Indicator sets for assessments (SIndbAT)
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Indicator sets for assessments

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1 Introduction

Since the UN Conference for Environment and Development (UNCED) 1992 in Rio de Janeiro indicator–based assessments of international, national, regional and/or local sustainability have received an increased amount of attention. Indicators are seen as important instruments to assess current situations and progresses towards more sustainability in societies. They should help to understand, capture and communicate information about the complexity of reality and to resume them to information with high insights about the assessed system.

Sustainability Indicators are also the basis for several other assessment tools, like scenario analysis, modelling or cost–benefit analysis.

A huge amount of different indicator sets, differing in their spatial temporal and thematic scopes, have been developed meanwhile by various agencies on all political levels. And the international scientific and policy community is making strong efforts to further develop appropriate indicator–based assessment sets for measuring sustainable development and to implement the collection of SI for assessments.

This overview paper presents the main characteristics of indicator–based assessment from a general perspective, without focusing on particular indicator sets. The aim should be to figure out the critical points as well as the strengths and weaknesses of indicator–based approaches to sustainability assessment.

2 Methodology

Chapter 40 of the Agenda 21 (UNCED 1992) asks local, regional, national and international, governmental and non–governmental organisations to contribute to the development (40.6.) and application (40.7) of indicators for sustainable development on all spatial and political levels, as the existing common indicators (e.g. GDP or indicators for specific resource and pollutants flows) are not providing sufficient insights to the actual state and development of the earth eco– and socio–economic systems. As “bellwether tests of sustainability” (Sustainable Seattle, 1993) indicators are supposed to provide both, insights to the state of a (eco– and/or socio–) system operationalized in different state characteristics and their linkages and definitions of a “desirable” future state of a system. Therewith indicators should measure the distance between the desired and the current state.

Indicators in general are defined as correlates or proxies depending on an interesting dimension or component of a complex system under consideration which cannot be measured directly (Coenen et al.,2001). The aim is a) to provide insights to the state and the development of the system by reducing the complexity, b) to assess by quantitative and/or qualitative criteria the interested issues and c) to describe a desired future stage of the system and its components.

According to MacLaren (1996: pp186) Sustainability Indicators (SI) in contrast to the already longer existing indicators for particular dimensions of sustainable development (e.g. ecological, economical, and social) should be:

- integrating in the sense of attempting to cover linkages among the environmental, economic and social dimensions of sustainability
- forward-looking to be able to measure progress towards achieving intergenerational equity, a key issue of sustainable development
- distributional, i.e. to be able to measure not only intergenerational aspects but also intragenerational issues in terms of accounting distributions of conditions within populations and spatial units and
developed with input from multiple stakeholder in order to archive influential, valid and reliable indicators within a value–laden and context–specific concept as sustainability.

The intended purpose is to set priorities and the request to take actions to achieve the intended goals of sustainability. However, as both sustainable development and indicators are complex and value–laden concepts with normative implications, they also provide broad space for discussion and controversy. Hence, indicators are never a complete and entire picture of the reality, which they should represent (Benninghaus, 1994). Due to a variety of reasons they are not coinciding exactly with the systems dimension of concern. There is always a difference between the indicator(s) and concerned dimension. The term “indicator” should be taken therefore literally as it provides just an indication of the systems conditions and problems (MacLaren, 1996). As an indicator can also fail in representing the issue under concern it is supposed to base the assessment always on multiple indicators and to develop indicator sets to address the different aspects of the interesting dimension However, this can lead to a conflict of the aim of reducing complexity, as such indicator set can become very complex itself. One has to find a balance between validation requirements and complexity reduction.

### 2.1 Classification of indicators

A lot of different SI–sets exist for an indicator–based assessment. Depending on their specific focus and understanding of sustainability these SI sets are rather different and can be grouped by different classifications.

First, all SI–sets are based on a specific conceptual framework, which defines the basic assumptions of the assessment, e.g. what are the issues of concern, from which perspective the assessment will be done and how sustainability is understood. These conceptual frameworks are supposed to ensure the comprehensiveness or at least the consistency of the selected indicator set. Each conceptual framework establishes a unique approach of assessing information about the system under consideration (Besleme/Mullin, 1997:43).

MacLaren (1996) provides a comprehensive overview on different conceptual frameworks of indicator development and use. She distinguishes 5 different frameworks, namely:

- **domain–based:** This framework starts with defining the key dimensions of sustainability and identifies indicators for each of them. According to MacLaren it is most effective in covering all dimensions of sustainability, but fails in linking the indicators with sustainability goals.

- **goal–based:** This framework starts with the identification of the sustainability goals and creates one or more indicators for each goal or goal combination. One weakness of this approach is that it has difficulties in capturing complex interrelations among the various dimensions of sustainable development, as it is still a fairly simple indicator approach.

- **sectoral:** Within this approach indicators are developed for each sector for which the administration has typically responsibilities. Therefore the actual coverage of sectors depends on the political scale the indicator set is aimed for. It is suited to assessments of policy performance, but is not very effective in indicating linkages across different sectors.

- **issue–based:** This framework starts with identifying and listing of key issues of sustainability in the system of concern, e.g. air quality, water resources, employment. To theses key issues one or more indicators are linked. Like the sectoral framework the issue–based framework is rather context specific as the key issues many differ among assessment contexts.

- **causal:** This framework goes beyond the above one by considering cause and effect relationships. Human activities are seen as affecting environmental conditions as stressors, which in turn has impacts to health, economy, and social conditions. To these impacts policy is responding due to alleviation of the stressor or modifying the environmental conditions directly. Within the framework indicators will be developed for the stressor, conditions and the policy reponses. However the distinction between the different cause effect relations are not always clear.

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The most commonly used conceptual frameworks in sustainability assessments are the domain-based and causal frameworks, often applied in combination.

Within the ecological dimension of sustainability the OECD (1993) has developed the Pressure-State–Response framework which groups the information about the underlying system in three interdependent categories. The first category „pressure indicators“ gives information about man-made environmental stress. The „state indicators“ aim at informing about environmental quality and last the „response indicator“ category indicates how and to which extent the society react to environmental changes. This causal framework within the ecological dimension of sustainability was enhanced in 1996 by the UN–Commission on Sustainable Development (CSD) and the UN Statistics Division (UNSTAT) with the Driving Force – State – Response (DSR) framework. This framework was developed together with a catalogue of 134 indicators for all three dimensions of sustainable development. This framework again has been enhanced by the EEA with the pressure–category and an impact–category to the Driving Force – Pressure – State – Impact –Response (DPSIR) framework considering all human activities (processes and archetypes) with negative and positive impacts to sustainability. Based on these three frameworks the most approaches of indicator–sets have been development. However, most often indicator sets for sustainability assessment focus either on the ecological dimension or on combinations of ecological and economic indicators.

The indicator set of CSD and UNSTAT should be the reference set for the national reporting about progress towards sustainability, asked by the CSD (UNCSD, 1996). Hence, the approach has been adopted as well by Eurostat, the European Commission and the EEA for their own indicator–sets (Commission, 2001).

Beside the distinction of indicators according to the underlying conceptual framework, SI–sets, as already mentioned, can differ widely with respect to geographical, temporal and or thematic scopes. According to this second classification SI–sets can be distinguished into hundreds of different groups, from the global to the local level, from society assessment to assessments of individual ways of life.

A third classification of indicator–sets is according to their complexity and the aggregation level. In general, existing indicator–set approaches can be grouped on an analytical level into two different classes:

**List of indicators**

A list of indicators consists of series of measures that do not stay explicitly in a relation to each other. The single measure can be, but not necessarily, observed and displayed directly on a scale. It is the most widespread approach to capture and measure sustainability in numbers. A series of lists of indicators have been developed by different governmental and non–governmental institutions. These lists are more or less detailed and differ in its geographical and/or temporal scale or thematic approach. Some approaches use one list for each of the three dimensions of sustainability, others link indicators for all three dimensions to only one list. Examples for lists of indicators are the OECD Environmental Indicators (OECD, 1993), the CSD Indicators of Sustainable Development (UNCSD, 1996), but also the European Environmental Indicators (EEA, 2005) and the majority of Local Agenda 21 Indicator–sets.

**Indices**

A second classe form indices, merely based on lists of indicators. In comparison to a list of indicators, however, indices aggregate the rather complex information of the underlying list into a single value to improve communication and quick reference. This implies a selection, appraisal and weighting of the underlying indicators. For this procedure, however, is rather subjective as a clear and objective basis is not existing (Landis/Sawicki, 1998) and the single variable can’t be observed and displayed directly. Furthermore, indices reflect a particular perception of and theory about reality (society and nature) and value judgement about what is important (Innes/Booher, 2000: 176) Hence, by reducing complexity through aggregation a loss in information about the underlying system and on transparency occurs as well.
The aggregation requires also a common denominator or unit. This is normally a dimensionless value between 0 and 1, a percentage figure of change, a monetary or currency unit or physical value like land-use or resources use. The selection of the denominator, however, influences as well the selection and weighting process of the variables. Aggregated measures, like indices, often only have little meaning to the potential users of the indicator set and there is agreement that it is not possible to define only one single index of sustainable development, rather that a substantial number of indicators are needed to capture all complex and important aspects of sustainability. Moreover, an Impact Assessment indicator-sets has to reflect the complexity of interactions of natural and human systems (Bossel, 2001) as well.

2.2 Aims and function of indicators

As with the most tools used for an assessment indicators have the general aim to inform the public, experts and decision makers on the actual state of the system of concern and to assist to analysis and decision making.

The particular aim of indicators, as said already above, is to densify information about complex systems, that are not directly capturable, into signs and measures which allow the description and communication of the underlying issue. In this sense indicators to assess sustainable development, should give information about (1) the stage of the described system and the need to act for sustainability (urgency), (2) whether the system of concern is moving towards more sustainability or rather away from it (direction) and (3) where and what has to be done to improve the current situation and to archive more sustainability (intervention). This reduction and classification of information enable a temporal and spatial comparison of different states and systems and its development (Birkmann, 2001), but also with the danger of undesired lost of information if indicators are not proper selected or developed. Therewith indicators should provide guidelines to management and decision making by focusing on relevant aspects.

However, as Innes and Booher (2000) argue, indicators are not aiming to evaluate the impact of a particular policy directly. Indicators are measures of specific characteristics of an eco–system, society or other systems, which are chosen because these characteristics are seen as important. Other characteristics are not considered, which might be important for a coherent policy evaluation as well. Indicators can show improvements and policy impacts in the observed characteristics of the system, but they can not tell about whether and what policy was the cause. Thus, SI–Sets can support decision–makers in policy development.

Nevertheless, indicators can be used to evaluate policies as well. By using indicator sets not to assess the policy impact on the system but to evaluated policy performance and customer satisfaction with a policy (Osborne/Gabler, 1992), the quality of a specific policy can be derived. In this sense indicator sets are not applied to the actual system of concern, but on the policy aiming to solve the problem at state. Within this approach other types of indicators are needed and it differ from other indicator aims because it emphasises dialog with relevant actors in the design and use of indicators and their interpretation.
3 Process for development of indicators

To ensure the adequacy of the provided picture of the system, the selection of indicators should be mainly driven by their relevance for the issue to assess. If an issue is identified, the indicator which represents this issue best should be selected. This selection or development process is mostly derived by scientists, a central authority, or another source external from the system under consideration but with expert knowledge on it. This traditional expert driven approach is working on an intuitive and discipline biased basis. By doing so the selected indicator should provide rather objective and knowledge-based measures of the reality. However, both the content of an issue (problem at state) as well as the indicator which should represent this content might be rather controversial. Even the desirable future state of the system might be controversial as well. Hence, the entire selection process is depending on normative implications and subjective perceptions based on personal norms and values, but also on interests. Therefore it can be judged that there is no value free indicator, but all serious indicator work is subjective and political because indicators mirror the perspectives, norms and values of the actor or group developing them. "Even with a solid scientific approach based on physical facts as well as systems theory and analysis, indicator cannot be defined without a significant amount of subjective choice" (Bossel, 2001: 9). Thus Innes (1990) give the process of development an important role in usage and application of indicator sets by arguing that if indicators are defined as instruments for managing, this should not only consider its application, but also the development of indicators. However, little attention is normally paid to the process of indicator production or development.

One of the most important precondition for a influential and effective indicator system is to focus on a clear purpose and to reflect the norms and values of the user, i.e. a community having a stake on the assessed system (Besleme and Mullin, 1997: 50). If this is not respected indicators sets might be of little use and meaning for the intended user. Thus Innes and Booher (2000) argue that indicator sets must be developed with the participation of those who will use and learn from them, if they expected to be useful in their application. This approach of collaborative indicator development and incorporation of stakeholders in the development and selection process is getting increased recognition meanwhile. In particular in North America various experiences in participatory or collaborative development of Sustainability Indicators are existing. In Europe this alternative approach is not that common up to now. Landeiro (2006) ascribe this to different traditions in public participation and participatory decision making. However, with the new European legislation according to public participation and transparency of policy this will change in the next years.

Beside focusing to the target audience and reflecting the purpose of the indicator sets several other important criteria and requirements for the development and selection of sound indicator-sets can be found in the literature. Most of them are rather technical driven. The most commonly mentioned technical requirements for SI-sets are:

- coverage of the major sustainability issues
- adequacy of the provided figure of the assessed issue
- international comparability
- availability of data and
- reliability of direction and target focusing

The actual development process of an indicators set follows several steps from defining the system under consideration and delimiting of the system boundary, via identifying relevant system components important for the problem at state, defining goals and the connected time horizon to reach these goals to selecting adequate indicators representing these issues. The detailed steps depending on the selected conceptual framework, the scale and thematic scope and on various other circumstance. An general overview about indicator development process is give for example by Reed (2002, 2005), Bossel (2001), Bell (1999), Redefing Progress (2002).
4 Review

The above delineation of indicators may illustrate the variety of indicator-sets and indicator-based assessments, particularly for sustainable development. Therefore it seems necessary to evaluate indicators with respect to the operational aspects to be considered for using this tool, the crosscutting aspects of the sustainable development concept defined for the European Sustainable Development Strategies and which impact are covered by an indicator based assessment. Furthermore strengths and weaknesses of an indicator-based assessment will be described, as well as possible linkages to other assessment tools to eventually overcome the weaknesses.

4.1 Evaluation results

4.1.1 Supported policy processes

In the process of policy development and implementation an indicator-based assessment may support the process on different stages. Within the policy-cycle framework (Brewer/de Leon, 1983) first of all indicator sets can support the initiation phase by identifying the „urgency“ to act. This may be described best with the application of state indicators, according to the DSPIR framework. Here indicators may play the role of initial impact for the exploration of a policy.

Secondly indicator sets can support the policy-estimation phase by providing parameters to other tools, analysing the likelihood that the explored policy proposal will be successful, like models or scenario tools. Parameters link to estimation can be the assessment of risks or costs and benefits of the policy proposal, for which an indicator-based assessment can provide measures.

Finally, in the Policy-evaluation phase indicators can assess selected and implemented policy option, if the target issue of the system is selected properly and stakeholder are involved in the process. However it is not possible to entirely assess policy outcomes and impacts of a specific policy by an indicator based assessment. Impacts of policies are mostly complex as well and have influence to many different components of the human-nature system. Although indicators can measure rather good certain states of system components and therewith also the impacts of a policy to this components, it is not possible to cover all possible components impacted by a policy.

4.1.2 Overview of operational aspects

Due to wide variety of different approaches of Sustainability Indicators, the operational aspects of an indicator based assessment differ widely as well. Some raw data for indicators are accessible easily from official statistics, like economic data or many ecological or even some social data. Costs and manpower to invest for the assessment in these cases are relatively low. However, often specific data considered as important for the assessment are rather difficult to obtain, e.g. many social data or other qualitative data and reliable perceptions of stakeholders. Then the efforts to obtain the required information can be rather high, which increases the costs to invest in the assessment.

In general: the more complex an indicator set is, the more cost intensive the assessment is. Both for the collection and the aggregation of data. In some cases the investments tends to increase that high, that it will be impossible to develop or incorporate indicators for a certain issue.

A second source of cost is the application of the indicator set. To be valuable for decision maker and other user indicator sets have to be updated frequently. The collection of new data for each indicator in the set might be cost intensive as well. The more complex and the more indicators the set consists of, the more cost intensive the assessment is.

However, due to participation the costs can be reduced. By incorporating stakeholders into the development process of indicators, the involved actors can contribute with their tacit knowledge and/or their data sources
which might be inaccessible otherwise. Furthermore stakeholder can provide access to data sources by their
own networks and further increase the data access for indicator sets.

4.1.3 Overview of crosscutting aspects

The European Sustainable Development Strategy (EU, 1998) defined twelve aspects of sustainable
development representing linkages between the three dimensions of the sustainability concept. For an useful
sustainability assessment or an impact assessment of a specific policy in particular these cross−cutting aspects
are rather important.

In this regard indicator−sets are rather suitable for assessments, as they can address particularly well
cross−cutting aspects of Sustainable Development and in general all defined aspects by the EU can be
addressed. However, often indicator−sets concentrate only on specific single aspects without considering
cross−cutting aspects. Depending on the approach and the class of indicators, they can more or less assess:

- Inter−generational equity
- Distributional equity
- Decoupling
- Global responsibility
- Spatial scale; differ widely in its spatial coverage

4.1.4 Overview of covered impacts

Indicator−based approaches to assess Sustainable Development are intended to cover all impacts of
sustainability. In fact it seems not possible to easily apply indicator−sets to of them. Impacts which could be
quantified in numbers, like the most environmental or economic ones can be cover more or less easily. But for
impacts which require not quantification, but rather a qualification indicator−sets have difficulties and deal
with high uncertainties. That counts in particular for social impacts of Sustainable Development.

In particular impacts like social cohesion, employment quality, public health, liveable communities or social
capital are quite difficult to cover with quantitative indicators. Nevertheless, in principle it is possible to provide and to assess qualitative data as well. But this needs a
translation of this qualitative data to quantitative data or another methodology to deal with qualitative
descriptions. Where this is not possible mostly these aspects remain uncovered (see chapter 3.7 Strengths and
weaknesses).

Easily to asse are impacts of environmental sustainability, because most of them can be quantified. Also
economic impacts can be covered quite good, as economists have developed a broad spectrum of indicators to
assess these kind of impacts.

Depending on the selected approach of indicator−sets and the process of their deveopement, an
indicator−based assessment can also cover cross−cutting impacts, like intergenerational impacts.

4.2 Discussion of practical experiences

Since the World Summit 1992 in Rio de Janeiro several governmental and non−governmental institutions on
all levels have developed approaches for indicator sets to assess the current state and the development towards
more sustainability with different geographical, thematic, temporal and political scopes. On the international
level the most citied approaches are the Indicator catalogue of the UN Commission on Sustainable
Development (CSD) (UNCSD, 1996), the Environmental Indicators of the OECD (OECD, 1993) and, in
particular for the European Union, the EU Commission's Sustainable Development Indicators (CEC, 1997)
and the Environmental Outlook Indicators of the European Environmental Agency (EEA, 2005).

As the CSD approach is the official reference frame for the national reporting to the UN commission, several
national indicator sets, as well as regional and local approaches, have been developed according to the indicator set around the world. In particular on regional and local levels also varies indicators sets using a different approach have been developed in the last decade. Hence, meanwhile on all political levels research and development activities for indicator based assessments are existing (Birkmann et al., 1999). Also the scientific community was very active in this field and provided lots of indicator sets as well. One could argue that indicator based assessments are the most applied approach to assess sustainable development and to evaluate impacts of specific measurements.

However, the influence of indicator sets and indicator−based assessments are often very weak. Some indicator sets have been rather influential within the scientific community, fews are also influential in policy making, while the most remain used but without any influence on policy and public action (Innes/Booher, 2000). This calls in particular for indicator based assessment of sustainability on higher levels than the local.

If indicator sets have influence on policy making this influence is most often indirect and it can take very long to occur. Nevertheless, in fact indicators have inspired debates in many fields of sustainability.

4.3 Strengths and weaknesses of Indicators

As shown above, sustainability indicator−sets depend strongly on the underlying comprehension of sustainable development. Therefore the quality of sustainability assessment hinges for a large part in first step on the quality of the system description. In a second step it is also depending on the selection and development of the indicators them−self.

Indicators are always subjective concepts, depending on normative implications and perceptions of the actors involved in the selection, development and application of them. There is no indicator set coming from law of nature. All of them are constructed in a more or less subjective social process. This means that for the application of indicators the applicant has to know the underlying axioms of choice and the boundary and description of the system. If not, indicators stick to be arbitrary and meaningless in communication. This holds in particular for the assessment of sustainable development, as an inherently complex and controvers concept.

From this nature of indicators it explains the most important weakness of an indicator−based assessment, namely the underlying subjectivity and therewith the implicit lacking influence. This weak point of an indicator−based assessment is also related to the process of the development of the indicator−set. Is the indicator−set developed according to the described requirements and considering the perspectives, norms and knowledge of the relevant actors, this weakness can be minimized.

A second weakness occurs from the fact that indicators tend to cover only quantitative aspects. Qualitative parameters were tried to commute into quantitative variables. Many aspects of sustainable development, however, could only be described in a qualitative way. These aspects remain often unconsidered.

Whereas ecological and economic parts of the sustainability concept could be quantified, normally social and institutional aspects are only ascertainable in a qualitative way (e.g. social tension or political stability). This excludes these issues and other which are difficult to capture in numbers from the analysis. Consequently a shift in weighting of the different dimension of the concept results from this with respect to comprehensive understanding of sustainability.

4.4 Possible linkages with other tools

Because of its variety and general broad usability indicator−sets have got various possible links to other assessment tools for sustainable development.

A clear link exits to stakeholder analysis tools, as indicator−sets, because of their subjectivity, depend
strongly on stakeholders. Also there is a required link to participatory tools, as stakeholders have to provide their perceptions and knowledge to a sound indicator-set and therefore give indicator-sets their meaning. Also stakeholder set the reference frame for indicator sets and the desired target state. Finally stakeholders are supposed to use indicator-sets to make them influential. Here the questions of interest and power are playing an important role, which is assessed by stakeholder analysis tools.

A further link can be identified to scenario tools and modelling tools. Indicator-sets provide the data basis for these tools and deliver the required numbers. However, also the other way round there is a link: Depending on the approach models might provide indicators to be incorporate into an indicator set. Further, scenarios can support indicator-based assessments and the development process of indicator-sets in defining the desired future state and delimiting the system boundaries.

For Simulation Tools indicator sets are applied as variables connected to each other by equations. Some authors are describing simulation models as an own class of indicators. Although this might go beyond the aim of indicators, there is a strong link between this kind of tools. Indicator can provide to data required for scenario building which are used in simulations.

Last but not least several tools considered in the Sustainable A-Test projects are based on indicators or are further aggregations of indicator-sets, e.g. Cost-Benefit-Analysis, Life-Cycle Assessments, Material-Flow-Analysis and the Ecological Footprint.

4.5 Literature


Indicator sets for assessments (SIndbAT)


Indicator sets for assessments (SIIndbAT)