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Sustainable Development Indicators and Environmental-Economic Accounting

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Sustainable Development Indicators and Environmental-Economic Accounting

Summary

The central subject of a policy for sustainable development is the co-ordination of the different sector policies with the objective of finding a balance between conflicting economical, ecological and social goals. The headline indicators for sustainable development itself are mainly a communication tool directed to the general public and the media. They are used for describing important problems under a sustainability perspective and they serve as an instrument for controlling general performance of political measures. But more detailed data are required for the analysis of the underlying mechanisms and reasons for change of the indicator values as well as for the formulation of measures and the assessment of the effects of these measures. Therefore, the individual indicators should be consistently embedded into an underlying database from which they can an be derived by aggregation. Further, the underlying data for the individual indicators should be part of a comprehensive framework that ideally integrates all relevant topics, in order to take account of the interdependencies between the different indicators. The accounting system with its three principle parts, the National Accounts (SNA) and the satellite systems Environmental-Economic Accounting (EEA) and the Socio-economic Accounting (SEA) provides an ideal framework to meet these data requirements. In Germany a rather high proportion of economic and environmental indicators of the national Strategy on Sustainable Development are embedded into the accounting system. The potential of the accounting data for an integrated analysis of headline indicators of the German strategy on sustainable development is illustrated with selected examples. The paper describes the steps for integrating the indicator set and the accounting system.

1 Introduction

There are two principle approaches for **measuring the "sustainability gap"**, the indicator and the accounting approach. The sustainability gap indicates how far the present state of a society differs from a situation that meets the requirements of the sustainability paradigm. Work on sustainable development (SD) indicator sets is usually carried out more or less independently from the accounting work. In this paper it is argued that linking these two approaches could yield considerable synergies.

The **indicator approach** describes the sustainability gap by a selected number of issues considered to be most relevant under a sustainability perspective. The selection of the indicators is based on facts and value judgements. In order to establish broad acceptance of the SD-indicators as being suitable for describing the state of the society objectively, a consensus about the underlying value judgements has to be found among the major protagonists. Ideally all indicators are linked to quantitative development goals. In that case the difference between the present development and the goal indicates the sustainability gap for an individual indicator and subsequently the need for action. To what extent the society as a whole is moving towards a path of sustainable development can only be estimated by a

summarising valuation of the development of the individual indicators of the SD-indicator set.

The **accounting approach** can provide multi-dimensional SD-indicator set as well as one-dimensional SD-indicators. One-dimensional indicators measure the sustainability gap by a one figure. The one-dimensional approach that is offered by the SEEA 2003 is limited to environmental sustainability. The gap is measured in monetary terms on the basis of the calculation of adjusted macro-economic aggregates, like the EDP (eco-domestic product). That type of one-dimensional indicators in principle could provide a very powerful description of the sustainability gap. However, an important precondition would be that the indicator is accepted by the public or at least by the main users as being relevant and adequate. With respect to that precondition it has to be noted that in the handbook itself the calculation of adjusted macro-economic aggregates is indicated as a still rather controversial issue and the calculation of adjusted aggregates is only mentioned as one possible option in the handbook. The controversy described in the handbook is especially related to the problem of monetary valuation of the degradation of natural capital.

In practice almost all countries that have a national strategy on sustainable development are using a multi-dimensional indicator approach. It is the aim of this paper, to introduce a concept for linking multi-dimensional SD indicator sets with the accounts. Therefore this work does not take up the approach of one-dimensional environmentally adjusted macro-economic aggregates, but rather follows the principal idea of describing the sustainability gap by a multi-dimensional indicator approach as well. But unlike in the simple indicator approach described above, the individual **indicators are systematically linked with integrated** physical and monetary economic, environmental and social **accounting data**.

2 Comparison of the indicator and the accounting approach

Originally SD-indicators and accounts are approaches with different purposes and characteristics. Four points could be highlighted (see figure 1):

Figure 1 Two separate worlds
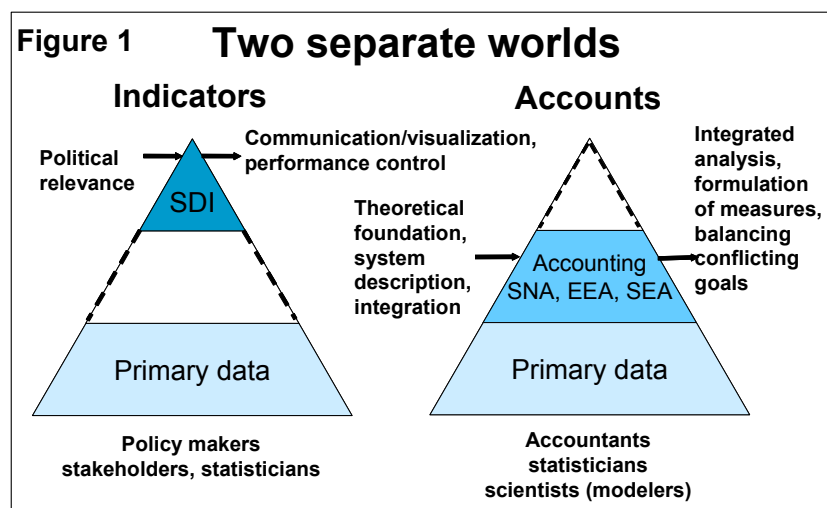
- **Purpose:** SD-indicators – like indicators in general – are intended for the purposes of **communication and performance control**. Very often they cover specific topics of the political agenda for which they shall deliver short-term information. Accounts, on the contrary, aim at the complete and coherent **description of a system** such as a national economy (national accounts) or the relationships between economy and environment (environmental economic accounting). They are set for the long term and try to respond to more general data needs.
- **Level of detail:** SD-indicators are located on the top of the information pyramid; they provide a very condensed or **aggregated kind of information**. Accounts are more detailed, they belong to a **meso-level** between indicators on the top and very detailed basic statistics at the bottom of the information pyramid.
- **Foundation:** Accounting systems have a strong **theoretical foundation**. They are based on a common set of classifications, rules and concepts which define how to describe the system. Indicator selection and formulation is not following such rigid rules. In most cases there is "only" a framework which helps to structure the indicator set. The indicator set should reflect the social preferences of a society and therefore in an ideal case both framework and indicators are the outcome of **negotiation processes** among politicians, experts and stakeholders.
- **Main strengths:** Indicators are an appropriate tool for pointing at **relevant political problems** as well as for **visualising information** in a focussed way. Accounting systems benefit from their coherence and system orientation which **supports further analyses** of interdependencies and underlying causes and subsequently the formulation of political measures.

The primary data are the source for compiling the data for the accounting system. As long as the SD-indicator and the accounting worlds are separated, the indicators are derived from primary data as well.

The vision presented in this paper is, to **merge the two pyramids** of figure 1. In terms of data that simply means, that the indicators should be embedded into the accounting data base, i.e. they could be derived by aggregation from the more detailed accounting data base. To merge the two pyramids will help to utilise the special advantages of both approaches with respect to political relevance of the data and the suitability as a communication tool, for integrated analysis as well as for formulation of measures. Why and how the two approaches should be linked and how it could be achieved is discussed below in more detail by referring to the German example.

2 Policy for sustainable development and data requirements

The respective advantages of the indicator and the accounting approach are of relevance for different steps of the **policy cycle**, i.e. problem description, diagnosis, measures and performance control (figure 2).

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Figure 2:

The policy cycle

- Problem description
- Diagnosis
- Measures
- Performance control
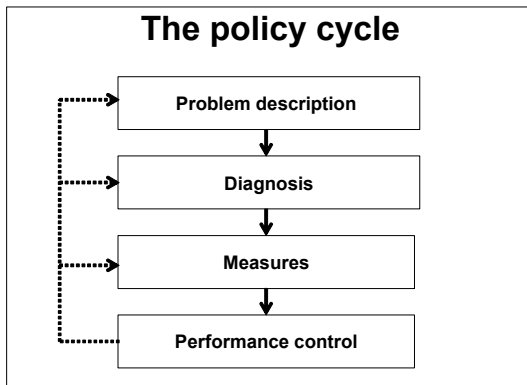
<u>**Problem description**</u>:
SD-indicators, which are usually highly aggregated, can reduce the complex reality to a limited number of figures. Therefore they can serve as a rather simple **communication tool** mainly directed to the general public and the media. They are used for describing important problems under a sustainability perspective and depending on the process of developing the indicator-set, may more or less **reflect the political preferences** of the society. The sustainability gap is measured indicator by indicator by comparing the observed values with the target values.

<u>**Diagnosis:**</u>
For the diagnosis or analysis highly aggregated indicators alone are generally not sufficient. An analysis of the underlying mechanisms and reasons for change of the indicator values requires **detailed disaggregated information**. The data-base for further analysis can either be provided by detailed basic statistics or by an accounting system, which is rather situated at a meso-level.

<u>**Measures:**</u>
Political measures for achieving the sustainability goals of the society should be cost efficient and above all should be tailored for **balancing conflicting goals**. The general objective of sustainable development requires a holistic policy approach, as the issues of a SD-policy are closely interlinked. A policy for SD is characterised by not only looking on how far the goals for the individual indicators can be achieved, but has to have in mind the interdependencies between the topics and the simultaneous achievement of different economic, environmental and social goals. Decisions on measures aiming at the improvement of one indicator at the same time have to consider the effects that may occur on the other relevant goals of the overall strategy for SD. The rather complex analytical tools required for that type of policy approach demand a **homogeneous and coherent database** depicting the interdependencies between the different indicators. For that reason it will usually not be sufficient to deal with the different indicators individually. That is, the underlying data for the individual indicators should be part of a comprehensive framework that ideally integrates all relevant topics.

The System of National Accounts (SNA) form together with its satellite systems Environmental-Economic Accounting (EEA) and the Socio-economic Accounting (SEA) an **expanded accounting data set**. Such an expanded data set is an ideal

framework to meet the above mentioned requirements[1]. The SNA is the world wide accepted standard for describing the economic process. The EEA and the SEA extend the economic accounts by a description of the interrelationships of the economic to the environmental and the social system and between the environmental and the social system. The satellite systems in principle use the same concepts, definitions and classifications as the SNA. That guaranties that the data of all three sub-systems can be combined with each other, i.e. they form an integrated database that covers the three principal topics of a sustainability approach.

An integrated analysis and especially the formulation of political measures require rather complex **analytical instruments**. It is one crucial advantage of the SNA data set that it is being widely used as a basis for already existing and proven analytical tools that are related to the economic process. The extension of those tools for analysing environmental-economic questions has already been put into practice successfully in Germany and other countries.

<u>**Performance control:**</u>
The indicators, especially if they are combined with quantitative goals, serve as an instrument for general performance controlling of political measures. A reduction of the gap between the observed and the target values indicates improvement of sustainable **score keeping for individual indicators**.

Modelling can provide a more complex approach of score keeping by **comparing the "business-as-usual Gross Domestic Product" (GDP) to a "sustainable GDP"**[2]. This can be achieved by comparing a modelling scenario for the economic-social-environmental system without measures (business-as-usual) with a scenario that simulates the effects of a bundle of measures which are orientated towards respecting the sustainability goals of the society.

3 The German strategy on sustainable development

In Germany the Government adopted the **National Strategy for Sustainable Development** in April 2002. The approval was preceded by a discussion of the draft with major groups and institutions of the society. With the adoption of the strategy by the government broadly agreed indicators on SD are available. The strategy was developed by the "Committee of State Secretaries for Sustainable Development" which was headed by the advisor to the Federal Chancellor. It has different elements, like defining the key focus points for SD, selecting indicators, formulating quantitative or qualitative goals related to the indicators and a set of measures related to some of the key focus points. The sustainability indicator set is comprised of 21 indicators.

By the **selection of the indicators** the responsible policy makers defined those issues which are particularly relevant under sustainability considerations. By

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[1] However it should be noted that even a highly developed accounting data base can not meet all analytical purposes in an exhausting manner. For example, it may be necessary to broaden the scope of the analysis by supplementing the headline indicators by additional indicators in order to obtain a more comprehensive description of the problem. Moreover not all data needs coming up in the course of sustainability analysis can be covered by the accounting data set. In those cases it may be necessary to use appropriate special data in addition to the principal accounting framework.
[2] See: Meyer, B. (1998) and Radermacher, W. (1998 (2)).

formulating **target values** the policy side signalised that they are prepared to promote the attainment of the goals by appropriate political measures.

The National Strategy for Sustainable Development contains, beyond the indicators, an identification of a number of priority areas for which political measures where formulated.

The role of the German Federal Statistical Office (FSO) in developing the national sustainability indicators was rather limited. Though the statisticians from the FSO took part in different stages as experts, they were not involved in a systematic way with clear responsibilities. Insofar, even in the field of formulating the indicators, there was an obvious **dominance of the political side**.

As far as the development of the environment-related indicators is concerned the strategy for SD could heavily draw on the work on the **German Environment Barometer** of the Ministry of Environment which was published in 1999. The Environment Barometer considerably influenced and focussed the public discussions on environmental issues. The development of the Barometer was closely related to the development of the EEA. Therefore it is not surprising that five out of six indicators of the Barometer (raw material use, the energy use, CO_2 emissions, emissions of acidification gases and land use for housing and transport) were fully embedded into the EEA data-set. That is, these indicators can be derived from the EEA data by aggregation. These five indicators from the Barometer, with a few changes, are also used as the core of environment related indicators of the sustainability indicator set.

5 German accounting data and the national sustainability strategy

The German Environmental-Economic Accounting of the FSO from the very beginning was viewed by the Ministry of Environment as a contribution to the sustainability debate and the sustainability paradigm played a central role in developing the concepts and the data of the EEA. In Germany a rather high proportion of the economic and environmental indicators of the National Strategy for Sustainable Development is embedded into the accounting system. The work on the development of a socio-economic accounting satellite system is under progress. Some results have already been publishes. Important examples are the Social Accounting Matrix for the year 2000 und comprehensive time series of monetary and physical data on characteristics of private households and population[3].

Figure 3 gives an overview about the degree of **integration of the 21 indicators** of the national SD-strategy into the **accounting system**.

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[3]See Opitz / Schwarz (2004) and Opitz (2006).

Figure 3

Integration of the German sustainability indicators into the accounting data set

1 Productivity of energy and raw materials
2 Emissions of greenhouse gases
3 The proportion of renewable energy sources in overall energy consumption
4 Increase in land use for housing and transport
5 Development of stocks of specified animal species
6 Balance of public sector financing
7 Private- and public-sector expenditure on research and development
8 Capital-outlay ratio
9 Educational outcomes for 25-year-olds and number of new students
10 Gross domestic product
11 Transport intensity and share of the railways in providing transport
12 Proportion of ecological agriculture and general statement on nitrogen surplus
13 Air pollution
14 Satisfaction with health
15 Number of burglaries
16 Labour force participation rate
17 Full time children care facilities
18 Relationship between male and female gross annual earnings
19 Number of foreign school-leavers who have not completed secondary school
20 Expenditure on development collaboration
21 EU imports from developing countries

A considerable number of the economic and environmental indicators are already embedded into the accounting data set. That refers to the following indicators: "public sector financing" (6), "capital-outlay ratio" (8), "gross domestic product" (10), "productivity of energy and raw materials" (1), "emissions of greenhouse gases" (2), "increase in land use for housing and transport" (4), "transport intensity and share of railways in providing transport" (11), "air pollution" (13) "and labour force participation rate" (16). Most of these indicators are rather strongly related to other indicators of the set. Among the remaining indicators (box with broken line) the embedding of the indicator "proportion of ecological agriculture and general statement on nitrogen surplus" (12) is under preparation. The other indicators in principle could also be integrated into the accounting data set. But at least for some of these indicators integration into the accounting system seems to be less urgent.

One central classification of the accounting system which is shared commonly by all three sub-systems is the **NAMEA-type break down** (National Accounts Matrices Including Environmental Accounts) by economic activities (homogeneous branches of production and final use activities).

All embedded indicators (except public sector financing) are available in a NAMEA-type break down, (71 branches and private households). Figure 4 shows which data of the German Environmental-Economic Accounting are available in the NAMEA-format.

Figure 4

Data of the German Environmental-Economic Accounting in a NAMEA-type breakdown	Unit
Primary material by aggregated categories of material	Tons
Abstraction of water from nature and water flows within the economy	m^3
Primary energy consumption (total and emission relevant)	Terajoules
Air emissions	Tons
Greenhouse gases by type	Tons
Air pollution by type	Tons
Waste water and other discharge of water into nature	m^3
Waste by waste categories 1)	Tons
Land use for housing and transport by land use categories	km^2
Figures on the transport sector by mode of transport:	
Transport related energy consumption, fuel consumption, air emissions	Terajoules/Tons
Kilometres driven, person kilometres, tonnes kilometres	km
Transport related environmental taxes by type	Euro
Stock of vehicles by type	Number and Euro

1) Only figures until 1995, old classification.   Part of the sustainable development indicator set

NAMEA-type environment related data are provided for Germany on a regular basis for energy, primary material (raw material and imported material), air emissions, waste, water and wastewater flows, land use for housing and transport and data for the transport sector.

The area used for housing and transport is shown in the NAMEA-format in a further breakdown by land use categories. The land use category housing and transport area indicates a particularly intensive structural pressure on the natural assets category land respectively on the eco-systems to be localised there. A number of variables related to transport appear in the German accounts also in the NAMEA-format. In the sense of the SEEA 2003 a part of them can be assigned to the world of physical flow accounting (transport related energy use and air emissions). Some belong to the category of environment related disaggregation of monetary SNA flows or stocks (e.g. environment related taxes, stock of vehicles). Others, like kilometres driven, person kilometres, freight transport performance (tonnes kilometres), are not covered in the SEEA-concept up to now.

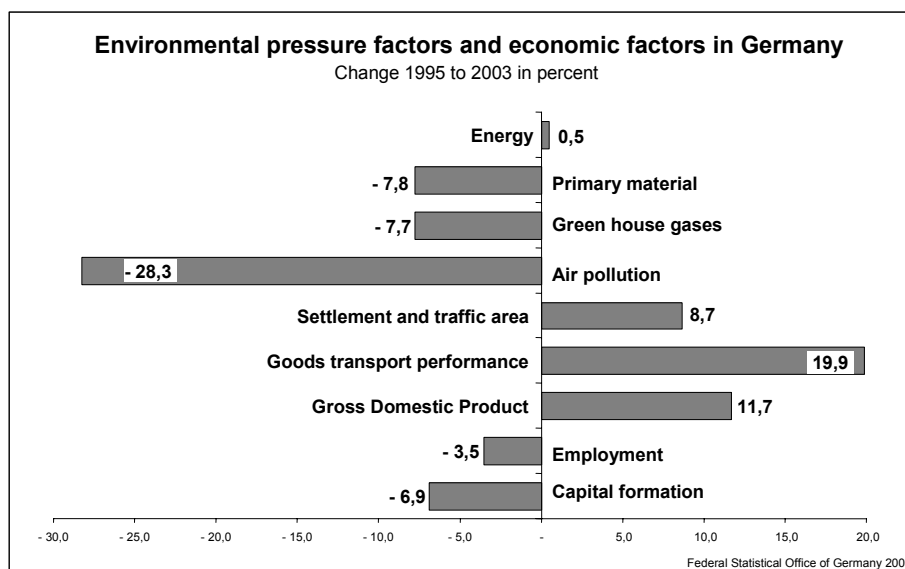## 5. Use of the German accounting data for SD analysis

The integrated accounting data can be applied for different types of analysis. Usually the environment related physical data are combined with monetary data in **hybrid analytical approaches**. Very common are descriptive approaches, like the calculation of eco-efficiency indicators on a national or a branch level, decomposition analysis (e.g. decomposition of the development of a variable by factors like economic growth, economic structure and intensity), and input-output analyses (e.g. calculation of indirect use of environmental resources). The most important and powerful application is the utilisation of the database in environmental-economic modelling approaches.

5.1 Descriptive analysis

5.1.1 Economy-wide indicators

Figure 5 shows important economy-wide SD-indicators which can be derived from the German expanded accounting system by aggregation.

Figure 5:

Environmental pressure factors and economic factors in Germany
Change 1995 to 2003 in percent

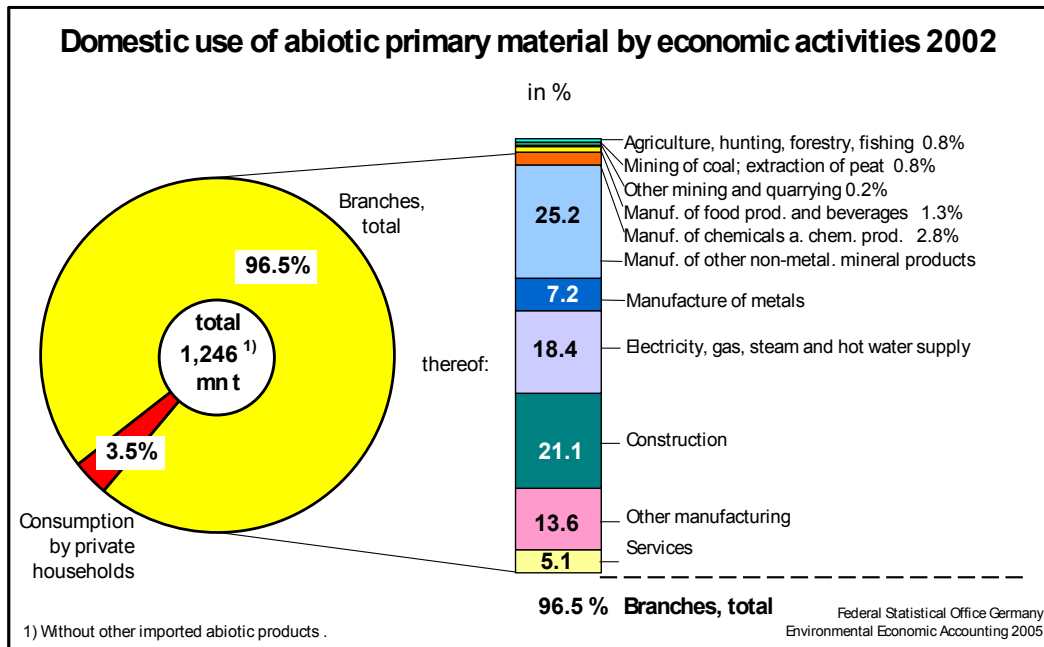| Indicator	Value
Energy	0,5
Primary material	- 7,8
Green house gases	- 7,7
Air pollution	- 28,3
Settlement and traffic area	8,7
Goods transport performance	19,9
Gross Domestic Product	11,7
Employment	- 3,5
Capital formation	- 6,9

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In the strategy the environmental pressure factors energy, primary material and transport performance are defined as efficiency indicators, i.e. they are related to the GDP. The figure shows that only goods transport performance was growing faster than GDP since 1995 in Germany. For the other pressure factors a strong **decoupling from economic growth** (decrease of environmental pressure factor with an increasing GDP) or at least a weak decoupling (increase of the pressure factor is lower than GDP-increase) can be stated.

5.1.2 Branch indicators

An important feature of the expanded accounting system is to provide a detailed and uniform break down by economic activities for various economic, environmental and also social indicators. Thus among others, the SD-indicators shown in Figure 4 are available in a **NAMEA-type breakdown** in Germany. For the environmental variables that type of subdivision **links** the respective **pressure** indicators **to the driving economic forces** (causing economic activities) in a rather detailed disaggregation.

As an example Figure 6 shows the indicator use of abiotic primary material in such a disaggregation for selected branches in physical units (tons). **Primary material** is comprised of domestic extraction or raw material and the imports of raw material and manufactured and semi-manufactured products. The share of the consumption of the private households of 3.5 % on the total use of abiotic primary material is rather small whereas the productions branches cover 96.5 %.
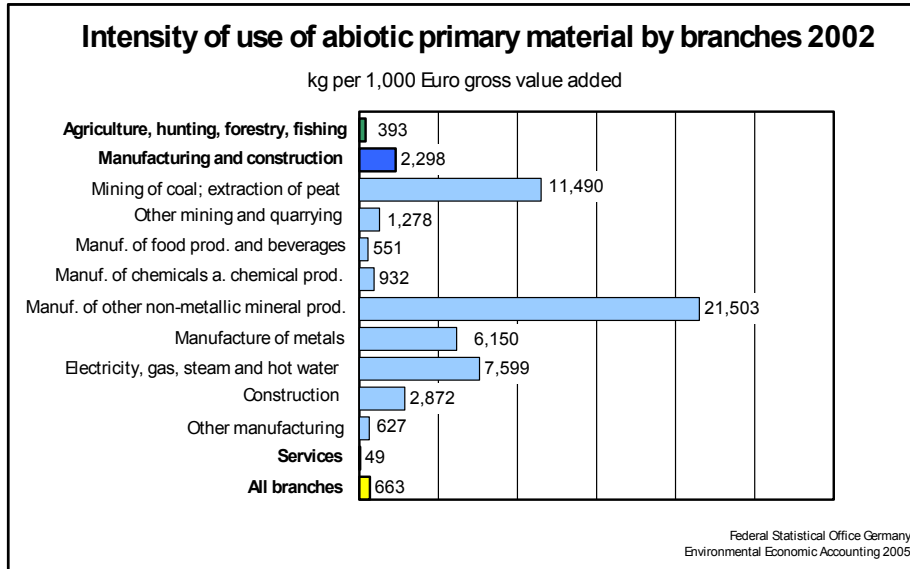
Figure 6:

Domestic use of abiotic primary material by economic activities 2002

in %

Branches, total 96.5%	Agriculture, hunting, forestry, fishing 0.8%
	Mining of coal; extraction of peat 0.8%
	Other mining and quarrying 0.2%
25.2	Manuf. of food prod. and beverages 1.3%
	Manuf. of chemicals a. chem. prod. 2.8%
	Manuf. of other non-metal. mineral products
7.2	Manufacture of metals
18.4	Electricity, gas, steam and hot water supply
total 1,246 ¹⁾ mn t	
21.1	Construction
3.5%	
13.6	Other manufacturing
Consumption by private households	Services
5.1	
96.5 % **Branches, total**	

1) Without other imported abiotic products .

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Among the production branches substantial direct users of primary material are "Manufacturing of other non-metallic mineral products" with a share of 25.2 % and "Construction" with a share of 21.1 % on the total of industries followed by "Electricity, gas, steam and hot water supply" with a share of 18.4 % and "manufacture of metals" (7.2 %). These branches together use almost two thirds of the total domestically used primary material. This high concentration of the total use of primary material on a few branches indicates that the overall development of the use of primary material as well as the **raw material indicator is mainly influenced by** the development of these **few branches**. This information alone may already be an important for policy makers to arrive at a more concise understanding about the driving forces that are behind the development of the indicator.

Figure 7 relates the environmental pressure variable to the economic world. It shows the **branch-specific intensity of the use of primary material**. Primary material intensity is defined as the ratio between the mass of the used material of a homogeneous branch to its gross value added.

Figure 7

Intensity of use of abiotic primary material by branches 2002

kg per 1,000 Euro gross value added

Branch	Value
Agriculture, hunting, forestry, fishing	393
Manufacturing and construction	2,298
Mining of coal; extraction of peat	11,490
Other mining and quarrying	1,278
Manuf. of food prod. and beverages	551
Manuf. of chemicals a. chemical prod.	932
Manuf. of other non-metallic mineral prod.	21,503
Manufacture of metals	6,150
Electricity, gas, steam and hot water	7,599
Construction	2,872
Other manufacturing	627
Services	49
All branches	663

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The **primary material intensity** in different branches is, depending on different technical conditions, quite **heterogeneous**. The average intensity over all branches achieved 663 kg per 1,000 Euro in 2002. Far bellow average was the intensity for the service branches with 49 kg per 1,000 Euro gross value added. The average value for the manufacturing and construction was 2298 kg per 1,000 Euro gross value added. Within manufacturing and construction several branches show rather high primary material intensities. Those branches are "Coal and lignite; peat" (11,490 kg per 1,000 Euro), "Mining and quarrying products" (1,278 kg per 1,000 Euro), "Other non-metallic mineral products" (21,503 kg per 1,000 Euro), "Basic metals" (6,150 kg per 1,000 Euro), "Electrical energy, gas, steam and hot water" (7,599 kg per 1,000 Euro) and "Construction" (2,872 kg per 1,000 Euro). Of course also the other the environmental pressure variable could the related in this way also to economic, environmental or social variables.

5.1.3 Decomposition analysis

In this chapter results are presented on the **decomposition**[4] of the change of various indicators of the German SD-strategy. The pressures go back partly to production and partly to consumption activities. The share of production ranges from 100 percent for goods transport performance and nearly 100 percent for primary material to about 40 percent for settlement and traffic area.
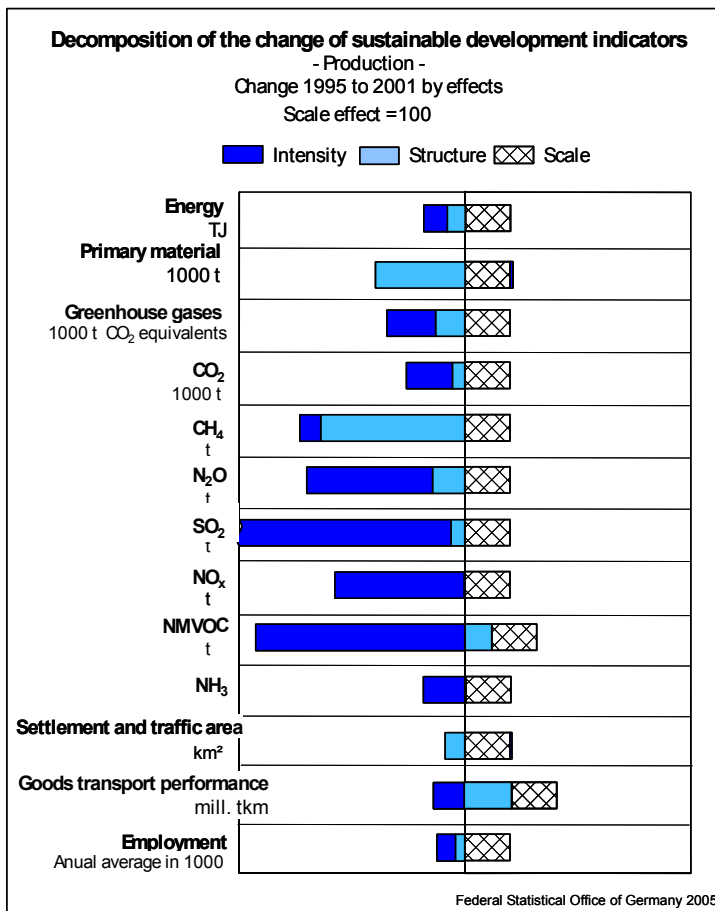
The following examples shown in figure 8 are confined to production related share of the indicators. The total change was decomposed into three effects by a mathematical approach: an **intensity effect**, a **structural** and a **scale effect**. Intensity is defined as the relationship between the respective pressure indicator and gross value added for the individual branches. Structure is depicted by a vector as the share of the individual branches at the total gross value added. The scale component is represented by development of the total gross value added. It should

[4] For the methodology of decomposition analysis see Seibel, S (2003)
http://www.destatis.de/allg/d/veroe/proser4fumw2_d.htm

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be noted that the calculation of that type of structural effect requires a breakdown by economic branches. The individual effects are calculated under the assumption that the other factors were unchanged over time. The approach transforms the relationship between the factors into an additive equation, i.e. the total change of the variable can be expressed as the sum of the three effects.

The results of the decomposition analysis for some German environmental SD-indicators and the indicator for employment for the period 1995 to 2001 read as follows:

Figure 8:

Decomposition of the change of sustainable development indicators
- Production -
Change 1995 to 2001 by effects
Scale effect = 100

Intensity | Structure | Scale

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As a matter of course, the increase of the total gross value added has a burdening effect for all environmental variables[5]. This reflects the principal conflict of goals between economic growth and reduction of environmental pressures. For most of the variables, but not all, there was a relieving intensity effect. Also the structural effect worked in most cases towards diminishing the environmental burden. I.e. the weight of economic branches with a high intensity went down over time. As far as environmental pressures could be reduced in spite of economic growth, in many cases this was the compound result of a favourable intensity and a favourable structural effect.

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[5] Unlike for environmental pressures for employment the scale effect has to be viewed as a positive factor ad vice versa a deceasing intensity is considered as a burdening effect.

But for example the decomposition of the development of primary material use yields a rather remarkable result. The analysis reveals that the positive trend of a decreasing economy-wide material use goes exclusively back to a strong favourable structural effect. Against this the development of the primary material intensity within the individual branches showed even an opposite trend and thus had a burdening effect on overall primary material use. In other words, **the decrease in the use of raw material** on an average was **not the result of** efforts to **improve the raw material efficiency** /which is roughly measured by the intensity) in the individual branches, but goes rather back to a general change in the demand structure. Among others the change of the demand structure in Germany is reflected in an increase of share of the service sector and a sharp decrease of the weight of especially construction activities.

The results of decomposition analysis can give an idea about important reasons for the change of an indicator in a summarising way, which can be communicated comparatively easy to policy makers and to an interested public.

Beyond the "standard decomposition approach" shown above various types of decomposition approaches with more than three factors are possible[6]. One further example for a **decomposition analysis** is shown below for **direct CO_2-emissions of private households by motorised individual transport activities**. Here, it is possible to distinguish between two central questions, and hence influencing factors:

1. How CO_2-intensive is private households' individual transport?
   The CO_2 intensity of individual transport is derived by the CO_2 intensity of fuel consumption (CO_2 emissions per fuel consumption in terajoules, TJ) and fuel intensity (fuel consumption in TJ per kilometres covered).

2. What is the volume of private households' individual transport? This mobility volume is quantified using the kilometres covered. The decomposition analysis provides the results shown in Table 1. Here, the mobility volume was split into an individual share (kilometres covered per person = individual mobility), the household size (persons per household) and the number of households. This means that the dissection of components carried out here creates the cross-relationships between social, transport-related and environmental values.

Table 1:

Decomposition of change of mobility-related CO_2-emission of private households by influencing factors, 1991 to 2000

Million tons

CO2-intensity of individual transport	-27.0
CO2-intensity of fuel consumption	-6.4
Fuel intensity	-20.6
Mobility volume	+18.2
Individual mobility	+15.6
Houeshold size	-4.4
Number of households	+7.0
Total Change in CO2-emissions	+8.8

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[6] See for example the GEEA press conference report 2002
http://www.destatis.de/allg/e/veroe/e_ugr02.htm

According to Table 1 the reduction in emissions caused by the decrease in the CO_2 intensity of individual transport was 27 million tonnes of CO_2 in the period 1991 to 2001. This factor is decomposed further into the emission-lessening impact of the fallen CO_2 intensity of fuel consumption, amounting to 6.4 million t CO_2, and the effect of the reduced fuel intensity, amounting to 20.6 million t CO_2. The reduced CO_2 intensity reflects the considerably increased share of fewer carbonaceous diesel fuels among the total fuel used. The fall in fuel intensity is mainly the result of a shift to passenger vehicles with lower fuel consumption per kilometre. The CO_2 intensity effect of individual transport is hence able to compensate for the increase of 18.2 million t CO_2 caused by the increase in kilometres covered, so that it was possible to reduce emissions overall.

The mobility volume was influenced by three factors. The fall in household sizes has the effect of reducing mobility volume, whilst the growing number of households increases the burden. The corresponding impact amounting to –4.4 and +7.0 million t CO_2 is however much smaller in volume terms than the arithmetical increase in emissions by 15.6 million tonnes which was caused by the increase in the kilometres covered per capita.

It becomes clear that there are **a number of highly unequal effects behind the total change of the mobility-related CO_2-emissions of private households** which are different not only in their extent, but also in their direction. The decomposition of the total change into individual factors opens the chance for formulating more well-directed measures to influence the development of that indicator.

5.1.4 Indirect effects

The **combination** of **disaggregated physical data on direct environmental pressures** with **monetary input-output tables** can yield further analytical insights. The input-output tables provide information on the intertwining of the economic branches. With that information also the indirect environmental pressures which are related to all steps of the production chain can be assigned to the products of final use with a Leontief-type approach.

Among others the results can be used for analysing the **environmental impact of external trade**. This will be demonstrated below at the example of German CO_2-emissions. The question to be answered will be whether the indirect CO_2-emissions related to the imported products are higher than the export-related indirect emissions.

The indicator of the national SD-strategy refers to the CO_2-emissions on the territory. I.e. they comprise the emissions related to the production and the consumption activities on the territory. According to that concept the emissions related to the imported products are assigned to the rest of the world. But on the other hand emissions that are generated by manufacturing the exported products are ascribed to the domestic economy. The comparison of indirect emissions for the imports and for the exports shows whether an economy is a net-exporter or a net-receiver of emissions.

The results are shown in figure 9 for Germany for the years 1995 and 2002[7]. In 1995 the export related CO_2-emissions (285,7 million tons) were higher than the import related emissions (257,3 million tons), i.e., **Germany** was **net-receiver of emissions**. Between 1995 and 2002 the imports and exports were increased substantially. However, the rise in export related indirect emissions (+89.2 million tons) was higher than the growth of import related emissions (+61,8 million tons). Consequently the German economy has become a net-receiver of CO_2-emission burdens to a growing extent.

This type of information on the effects of the development of external trade is an indispensible supplement for analysis and political decision making.

Figure 9:
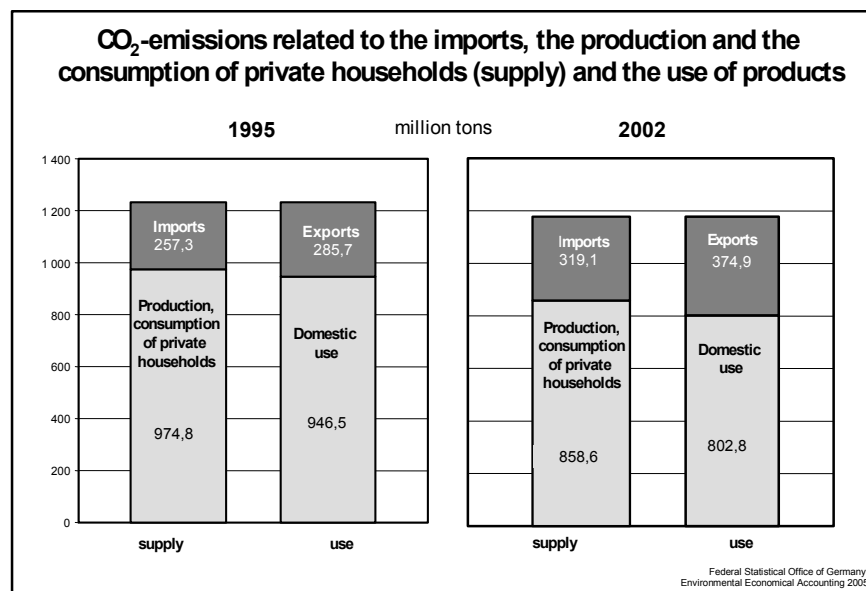
5.2 Econometric modelling

The approaches for analysing the underlying causes of the development of SD-indicators discussed above are confined to the description of the past (ex post). Additional insights can be obtained by relating the indicators **to empirically founded econometric models**, which can cover the relationship between the economic and the environmental system in a much more systematic and comprehensive manner and in an **ex ante perspective**.

In Germany such instruments for environmental-economic modelling have been developed parallel to the implementation of the German system of environmental-economic accounting (GEEA). The scientific advisory committee of the ministry of

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[7] Following the concepts of the National Accounts, the monetary data refer to the resident units. The emission data had to be demarcated accordingly. The quantitative difference between the "residence concept" and the "territory concept" can be obtained by adding the emissions of non-resident units on the domestic territory and deducting the emissions of resident units on the territory of the rest of the world. For Germany the difference is comparatively small.

environment for GEEA played a leading role in promoting the development and the use of that instrument[8].

The starting points were already existing modelling instruments for the economy. By utilising the data of the EEA these models were extended by including important environmental-economic interactions. Meanwhile the **Panta Rhei** model of the GWS Osnabrück[9] turned out to be the most used model for that purpose. That model is a multi-sectoral approach which can make maximum use of the disaggregated data base.

Such models relate the integrated data of the expanded accounting system to each other by a complex system of empirically based mathematical behaviour equations. The model-relationships, which are based on that equations can be of economic, environmental-economic or socio-economic nature. The models can be used for forecasting and scenario simulations. Those simulations are indispensable for an SD-policy approach, as they can **quantify the effects of political measures** on the target variables but at the same time the side effects on other economic, environmental and social variables, which are relevant for the SD-policy. That type of information supports the process of finding cost-efficient solutions and **balancing conflicting goals**.

The examples for the application of environmental-economic models in Germany range from modelling scenarios of rather comprehensive SD-policy approaches to more specialised exercises[10].

An important example is the contribution of those modelling scenarios to the decision making process for the introduction of an eco-tax in Germany. The basis idea of the German eco-tax system is to get a double dividend by reducing environmental pressures and by improving employment. For that purpose energy consumption is taxed and the revenue is used for subsidising the public old age pension system in order to reduce the rate of social contributions on wages. The simulations of the proposed measures demonstrated the effects on energy use, CO_2-emissions and economic variables like GDP, tax revenue and employment.

Similar more specialised exercises have been carried out referring to the situation of individual economic branches (e.g. steel industry or coal mining) or other SD-indicators, as area use. The Ministry of Research and the EU also financed more comprehensive approaches, which included a wide range of political measures for improving simultaneously the performance of economic, transport related and environmental variables like energy use, air emissions and area use.

A recent example refers to the **simulation of transport related measures** which were formulated by the Federal Environment Agency. The proposed measures were aimed at improving the performance of transport-indicators of the national SD-strategy. In addition to the direct effects on the transport indicator values the trends of a number of other environment-related, economic and social SD-indicators were simulated with the Panta-Rhei model.

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[8] See: The Advisory Committee on " Environmental-Economic Accounting " at the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (2002)
[9] See: Meyer, B. (1998)
[10] See for example Mayer, B. (2004).

Table 2 shows the forecast for the basic scenario for a number of SD-indicators until the year 2020.

Table 2:

German sustainability indicators: business-as-usual forecast

Indicator	Unit	1991	2000	2010	2020
Intensity of passenger transport	1999=100	102.9	94.7	84.9	77.1
Intensity of goods transport	1999=100	90.6	99.8	102.8	106.4
Share of rail transport to total goods transport performance	in %	20.0	15.1	13.3	11.6
Energy productivity	1990=100	104.6	122.5	137.7	170.5
Green house gas emissions	1990=100	95.6	81.2	78.8	78.1
Air pollution	1990=100	85.7	50.2	44.5	38.9
Increase of the settlement and traffic area	hectare per day	119.7	129.2	93.4	81.5
Gross domestic product per capita	Euro	21312	23943	27034	32010
Employment ratio	in %	65.8	65.5	67.2	73.2
Increase of budget deficit	in % of GDP	3.0	-1.3	3.3	2.7
Capital formation ratio	in % of GDP	23.8	21.7	17.3	15.6

Source: Gesellschaft für wirtschaftliche Strukturforschung

As one example of the results of the project the **effect of doubling** the existing **road toll for heavy goods vehicles** is shown in table 3. The table describes the differences between the results of the "measurement scenario" compared to the "basic scenario" for a selected number of variables.

According to the modelling results it can be expected that the measure will yield an improvement for the indicators values related to goods transport. The intensity of goods transport will go down by 3.6 percent points and the share of rail transport will rise by 1.8 percent points. However, compared to the target values of the strategy the proposed measure alone will not be sufficient. For reaching the target it is necessary to achieve a decrease of the transport intensity by more than 11 percent points and an increase of the share of rail transport by nearly 13 percent points compared to the business-as usual scenario. The side effects of the measure on other SD-variables are positive. CO_2-emissions will go down – but only by 2.9 million tons against a current level of total CO_2-emission of more than 800 million tons – and there will be no negative effects on GDP and employment, but a slight increase.

Table 3:

Simulation of the effect of doubling the road toll for heavy goods vehicles

	2010	2020
Intensity of goods transport (1999=100)	-3.3	-3.6
Share of rail transport to total goods transport performance (%)	1.6	1.8
CO2-emissions (million tons)	-2.7	-2.9
GDP per capita (Euro 1995)	16.0	34.0
Employment (1000)	10.0	28.0

Source: Gesellschaft für wirtschahftliche Strukturforschung

6 A strategy for integrating indicators and accounts

A **strategy** for the development of integrated indicators and accounts as the basis for an **integrated SD policy** consists of three elements to be worked on: further adjustment of the indicator set, expansion of the accounting system and development of appropriate tools for integrated SD analysis (see figure 10).

The formulation of an indicator set for SD and the creation of an integrated database necessarily has to be a long-term task. On the one hand policy demands indicators on relatively short notice for describing the sustainability problem. But on the other hand the methodological concepts for approaching the sustainability problem scientifically and politically and, above all, the appropriate database are still under development. This dilemma can be solved only by a stepwise approach.

It is the task of the political side to identify the priority issues to be included into the indicator set for SD. On that basis concrete indicators can be formulated on relative short notice by using already existing data. That was what happened in developing the present national indicator system in Germany. But indicators which were developed in such an ad-hoc manner necessarily run the risk of putting together indicators which are not linked with each other and which therefore can only be of limited use for an integrated policy on SD.

Developing an indicator set for SD that on the one hand perfectly covers the politically important issues and on the other hand is embedded into a coherent and rather comprehensive database can only be an iterative process with a threefold movement:

Figure 10

The way forward:
Strategy for an integrated sustainable development analysis and policy
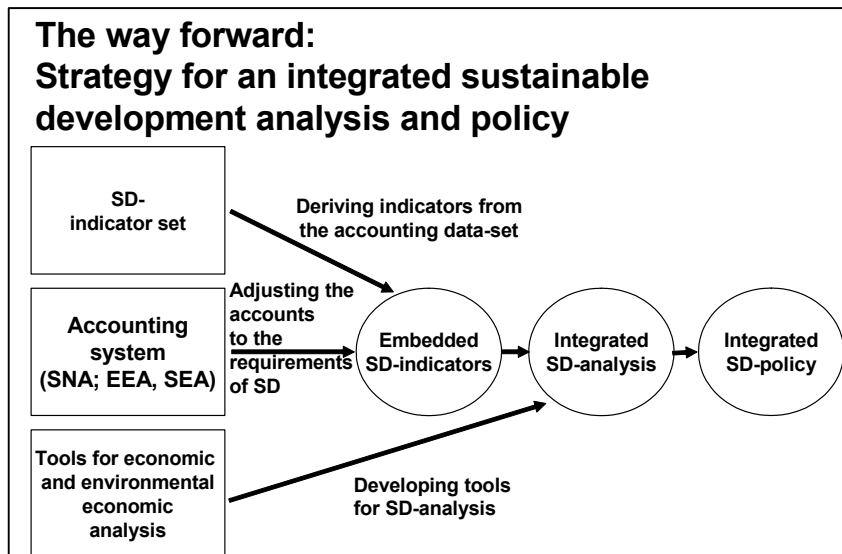
1. Future revisions of the indicator set should try to **derive** as much **indicators** as possible **from the** existing **accounting data set by aggregation**. In any case, in future it will be necessary to review and improve the existing indicator

set in the light of new problems, methodological progress and with the goal of attaining better international harmonisation.

2. The **accounting system** itself **has to be adjusted** to the new data needs. It has to be put high priority on extending the accounting data set **towards the priority issues of a policy for SD**. The accounting framework offers rather good and cost efficient opportunities of generating the required data by reformatting already existing figures. But beyond this, depending on the quality requirement, in the long run it may also be necessary to improve some of the accounting estimates by new primary surveys.

3. At the same time, also further investment in developing appropriate **tools (modelling approaches) for an integrated environmental, social an economic analysis** will be necessary. The feedback arising from concrete analytical applications of the data have also proven to be very important for a targeted development of the accounting data set

In the economic domain statistical data and especially accounting data as well as the analytical instruments utilising those data are a common basis for dealing with conflicts of interest and for decision finding. A policy for sustainable development can only stand firm in the social discourse against particularistic interest and particularistic policy approaches in the long run, if it is also sufficiently founded on data and facts. Insofar, investment in the development of a data base for a policy on sustainable development and the related analytical instruments is a necessary condition for carrying through that policy approach.

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