.* Note however that such maintenance or avoidance cost does not represent environmental damage from pollution. It is therefore not surprising that damage estimates, applying for instance methodologies proposed in an EU sponsored project (EXTERNE) indicate a quite different importance of greenhouse gases — amounting to 15.6% of total damage costs in Germany (1990). The well-known problems of national-level damage valuation, indicated above (see note 15), make these estimates highly questionable. Noise, for example, carries the bulk of nearly 50% of total damage cost in Germany!