DIW Berlin

Messung von Nachhaltigkeit

Sondierungsbericht

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1 Introduction

This report aims at reviewing and structuring the body of knowledge that is available about measuring sustainability. The paper has been produced in the context of a research project on "Economics and Sustainable Development" funded by the German Federal Ministry of Education and Research (BMBF). This research project aims at surveying economic approaches to sustainable development in a wide context of related scientific disciplines. It attempts to make out promising lines of economic research, especially those that can bridge the gap between mainstream neoclassical economics and ecological economics.

The main purpose of the paper is to survey the existing literature, to propose a possible structure for organizing different approaches to measure sustainability, and to draw some conclusions with respect to focal topics and needs for future research.

The paper starts with issues of measuring sustainability which are relevant to all approaches to measurement, highlighting the role of economics in this field. It is shown that different that approaches to measurement are appropriate for different concepts of sustainability. It is also argued that the desired properties of indicators depend to some extent on the objectives of measurement.

In the main part of the paper three different approaches for the measurement of sustainability are discussed in some detail, name welfare related approaches, indicators derived from satellite accounts and system-analytic methods. The principal features as well as possible advantages and shortfalls of each group of methods are presented.

Central to the research project on "Economics and Sustainable Development" is an integrated, three-dimensional view on sustainability. As the discussion on measuring sustainabilty is preoccupied with ecological objectives, a special section is devoted to the measurement of social and economic sustainability.

The final chapter of the paper derives some research recommondations.

2 Cross-Cutting Issues of Measuring Sustainability

2.1 Concepts of Sustainability

A basic prerequisite for measuring anything is a clear concept of what is to be measured. The concept of sustainability, however, is rather not clearly defined. The most often quoted definition of sustainability is that of the UN Commission on Environment and Development (the so-called Brundtland Commission) (UNCED 1987).[1] Although objections to this definition can be raised (Heal 1998) it is most widely accepted, this fact being frequently attributed to its imprecision.

It captures the two concerns that are regarded to lie at the core of sustainability, namely that for the well-being of future generations and that for the constraints imposed on human life by the laws of nature (Heal 2001). Depending on whether the one or the other concern is emphasised, different approaches to measuring sustainability may be favoured. It may be argued that, as a rule of thumb, environmental and resource economics approach sustainability rather from the perspective of the present-future trade-off and remain rather vague about ecological constraints while ecological economics focus on the limited capacities of nature to support human activities.

Different approaches to intergenerational justice and different specifications of ecological constraints may be paired with each other to result in different rules for sustainability (Heal 2001), thus possibly requiring different methods of measurement. If, for example, a discounted utilitarian view is taken on the present-future trade-off, and if pure depletion is assumed to describe the constraint on the economy, the sustainability concept of Hotelling 1931 results.

Jöst 2003 makes a distinction between an ethical and a scientific-technical-economic concept of sustainability which seems to correspond to the two concerns above; he claims that only aspects of the scientific approach can be monitored by indicators.

The concept of sustainability has roots in the debate about the development of poor countries. This is caught in the requirement of intra-generational justice, also implicit in the definition of the Brundtland Commission. Together, inter- and intra-generational equity

[1] For some 30 other definitions of sustainability see the list in Pezzey 1992, Appendix 1.

can be represented in an integrated, three dimensional concept of sustainability, comprising ecological, social and economic objectives (Kopfmüller et al. 2001). There is a debate about whether or not the three dimensions should be regarded as equivalent. Ecological economist tend to give priority to the ecological dimension. Rennings 2003, for example, proposes to focus on trade-offs and synergies of economic and social with ecological objectives which in his view are the focal point of debate about sustainability. Traditional economist usually do not emphasize this distinction at all.

Economists have tried to work out more precise definitions of sustainability.[2] They may be grouped into two categories[3], namely definitions requiring non-decreasing utility and definitions requiring non-decreasing resource stocks over time (Asheim et al. 2001).

Traditionally, economists regard utility as derived from consumption of man-made as well as natural resources. A more controversial view – with consequences for measuring sustainability - is that of an existence value of stocks of natural resources which is equivalent to regarding the stocks - besides consumption - as a proper source of utility. It is debated if the view that species have an inherent right to existence (deep ecology; eco-centric view) is appropriately incorporated in the (economic) notion of an existence value. Acknowledging the multitude of sources of utility may also lead to look more closely at the social foundations of well-being (e.g. with systems of social indicators).

The attempt to determine the utility derived from non-market goods is confronted with a large number of well known difficulties (Freeman 1993, Shechter 2000) which has lead some researchers to reject this concept of sustainability as a basis for empirical studies (UGR Beirat 2002).

Both categories of definitions of sustainability are linked to each other. A non-decreasing stock of resources measured in value terms (wealth) can be seen as a prerequisite for non-decreasing utility. More precisely, sustainable development may be defined as non-decreasing intergenerational well-being, intergenerational well-being at time t being defined as the present discounted value of a stream of current well-beings derived from a

[2] See Pezzey 1992 and Pezzey/Toman 2002.

[3] Pezzey 1992 has shown how specific sustainability criteria can be derived as special cases of more general concepts such as “maintaining the capital stock”. See also Krysiak/Krysiak 2001 who use envy-freeness of the future with respect to the present as a general concept from which they derive a number of specific criteria.

consumption stream from t onward (Dasgupta/Mäler 2001). The future consumption stream of an economy depends on a variety of factors, including the economy's productive base. It can be shown that under quite general conditions intergenerational well-being increases if wealth increases (Arrow/Dasgupta/Mäler 2003). Depending on what is regarded as a source of welfare, the definition of wealth may comprise different components including natural resources, human skills, and institutions.

A non-decreasing productive base as a prerequisite for sustainability can also be justified by referring to the definition of the Brundtland Commission which demands not to compromise the economic possibilities of future generations; this implies that the productive base bequeathed to the next generation is at least as large as the one inherited from the preceding one.

Valuation of resources implies that they are substitutable against each other in their function to generate utility. This notion is termed weak sustainability: the stock of natural and men-made capital aggregated by value must be non-decreasing. In contrast, strong sustainability assumes limited substitutability between man –made and natural capital and requires that each component is non-declining. This notion can be extended to various components of the stock of natural capital if they are regarded as non-substitutable.

A position which regards some natural resources as essential for supporting human life is termed critical sustainability. It requires that the physical stock of such resources is never below a necessary minimum. To emphasize threshold effects and critical minimum stocks of natural resources in strong and critical sustainability concepts is typical for ecological economic approaches to sustainability (Pearce 1987, Steger et al. 2002).

Related to the concepts of weak, strong, and critical sustainability, a distinction is sometimes made between sufficient and necessary conditions for sustainability (Kuik/Gilbert 1999). While non-decreasing wealth is regarded as necessary for sustainability, it is frequently not considered to be sufficient: minimum conditions for specific resources have to be met in addition. This may result in a combination of welfare-related and physical indicators (Endres/Radtke 1996). There is no general consensus on what are sufficient conditions for sustainability, however (Kuik/Gilbert 1999); it has even been doubted if such conditions can be derived at all (Faber/Manstetten/Proops 1995).

Appropriate sustainability concepts may also differ according to the geographical and temporal context (Pezzey 1992, Kuik/Gilbert 1999). For example, looking at the resource base may be more relevant than observing intergenerational welfare when studying poor countries, and different resources may need protection to a different degree in different countries.

(Sustainability) Management rules can be seen as an intermediate step between sustainability concepts and indicators of sustainable development; indicators can be developed which show if these rules are observed. Famously, the Hartwick Rule describes how under certain conditions constant consumption can be maintained (Hartwick 1977). Less formal rules have been developed, for example, in a joint project of German research centres (Helmholtz-Gemeinschaft; HGF) (Kopfmüller et al. 2001). This work makes a distinction between substantial and instrumental sustainability rules and proposes indicators related to these rules. The substantial sustainability rules are classified according to the three dimensions of sustainability:

- ecologic objective: safeguarding human existence;
- economic objective: conserving the production possibilities of a society;
- social objective: securing the chances of the society to act and develop.

Each of these rules is broken down into a number of sub-rules.

Sustainability rules can also be interpreted as a pragmatic solution to the problem that necessary conditions for sustainability cannot be unambiguously determined. Sustainability rules are frequently not intended to describe a state of sustainability but rather to characterize policies directed towards sustainability (Steger et al. 2002, DIW/WI/WZB 2000); this distinction has occasionally been applied in relation to indicators.

2.2 Objectives of Measurement and Desired Properties of Indicators

Indicators of sustainable development are intended as a means of communication; a general requirement is therefore that they must reduce complexity without missing the essence (Kuik/Gilbert 1999).

Atkinson et al. 1997 quote the OECD's (OECD 1994) list of desirable characteristics for environmental indicators

- policy relevance, entailing that they
    - are easy to interpret,
    - show a trend over time,
    - be responsive to changes in driving forces,
    - can be compared to threshold or reference values;
- analytical soundness;
- measurability (at reasonable cost).

Indicators can be constructed with different objectives in mind (Endres/Radke 1998, SRU 1994). Depending on the objective different properties may be desirable. A retrospective assessment of sustainability can be based on indicators of the state of the environment (as well as the available stocks of other assets). Forecasting if an economy will be sustainable in future and formulating policies requires to describe pressures on the environment as well as modelling inter-linkages between social, economic, and ecologic variables. In principle, this knowledge can be incorporated into accounting prices (Dasgupta/Mäler 2001, Endres/Radke 1998).

For multi-dimensional systems of indicators taking account of inter-linkages requires that indicators must be based on causal relationships derived for example from economic theory. To take into account direct as well as indirect inter-linkages, system analytic (modelling) approaches can be applied.

3 Approaches to Measuring Sustainability

Various classifications have been proposed for approaches to measuring sustainability. Kuik/Gilbert 1999 distinguish

- approaches condensing all available information into one single indicator; this requires a common metric which can be e.g. money, energy, weight;
- approaches linking indicators and sub-indicators closely to National Accounts;
- free form indicators.

Rennings 2003 points to the chronology of the development of sustainability indicators. Beginning in the 1970s attempts have fist focused on the construction of a Green National Product. In the early 1990s physical indicators have been emphasized. Since the mid 1990s attention has been paid to the construction of three dimensional (3-D) indicator systems.

In the present section, we adopt the scheme of Kuik and Gilbert 1999 in a modified form. We first deal with approaches aggregating information, but limit the discussion to monetary indicators. Subsequently, we look at approaches deriving physical indicators from satellite accounts and deal with proposals to aggregate different indicators by physical units. Finally we discuss approaches resulting in multiple related indicators; we focus on methods which explicitly model economy-environment interaction.

3.1 Welfare-related Approaches

A great number of efforts to develop aggregate welfare-related indicators have been made. They include Repetto et al. 1989, Hueting 1989, Daly and Cobb 1990 and Pearce et al. 1997.

When measuring social (intergenerational) well-being, a distinction can be made between approaches focusing on constituents or outputs, and attempts looking at determinants or inputs of well-being (Dasgupta/Mäler 2001).[4] The former ones are to be aggregated by social weights, the latter by accounting prices. Measuring output is favoured by moral phi-

[4] Education for example is both, a constituent and a determinant of well-being (Dasgupta/Mäler 2001).

losophers, measuring inputs is preferred by economist, according to Dasgupta/Mäler 2001; a similar divide seems to exist between ecological economics and mainstream economics.

Pearce and Atkinson (1995) have calculated a Green Net National Product for different countries to test if the Hartwick rule is fulfilled, valuing natural resources at market prices. This procedure is criticised by Asheim/Buchholz 2000. They argue that the fulfillment of the Hartwick rule at a moment in time does not allow to infer that it can will be fulfilled in the long run, or – put differently – that substitution is possible between natural and man-made capital in the long run.

Dasgupta/Mäler 2001 argue for positive genuine investment per head to be an appropriate criterion for sustainability[5] (even in imperfect, non-convex economies with non-optimising governments (Arrow/Dasgupta/Mäler 2003)).[6] Genuine investment is the change in the social worth of an economy's (broadly defined) capital base. The social worth of the capital base (called wealth) is calculated on the basis of accounting (or shadow) prices, (which reflect trade-offs among present and future well-beings as well as the contemporary well-beings of different individuals). More precisely, the accounting price of a good (bad) is the improvement (deterioration) in the quality of life that would arise if one more unit of that good (bad) were made available costlessly. Limited substitution possibilities between man-made and natural capital would express themselves in accounting prices which make it impossible for genuine investment to be positive at the time at which natural resources run out. Accounting prices for market goods can be negative if property rights are dysfunctional as in the case of the "tragedy of the commons" (Arrow/Dasgupta/Mäler 2003).

For wealth to increase, consumption must not exceed the properly calculated net national product (NNP), but it is possible for NNP to grow for a time while a country becomes poorer.[7]

Rules for estimating accounting prices of specific natural resources under various economic institutions are developed by Arrow/Dasgupta/Mäler 2003. Empirical estimates of

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[5] See section 2.1 above for their definition of sustainability.

[6] The same index can be used to conduct social cost-benefit analysis of policy reforms (Arrow/Dasgupta/Mäler 2003). Project evaluation is not the concern of the present paper, however.

[7] Dasgupta/Mäler 2001 criticise the approach of Asheim/Weitzman 2001 to re-estimate NNP in such a way as to be proportional to social well-being.

accounting prices are easy to obtain for some assets but impossible to calculate for others (Dasgupta 2001).

Empirical estimates of genuine investment including manufactured, human, and natural capital assets have recently been derived by Hamilton and Clemens 1999 for a number of countries. Despite several limitations[8], their results for 1970-93 show that the development of several countries, despite growth of per capita GNP, has not been sustainable.[9] Earlier empirical explorations of this concept were presented by Serageldin 1995 and Pearce/Hamilton/Atkinson 1996.

Welfare related approaches – besides encountering difficult practical problems of valuation - are based on the neoclassical paradigm which has been criticised as conceptually inappropriate for dealing with ecological and sustainability issues. Pezzey 1992 quotes five criticisms

- preferences are treated as exogenous instead of being looked at as being socially and culturally determined;
- utility and production functions are assumed to remain unchanged in contrast to the view held be evolutionary economics that they may change irreversibly with variables like consumption or the state of the environment;
- utility is derived from absolute rather than relative consumption;
- inherently un-quantifiable variables such as social disruptions are neglected;
- utility and production functions show feasible trade-offs but it is unclear if these are acceptable by future generations.

A similar list of the limitations of attempts to attribute monetary values to natural resources is presented by UGR Beirat 2002 leading the advisors to a renunciation of a comprehensive valuation; for partial areas the usefulness of valuation is acknowledged, however.

Jöst 2003 lists a the advantages of welfare related approaches that

8 These are pointed out by Dasgupta/Mäler 2001.

9 China's economy has grown by 6.7 per cent annually per capita while its per capita wealth has increased by just 0.8 per cent per year.

- the intertemporal price system contains information on past, present, and future production and consumption possibilities, the state of the environment, and the scarcity of ressources;
- prices have a clear interpretation and allow to solve the aggregation problem.

As disadvantages he notes that

- the discount rate can not be determined scientifically;
- uncertainty and ignorance are not taken into account;
- intertemporal optimisation may not be tractable;
- an endogenous population cannot be dealt with.

Welfare-related approaches result in one-dimensional indicators. This is regarded as an advantage because it facilitates communication.

Because of the conceptual and practical difficulties of valuation welfare-based indicators are not comprehensive in practice but take into account a subset of society's assets only.

Plans to calculate a modified National Product which would account for environmental damages and household production have been abandoned in the German Statistical Office UGR Beirat 2002). This decision was motivated not only by the above mentioned difficulties of valuation but also by the perception that important interdependencies between the economy and natural capital cannot be adequately described within the framework of extended national accounts, and that this approach does not correspond to the need to develop prospective strategies to safeguard ecological resources.

In particular it is argued that taking into account only present changes of the quality of the environment within a specific country – as has been proposed by some authors for the next revision of the System of National Accounts – represents a short term view and corresponds to the concept of weak sustainability. Taking present economic activities - including imports - as the point of departure instead and asking how to construct them in order to avoid future ecological degradation at home and abroad corresponds to a long-term perspective and to the concept of strong sustainability. The latter approach is characterized as an avoidance cost approach while the former could be termed a damage cost approach. In the framework of the avoidance cost approach a gradual transition to a sustainable economy could be modelled and strategies which increase the efficiency of the use of natural resources as well as strategies to delimit economic activities could be considered.

Instead of calculating a green GDP the advisory committee on environmental economic accounting (UGR Beirat) recommended to the German Statistical Office to focus on the estimation of avoidance costs (mitigation costs) through modelling as these are easier to calculate than damage costs and because they incorporate the idea of precaution for future generations (UGR Beirat 2002).[10] It should be noted, however, that avoidance costs depend on the degree to which environmental damages are to be avoided; thus the proposed approach requires that ecological sustainability objectives are somehow (politically) specified.

3.2 Indicators Derived from Satellite Accounts

The theoretical and foremost the empirical difficulties encountered when discussing and generating welfare-related measures of sustainability are one incentive to strengthen the idea to build satellite accounts.

Satellite accounts can be viewed as an extension to existing (national) accounting systems. A variety of indicators can be collected and organized in such a way that a common nomenclature is used. In general this approach allows for great flexibility with respect to the unit of measurement and applied analytic tools. The possibility to organize a variety of indicators in different units of measurement without the necessity of aggregation and/or valuation is one of the distinctive features of the satellite account concept. The advantages and set-backs of this feature have to be discussed carefully e.g. with respect to the potential impact of this property for the process of (political) decision making.

The concept of satellite accounts is not restricted to environmental data (in physical terms) but encompasses also other types information sets e.g. socio-economic accounts.[11] However, in the context of indicators of sustainability satellite accounts have so far mostly been applied for the measurement of environmental facts in physical units. Relating to dif-

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10 The System for Integrated Environmental and Economic Accounting (SEEA) of the United Nations as revised by the "London Group" contains monetary valuation and calculation of an ecological national product as an option (EC et al. 2002).

11 See for example Stahmer on social accounting

ferent concepts of sustainability physical indicators can be regarded as appropriate if strong or critical sustainability is to be achieved.[12]

Following early methodological work done in the eighties and early nineties e.g. by the Statistical Office of the United Nations on a System of Integrated Environmental and Economic Accounts (SEEA, see UN 1993) a large number of international bodies as well as national bodies, e.g. statistical offices, follow the satellite account approach in their attempt to collect and organize data on sustainable development.[13] In Europe EUROSTAT and several national statistical offices[14] have decided to establish a National Accounting Matrix including Environmental Accounts (NAMEA), a concept developed in the Netherlands (Keuning 1993 and De Haan, Keuning 1996) following the approach of a Social Accounting Matrix (SAM) in the tradition of Stone (Stone 1961).

The future of accounting for sustainability will be influenced by a new handbook for Integrated Environmental and Economic Accounting (SEEA 2003). The work on this handbook was undertaken under the joint responsibility of the United Nations, EUROSTAT, IMF, OECD and the World Bank. Much of the work was done by the London Group on Environmental Accounting.[15]

The handbook comprises four categories of accounts:

- *Flow accounts for pollution, energy and materials*. These accounts provide information at the industry level about the use of energy and materials as inputs to production and the generation of pollutants and solid waste.

- *Environmental protection and resource management expenditure accounts.* These accounts identify expenditures incurred by industry, government and households to protect the environment or to manage natural resources. They take those elements of the existing SNA which are relevant to the good management of the environment and show how the environment-related transactions can be made more explicit.

12 However, as Endres/Radke 1998 point out, if critical limits are uncertain and therefore depend on social risk preferences the choice of thresholds requires valuation.

13 Beside these activities there exist other indicator sets for the measurement of sustainability which do not follow the satellite account approach, e.g. CSD

14 Pilot studies for the Netherlands, Germany, Sweden and the UK have been published in a special issue of Structural Change and Economic Dynamics in 1999 (Keuning, Steenge 1999).

15 For detailed information on the London group see www4.statcan.ca/citygrp/london/london.htm

- *Natural resource asset accounts.* These accounts record stocks and changes in stocks of natural resources such as land, fish, forest, water and minerals.

- *Valuation of non-market flow and environmentally adjusted aggregates*. This component presents non-market valuation techniques and their applicability in answering specific policy questions. It discusses the calculation of several macroeconomic aggregates adjusted for depletion and degradation costs and their advantages and disadvantages. It also considers adjustments concerning the so-called defensive expenditures.

The Federal Statistical Office of Germany organizes its sustainability indicators in a system called German Environmental Economic Accounts (GEEA) (Schoer 2003). The system combines information on physical flows, physical stocks and monetary expenditure on environmental protection and resource management. The national accounts and its satellite systems (environmental-economic and socio-economic accounts) are viewed as an appropriate framework to meet the information requirements of integrated analysis. The GEEA is seen as communication tool in itself on the one hand and as the data pool for model based integrated assessment tools on the other hand. The activity of modelling and assessment is seen as the realm of research institutes following the (German) tradition of division of labour between statistical offices and research institutions.

Material flow analysis (MFA) is a prominent tool for analyzing the impact of economic activity in physical terms (Giljum 2003). The basic idea of MFA is to analyse the composition of the physical metabolism of societies/economies and provide a measure for the physical scale of an economy. The basic hypothesis of the measurement approach is that all material extracted or moved by humans exerts pressure on the environment. It is argued that many environmental problems are directly or indirectly related to material metabolism as measured in MFA.[16]

The data for MFA are organized in satellite accounts (see above) compatible with the System of National Accounts (SNA) so that integrated economic-ecological indicators can be generated. The methodology of MFA has been improved and standardized over the

[16] The theoretical advantages and disadvantages of the industrial metabolism approach – besides the special problems of the design of indicators and measurement problems – are discussed in Gawel 1998, Hinterberger. Luks, Steven 2000 and Gawel 2000.

years.[17] The method can be applied at different levels of aggregation (e.g. micro, sectoral, macro) always using weight of material as an unifying unit of measurement. The weighting of material flows without any consideration of qualitative characteristics (scarcity, toxicities) is seen critical. This could be viewed as implicit valuation which might result in even misleading results regarding certain sustainability developments. From a analytical point of view MFA looks at the economy as a black box, e.g. no separation possible between inputs for intermediate use and for consumption – a disadvantage compared to physical input-output-tables (PIOT).

As topics of future research it seems necessary to consider alternatives to weight based aggregation and to link MFA to other physical accounting approaches e.g. land use accounting. It should also be discussed how welfare related and physical indicators could be viewed as complementary to each other.

3.3 System-analytic Methods

The term systems analytic methods is used as a heading for a variety of primarily model based analytical tools to measure sustainability. One distinct feature of these models is their ability not only to analyze direct linkages but also to cope with secondary effects.

Analytical tools are often used to explore the outcome of different possible options (scenarios) and to provide useful information (e.g. model results) for decision making and assessment. The term integrated assessment is used for the analysis of environment-economic linkages or in a broader sense for the multi-disciplinary analysis of complex, policy-relevant environmental problems. Rothmans 1998 (as cited in Tamborra, p.5) defines integrated assessment as " a structured process of dealing with complex issues, using knowledge from various scientific disciplines and/or stakeholders, such that integrated insights are made available to decision makers". Climate change is on of the current dominant domains for the application of integrated assessment. With respect to sustainability integrated assessment tries to identify unsustainable paths of development and to assess the optional outcome of potential countermeasures. Until today integrated assessment can only

[17] The analytical tool has close resemblance to input-output-analysis, e.g. there is an analogy between ecological rucksacks in MFA and indirect effects in input-output-analysis. EUROSTAT 2001 has published a

partially live up to its goal to analyse the long-term perspectives of coupled social-natural systems; up now to the focus is mainly on economic-physical interactions (Tol 2003). The integrated assessment methodology is only at the beginning to include and evaluate the feedbacks of environmental change on economic development. The same holds true for the effects of economic development on vulnerability. In current integrated assessment models the anthropogenic effects are only included in a crude form.

Concerning the general type of the analytical tools it is possible to distinguish between macroeconomic oriented models and biosphere-oriented models (Tamborra). Macro-economic oriented models are based on economic concepts and often use an equilibrium framework, but tend to put small emphasis on environmental dynamics. Biosphere-oriented models are representing descriptions of biochemical and geophysical processes and repercussions but are weak concerning the representation of the economic and social system.

Different types of models can be listed in a typology of analytic tools[18]:

- *Macro-econometric models* have originally been designed to assess the impact of economic measures and policies at macro or sectoral level. Some models have been extended to incorporate economic-ecological linkages. The models are based on coherent datasets on basis of which model parameters are estimated using econometric methods.

- *Computable general equilibrium (CGE) models* are based on a Walrasian type economic theory in which all markets are in equilibrium (implying an efficient allocation of resources). The parameters are calibrated (not estimated) on basis of a input-output-type of data sets.

- *Sectoral Models* are modelling one specific sector of an economy (e.g. the energy sector). These models are normally very detailed and fact-rich but neglect the repercussions with other markets.

methodological guide for economy-wide MFA.

[18] In addition to the model based approaches which will be discussed in more detail there exist participation oriented approaches e.g. dialogue methods, mutual learning methods and the Delphi method (Tamborra , p. 11ff)

- *System models* are based on the interdisciplinary systems theory. The system structure is characterised by positive or negative feedback loops resulting in complex, non-linear model behaviour. Large data requirements and complicated parameter identification and estimation are problems of this approach. A newer type of models simulates populations of autonomous agents interacting with each other (*multi-agent models*). The agents act in artificial surrounding which is characterized by specific economic, ecological and social properties.

Given the fact that models always can only represent a subset of the linkages and repercussions relevant in reality and given the uncertainty of exogenous variables techniques like sensitivity analysis and scenario analysis help to generate and analyse different sets of optional model based outcomes taking into account risk and uncertainty.

Based on different sets of model based outcomes or other data sets some methodologies help to assess the final, overall impact of certain policy strategies.

Cost-benefit analysis (CBA) is a comprehensive method which accounts for the negative (costs) and positive (benefits) effects of policy measures. Practical limitations of the approach are the difficulties to quantify certain benefits (and costs) and the definition of the appropriate social discount rate. *Cost-effectiveness analysis (CEA)* relates the effect of a policy measure to the amount of inputs (total costs) required. By avoiding the difficulties to quantify benefits this method aims at minimising costs. The question of an optimal level of intervention and net welfare gains is not tackled by this approach.

The approach of *multi-criteria analysis (MCA)* covers a range of different methods. The common goal of these techniques is to combine a diverse set of (positive and negative) impacts – eventually produced by different analytical tools – into a single (decision-) framework. The impacts taken into account could be a mixture of quantitative and qualitative data showing varying degrees of uncertainty. The decision framework should be constructed in a way that it facilitates a consistent and easier comparison of results and in such a way assists the decision-making process. A feature of multi-criteria analysis is to embed the people involved, e.g. politicians, scientists and stakeholders, into the social context of decision-making.

From the viewpoint of measuring sustainability MCA is especially appropriate as it explicitly acknowledges the interdisciplinarity and multi-dimensionality of sustainability. Three special requirements for MCA can be listed with respect to the application in the field of sustainability measurement (Rauschmayer 2003:

- inclusion of the rights of future generations by discounting, critical nature capital or representatives
- hierarchical relation between nature, social system and economic system
- role of science and scientist in decision process should be made explicit

In future the robustness of results of MCA over a long-period of – a time horizon typical for sustainability problems – should be investigated more closely. It might also be useful to start research on the meta discussion of defining appropriate weights for aggregation.

4 Measurement of Social and Economic Sustainability

It has been mentioned (in section 2.1 above) that sustainability can be interpreted as a three-dimensional concept, comprising ecological, economic, and social objectives. This view has not remained undisputed; for various reasons many policy makers and researchers have proposed to focus primarily on natural resources and the environment. This narrower focus also has a longer tradition as a subject of research on sustainability, e.g. in forestry. It is therefore quite understandable that the discussion on measuring sustainability reported in the previous sections is primarily centred around ecological sustainability. There are a number of reasons, however, to adopt the three-dimensional perspective.[19] We therefore devote this section to the problems of measurement of social and economic sustainability.

It seem essential to clearly distinguish between social and economic sustainability objectives on the one hand and a social and economic perspective on sustainability objectives on the other hand. The latter interpretation relates to a division of labour between academic disciplines (and points towards the challenges of interdisciplinary research). For example, ecological sustainability can be analysed applying concepts and tools of economics, i.e. from an economic perspective, as we hope we have shown in this paper. The former interpretation rather assumes different objectives of separate societal systems and seeks to mitigate trade-offs among them. This is the view upon which the following discussion is based.

Since the mid 1990s attempts to measure sustainability have focused on three dimensional indicators according to Rennings 2003. They include the Driving Force-State-Response approach of the Council on Sustainable Development, the indicator systems developed by the HGF-Project (Kopfmüller et al. 2001), and indicators related to company ratings such as the Dow Jones Sustainability Index (DJSI) and the Sustainability Asset Management (SAM) Indicator.

4.1 The Social Dimension of Sustainability

The social dimension of sustainability has been interpreted in different ways (Kneer 2000). Often the social system is understood to be an overarching entity that comprises economy, policy, science and other systems in which human interaction is organised. Alternatively, it

[19] To mention just one: it is difficult for some societal groups like labour unions to connect their traditional concerns to one-dimensional, ecologically oriented sustainability strategies. See DIW/WI/WZB 2000.

is understood to be a branch of policy related to equity and redistribution and thus relying on institutions different from markets.

More so than for the ecological dimension of sustainability (and probably more than for the economic dimension, too), the interpretation social criteria depends on the context. Therefore it is difficult to formulate something equivalent to minimum standards or carrying capacity of social systems. As with ecological and economic systems unavailable contributions of systems can be sometimes substituted by functional equivalents.

Approaches to define and measure the social dimension of sustainability can be classified according to the following keywords (Kneer 2000):

- social capital;
- basic needs;
- social indicators;
- social compatibility; sometimes this is understood as a just distribution of the costs of ecological sustainability policies.

It has been proposed to capture the social dimension of sustainability through a time accounting system (UGR Beirat 2002, Stahmer 2003). Together with a monetary accounting system for the economic dimension and a physical accounting system for the environmental dimension a complete representation of sustainability issues is envisioned. All three accounting systems could be embedded into the Input-Output framework thus permitting an integrated assessment, e.g. of the sustainability of social security systems. It is regarded as essential, however, not to restrict the accounting of time budgets to paid work. By accounting for the entire use of time of all members of society distributional and gender issues could be made visible.

A number of difficulties of implementing such systems is expected, starting from the collection of data to the application for modelling. In particular, it is an open question how different "qualities" of time could be distinguished.

The vision of an integrated accounting and modelling system touches upon unresolved problems of inter-disciplinary cooperation in sustainability research. It is generally agreed upon, that the multi-dimensional nature of sustainability issues requires such cooperation.

There also seems to be a broad consensus that specific problems should be dealt with from different disciplinary perspectives first, but that than a discourse between the disciplines has to follow (Stahmer 2003).[20]

4.2 Social Capital

Approaches to measuring sustainability can be based on wealth – the social worth of an economy's productive base. The productive base of an economy includes social relations, civic engagement etc. which have been termed social capital.[21] More specifically, social capital has been defined as "…features of social organisation, such as trust, norms, and networks that can improve the efficiency of society by facilitating coordinated actions." (Putnam 1993, p. 167). Although it seem attractive to deal with the social dimension of sustainability in an integrated framework with the ecologic and economic dimension (Bizer 2000), it is quite obvious that this definition isn't well suited for measurement.[22]

Social capital has frequently been identified with institutions by economists. One can then argue that institutions should not be regarded as a form of capital but as a resource allocation mechanism (Dasgupta/Mäler 2001), not constituting a part of the productive base but – among other influences – determining accounting prices. Then institutions and their co-evolution with the state of the economy have to be understood but need not to be measured.

Apart from measurement problems, arising from the heterogeneity and ambiguity of the features summarized as social capital, several conceptual problems have been raised:

- Social capital – as introduced by Coleman 1990 - seems rather appropriate for characterising social systems in less developed societies while modern industrial societies depend on formal institutions (Kneer 2000);
- Focusing on social capital obscures the issues of justice (Feindt 2000);
- It is unclear if and under which circumstances social capital is positively correlated with ecological sustainability (Feindt 2000, Linscheidt 2000).

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[20] For an attempt to conduct such a discourse see DIW/WI/WZB 2000.

[21] A positive relationship between economic performance and indicators of civic engagement has been shown empirically for Italian regions by Putnam (1993).

[22] See the contributions in Dasgupta/Serageldin eds. 2000 for a critical discussion of this concept.

4.3 The Economic Dimension of Sustainability

Frequently the view is expressed that the economic dimension of sustainability is elaborated more clearly than the social dimension. However, this opinion seems due to a confusion of the economic perspective on sustainability[23] which is actually quite elaborated and economic sustainability objectives which are not well defined at all. Many different interpretations of the economic dimension of sustainability have been proposed. Frequently they are overlapping with social and/or ecological sustainability criteria. For example:

- The concept of sustainability is strongly rooted in the debate about economic development; thus economic sustainability is frequently identified with development objectives such as the alleviation of poverty.

- Often economic sustainability is identified with safeguarding the productive base of an economy (although this concept integrates ecological (and social) objectives as well).

- A different interpretation links economic sustainability to optimal allocation (Rennings 2003, Stavins et al. 2002, Requate 2001)

- Distributional issues – either inter- or intra-generational – have been interpreted as predominantly economic objectives (they are claimed as the domain of social sustainability as well).

- It has also been argued that the economic dimension of sustainability should focus on criteria of stability; this implies that the composition instead of the level of economic activity is emphasized (Stahmer 2003, DIW/WI/WZB 2000).

- Further proposals for criteria of economic sustainability include growth, full employment, international competitiveness, the ability to innovate, competition etc. (Rennings 1999).

[23] It can be argued that the economic perspective on sustainability integrates different sustainability objectives as in the (broadly understood) concept of sustained wealth.

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