Indicator development as "boundary spanning" between scientists and policy-makers

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Abstract:

In sustainability impact assessments the development of widely accepted indicators that structure the subject area and provide the framework for assessing sustainability impacts is evidently important. We argue that the development of sustainability indicators in science-based initiatives works across the science/policy interface where social and natural scientists as well as stakeholders and policy-makers both translate concepts and ideas to each other and perform therein value judgments regarding the selection of indicators and related sub-classes. This explains why pure scientific indicator initiatives based on simple "knowledge transfer" models are unlikely to succeed. Sustainability indicator development rather requires a "knowledge transaction model", spanning the boundary of the scientific and the political domains.

Keywords: sustainability indicator development, sustainability impact assessment, science-policy interface, knowledge transfer

1 Introduction

Sustainability impact assessments have recently gained much attention. The European Commission for example has funded a number of large impact assessment projects within its Sixth Research Framework Programme, including SENSOR on land use policy, EFORWOOD on the sustainability of the forestry-wood chain, SEAMLESS on impacts of agri-environmental policies and external shocks on agriculture and environment, and PLUREL on sustainability of peri-urban land use relationships etc. Many of these sustainability impact assessments are performed through models which do quantitative or qualitative assessments based on sustainability indicators. Indicators and here especially indicators for sustainability assessments are meant to support decision-makers, scientists and the public in the assessment of the present situation and frame changes and trends in key dimensions considered relevant for sustainable development. These do usually not only pay attention to the ecological dimension, but also economic and social aspects of human-environmental systems interaction are addressed. Indicators and sustainability indicator frameworks covering different natural and social science domains come in a range of formats. Some indicators or indicator frameworks are indices covering a range of dimensions and several variables (e.g. the aggregate human development index), others are single variables (e.g. number of fe/male population). However, not all indicators are based on quantifiable information but capture also phenomena in descriptive and qualitative formats.

Particularly over the last decade, several sustainability indicator sets have been elaborated in Europe, including indicator sets developed by the European Environmental Agency (EEA, 2005), Eurostat (European Commission, 2005a) and for specific sectors, such as for forests and sustainable forest management by the Ministerial Conference on the Protection of Forests in Europe (MCPFE, 2002). Indicators for sustainable development beyond Europe have for example been developed amongst others in the context of the Commission for Sustainable Development of the United Nations (CSD, 2006). The development of such indicator sets does not follow a well developed or widely agreed procedure, despite the fact that the choice of indicators defines the core of what is understood to be the key dimensions of sustainability. Technical documentation accompanying indicator development processes, which usually exist in some form, concentrate particularly on outlining the methodology of how to develop indicators or the description of the procedure on how indicators were developed, drawing mainly on technical expertise, as well as pragmatic feasibility and cost aspects.

A range of authors identify a need to improve the indicator selection process (e.g. Niemeijer and Groot, 2008; Cimorelli and Stahl, 2005; Niemeijer, 2002; Kelly and Harwell, 1988). They frame the exercise of developing indicators and here especially indicators for natural resource use and management as 'technical' challenge (Niemeijer and Groot, 2008, Donnelly *et al*., 2007; McCool and Stankey, 2004; Failing and Gregory, 2003; Reynolds *et al*., 2003) or as theoretical exercise (Frones, 2007). In other words the current literature focuses on the one side on outlining technical and practical aspects for improving indicator development processes and on the other side they concentrate on discussing e.g. the meaning and power of such indicator sets. Scholars however tend to neglect political aspects, and here in particular the normative and value judgements involved, issues of interest representation and power relations connected to the development of indicators (for a similar argument see Turnhout *et al*., 2007: 216). In addition only some scholars (e.g. Turnhout *et al.*, 2007; Sheil *et al.*, 2004) seem not to lose sight of the importance of context in which indicators and indicator sets are being developed. Others (e.g. Cimorelli and Stahl, 2005) concentrate more on the need to overcome the science/policy interface while developing environmental indicators. In their view both, the scientific and political dimensions which are reflected by the indicators finally selected need to be explicitly recognized already during the development of such indicators. This article focuses particularly on the development of sustainability indicators in the context of science-driven assessment approaches which are intended to be useful tools for practical policy making.

Different conceptions on how science interacts with policy are available that could be employed to explain the development of sustainability indicators. We expand on those science/policy conceptions by outlining their implications for indicator development processes. Therein, we are not interested in showing how successful or unsuccessful different conceptual models of science/policy interfaces have been in their application, thus in mediating between scientists and policy-makers. We are more interested to show how the development of sustainability indicators works, as an integral conceptual component, across the science/policy interface. To our mind the development of sustainability indicators provides a particular challenge to scientists (both natural and social scientists) as well as to policy-makers, stakeholders and citizens. In the present article we argue that the development of those indicators is highly dependent on scientific knowledge from both, the natural and social sciences, as well as on normative political judgements, which requires the involvement of scientists from the natural and the social sciences, as well as policy-makers, stakeholders and citizens. Those interact at the natural science/social science interface as well as the science/policy interface. Our thesis is that this work across the science/policy interface, or ‘*boundary spanning’*, where scientists and policy-makers both translate concepts and ideas to each other has widely been followed in sustainability indicator development in practice, but in an implicit way. This hypothesis would also imply that pure science-based initiatives of sustainability indicator development are unlikely to succeed. It would help to explain, why the science community has grappled without much success to develop a consistent conceptual framework on sustainability measurement through indicators so far.

In this paper we use one example of developing a sustainability indicator set for the forestry-wood chain which is being developed in the context of the EFORWOOD (Sustainability Impact Assessment for the Forestry Wood Chain) research project. The indicator development approach used has not attempted to follow a purely science-based model for sustainability indicator development. Despite EFORWOOD being a scientific research project, the approach used a model for indicator development that tries to take the science-policy interface better into account by focusing on the ‘*boundary spanning’* between natural and social sciences, as well as between scientists and policy-makers. The experiences made so far allow analysing elements of ‘boundary spanning’ in practice and discuss lessons learned.

The paper is structured as follows: firstly, we introduce different conceptions of the science/policy interface and outline factors of analysis that characterise and distinguish these different conceptions. Secondly, we discuss implications of these different conceptions for indicator development. Thirdly, we present our case study describing the development of indicators within the EFORWOOD project. Finally, we discuss our findings in the context of the theoretical framework from which we departed.

2 Science/policy interaction – two theoretical approaches

Many models are available that describe the science/policy interactions. However in this chapter we concentrate on outlining two ideal types that are described by Pregernig (2004).

He distinguishes between a 'transfer model' and a 'transaction model' to examine the relationship between science and politics.

The transfer model conceptualises the two dimensions, science and politics, as separate domains that are disconnected from each other. Following this model, science is seen as "place of knowledge production" (Nowotny, 1994) and is supposed to produce facts. This scientific production of facts is considered value-free. Politics on the other hand is viewed as employing facts generated by scientific activity. It is conceptualised as a "place of knowledge use" (Nowotny, 1994). Political activities in that regards are considered value- and power-driven. This model assumes that values and facts are clearly separated from each other. The way knowledge is 'transferred' from the scientific to the political domain is described by the conceptual framing of Price (1981 in: Pregernig, 2004) as 'speaking truth to power'. This knowledge transport hence the interaction mode between science and politics remains linear and one-dimensional as politics is not considered to consult with the scientific domain, but to *receive* knowledge only. Elsewhere Pregernig (2007: 131) indicates that the transfer of knowledge from the scientific to the political domain in the linear model can only happen once the knowledge generating process in the scientific domain has been closed for specific individual knowledge "packages" that are ready to use. All related scientific aspects and questions have to be resolved by this point in order to be able to be handed over as a ready-made product to policy-makers. Those expect science to give answers and not to raise further questions relating to the subject. Pregernig (2004: 200) argues that the transfer model implies a type of knowledge use by policy-makers that is "instrumental".

We can see that connected to this linear idea of separating science from non-science (here politics), a process that implies work at the boundary between the two separate domains, or *boundary work* is on-going. What is boundary work? Science studies argue with the term "boundary work" that barriers or demarcations between scientific and non-scientific domains are being created. It is driven by scientists that are engaged in demarcating science from non-science. Gieryn (1983) discusses the problem of demarcation between science and non-science and argues that "boundary-work" is an "ideological" form of demarcation between science and non-science. Employed to the context of the transfer model this would mean that boundary work helps keeping both domains separate and avoids interference by policy-makers in the scientific domain as well as interference from scientists in the political domain. Not only the sociology of science studies community (e.g. Pregernig, 2007; van Eeten, 1999;

Jasanoff and Wynne, 1998; Nowotny, 1994), but also the policy analysis community (e.g. Fischer 1998, 1995; Hajer and Wagenaar, 2003) questions this linear conception of knowledge production, transfer and use on theoretical and practical grounds. Those boundaries that seem to be rational and clearly established between the scientific and the political realm are in their view much more undefined, fuzzy and dynamic (see Gieryn, 1983, 1995; Jasanoff, 1990). Science and scientific facts are much more diffused into society than the first model makes us believe. Therefore a second model that shows a somewhat different approach to the science/policy interface is outlined.

Pregernig suggests (2004: 202) to call the second model that describes the interface between science and politics the transaction model. According to this model the production of scientific truth cannot be characterised as technical and value-free. Scientific work is not only a search for truth, but also understood as a social activity, where scientists make decisions that are not neutral, and where a separation of values and facts cannot be ascertained. Policy advice is considered to be a "hybrid activity" (Pregernig, 2004: 198) where scientific knowledge intermingles with political judgement. Similarly, the politics domain is viewed as not only being driven by values and power, but it also produces knowledge that is then employed in the process. Thus, this model suggests that a complex intermixture of values and facts between both domains are given. Pregernig (2007: 132) elsewhere and following Miller *et al*. (1997), suggests interpreting these science/policy interactions as a dynamic process, which is two-sided and non-linear. The model conceptualizes (scientific) knowledge not as ready-made product available to policy-makers upon their request, but knowledge input into the political process is to be seen as a dynamic social process (Cash and Clark, 2001 in Pregernig, 2004: 198). This process may change frequently over time and develops in iterative steps. Accordingly it involves interactions between scientists and policy-makers, interest groups as well as citizens. In that model the boundary-activities between science and politics domains are to be understood as an on-going process of co-operation, competition and confrontation and are therefore considerably more blurred. Turnhout *at al.* (2007: 221) conceive of this interaction between science and politics as a "kind of joint knowledge production". Pregernig (2004: 202) adds that reflexive learning occurs on both sides.

Again if these boundaries between science and politics are blurred and fuzzy, the idea of passing on knowledge from one domain to the other one has to be reconceptualised. This requires what organizational theorists call "*boundary spanning*". According to Martin and

Tipton (2007: 186), boundary-spanners are seen to connect sub-units within and outside their organizations. They emphasise also that this boundary spanning activity involves learning the special language used by given organizational units. Only then boundary spanners can meaningful engage in translating concepts and ideas. If this idea is employed to the second model presented above, it would mean that a boundary spanner would connect to the scientific and to the political world. Such a boundary spanner understands both concepts and terms used by both domains and would hence employ this knowledge for translating between them. A summary of all outlined ideas connected to both ideal types can be found in Table 1 below:

Table 1: Characteristic elements of two science/policy interface models

	Transfer model	***Transaction model***
Boundaries between science and politics	▪ Boundaries well delineated	▪ Boundaries blurred
Integration of values and facts	▪ Separation of values and facts	▪ Complex intermixture of values and facts
Mode of interaction	▪ (One-sided) transfer; linear	▪ (Two-sided) transfer; non-linear
Type of output	▪ Product	▪ Process
Type of knowledge use	▪ Instrumental use	▪ Reflexive use

Source: Pregernig 2004: 202, modified by the authors

Both models serve on the one side as analytical lenses that describe how science and policy interact, but on the other side these models may also help to organise the interface between science and policy. So depending on how the models are employed they serve an analytical or a prescriptive function.

In the following chapter we discuss the implications of the two ideal types to the development of indicators and indicator sets.

3 Implications of SPI models for indicator development

The two theoretical approaches to knowledge production and use, and in particular the way knowledge transfer is conceived have far reaching implications to indicator development: Following the logic of the ‘transfer model’ it would mean that the production of indicators is seen as task of the scientific community, while the political realm only uses those indicators, once developed by the scientific realm. This conception of the science/policy interface does not leave room to interpretation or decision-making activities in the policy domain with regards to the development of indicators. This implies that indicators are to be viewed as ready-made scientific products for use by the political realm, where facts and values remain separate. In other words the production of indicators is seen as based on facts and not on value judgements. Indicators may then serve in the political sphere as instruments for evaluation of condition and trends etc. This linear ideal-type model seems to underlie a range of attempts by science-driven initiatives to develop sustainability indicator sets, in particular indicator sets that are mainly grounded in the natural sciences, such as for example ecological indicators, or indicator sets based on complex ecosystem-human systems interaction frameworks (see e.g. Niemeijer and de Groot, 2008; Guldin and Heintz, 2007; The Heinz Center, 2002; OECD, 1993; EEA, 2005).

When following the ‘transaction model’ this means that the development of indicators needs to take into account that the production of knowledge is not purely scientific or purely political. It is also not linear, but requires the interaction of social and natural scientists as well as policy-makers, interest groups and citizens etc. These groups or their representatives engage in a struggle over ideas over the definition of elements and specification of indicators, whereby knowledge is one means to exert power and/or to implement one’s interests. The development of indicators is therefore less a technical activity, but much more a social process. While developing indicators, decisions are made that makes this concept of separate domains for science and policy leaky. Turnhout *et al.* (2007: 218) draw for example our attention to the fact that ecological indicators represent actually a “simplification of nature” and their development is value-laden. In the words of Bossel (1997) this means that indicators are to be understood as expressions of values, where compromises on what is in the definition and what remains outside have to be made. Turnhout *et al.* (2007: 221) therefore conceive of this interaction between science and politics in the context of indicator development as a “kind of joint knowledge production”. In their view the development of indicators is guided by scientific concerns and shaped by political preferences. This means that the development of indicators shall be understood as joint activity between scientists and policy-makers, that goes from general problem structuring to details of data collection, monitoring and assessment issues, which are relevant in the course of indicator development. Developing indicators thus rather requires an open communication in the policy process (Valentin and Spangenberg, 2000).

Based on these observations above we need to look at first at the interaction between scientists and policy-makers, interest groups and citizens during the development process of sustainability indicators. Can we describe this interaction as static process where scientists develop and policy-makers use indicators or does it resemble a dynamic process where scientists, policy-makers and others develop together sustainability indicator sets? Secondly, we will need to observe whether the scientific domain produces a so-called 'ready-made' scientific indicator set or whether the development process involves long-term interactions between both domains that evolve over time and occur iteratively? Further, we need to investigate whether the emphasis is solely laid on the content and quality of the indicators that help measure sustainability, or whether the indicator development process as such is seen as equally important. In that regards we will examine whether facts and values are understood as separate aspects or whether the indicator development process represents a complex mixture of values and facts wherein scientists and policy-makers respectively are intermingled. Finally we will ask whether the type of knowledge use can be conceptualized as instrumental or as reflexive where policy learning is possible. Along the same lines we will explore what role knowledge and ideas play in the creation of indicators. A list of all criteria to delineate the underlying ideal types is shown in Table 2 below.

Table 2: Characteristic elements of main indicator development models

	Transfer model	***Transaction model***
Mode of interaction	▪ (one-sided) production of indicators by scientists to be used by policy-makers	▪ (two-sided) interaction in development of indicator set
Type of output	▪ 'ready-made' scientific indicator set	▪ Indicator development process that involves long-term interactions and evolves over time (indicators are time and process dependent and change iteratively)
Integration of Values and facts	▪ Indicators are seen as technical devices that help "measuring sustainability	▪ Indicator development involves a complex intermixture of values and facts
Boundaries between science and politics	▪ Boundaries well delineated	▪ Boundaries blurred (also between social and natural

		science)
Type of knowledge use	▪ Instrumental use	▪ Reflexive use

In order to transfer the theoretical ideas to our case study (development of sustainability indicators within EFORWOOD), we hypothesise that the specification and selection of sustainability indicators is either a scientific activity driven by the scientific knowledge process or resembles a struggle over ideas, facts and values, where boundaries between different disciplines in science as well as between science and policy are clearly delineated or become blurred. How indicators are conceptualized, become defined and specified depends on the underlying conception of the main promoters of indicator development of the modus of *boundary work* or *boundary spanning* between natural and social scientists on the one hand, and between science and policy on the other. Thus, we hypothesise also that the distinction and mechanisms between the science and policy interface in the ideal type models can also be applied to the two science domains of natural science and social science. In our view, a sustainability indicator development process following the transaction model involves negotiation between both the natural and social scientists and policy-makers, as far as they are involved. All actors involved contribute with specialist knowledge of their respective domains. They are likely to recognise different aspects (e.g. operationalized in indicator subclasses) and attach different importance to different aspects. At that stage, indicator selection criteria such as indicator relevance and scale, data availability, technical and political feasibility, as well as the cost of the indicator application are important. These aspects are often-used criteria for structured indicator selection processes. In the process of elaborating and developing indicators, which requires to consider a large number of interrelated factors, scientists do not engage as value-free agents in their professional capacity, but also as stakeholders for their respective domains and sub-domains, as well as in their role of informed citizens. The same holds for stakeholders and policy-makers.

4 EFORWOOD – the case of sustainability indicator development

EFORWOOD is a project funded by the European Commission under the Sixth EU Framework Programme for Research and Technological Development. Its main objective is to develop a quantitative decision support tool for sustainability impact assessment of the European Forestry-Wood Chain (FWC) and all its stages. One aim of EFORWOOD is the development of indicators that reflects all aspects of sustainability and addresses demands of a multiple user group including policy-makers.

4.1 Introduction to the case: EFORWOOD

A team of social scientists with experience in indicator development were tasked to implement and coordinate the EFORWOOD indicator development process that followed a number of iterative steps over a total period of more than two years. Firstly, the development of the indicator set aimed at consistency with relevant existing sustainability indicator sets with respect to issues and themes covered. It was therefore based on the Impact Assessment Guidelines of the European Commission (European Commission, 2005a) and four reference indicators sets. Those are, the Sustainable Development Indicators for the European Union presented by Eurostat (European Commission, 2005b), the Indicators of Sustainable Development of the Commission for Sustainable Development of the United Nations (2006), the Improved Pan-European Indicators for Sustainable Forest Management of the Ministerial Conference on the Protection of Forests in Europe (2002) and the European Union Rural Indicators as suggested in the report of the PAIS project (Bryden *et al.*, 2002).

At first, partners[i] involved in the EFORWOOD project, which comprise natural and social scientists as well as stakeholders (amongst those forest and land owners as well as industry associations), were asked to propose indicators. The project team does however not include environmental interest groups. The proposed indicators were added to the main sustainability indicator lists as described above. Project partners were then asked to provide comments and an input in each of a series of five steps of refinements for the definition of the first Forestry Wood Chain Sustainability Indicator set (Rametsteiner *et al.*, 2006). These inputs on detailed specifications (sub-classes, definitions to be used etc.) were requested to be based on four quality criteria, two of which were more science-oriented (indicator relevance, technical feasibility) and two were practice-oriented (data availability, cost of indicator application). In addition to involving all partners of the EFORWOOD project, advice was requested from stakeholders. A draft set was presented to a large group of stakeholders (also from outside the project) and policy-makers at an open workshop (for the stakeholder meeting see Gamborg, 2006) during a one-day meeting. The resulting first set of the Forestry-Wood Chain sustainability indicators was used as the basis for developing data collection protocols, collecting data and testing the sustainability impact assessment (integrated modelling) tools. In a second phase, experiences of all stages from indicator development, data collection and data use in impact assessment models were systematically included in the design of a process to develop a revised Forestry-Wood Chain sustainability indicators set, which should undergo a second round of testing in a different context before a third and final revision and adjustment of the Forestry-Wood Chain sustainability indicators set should be made. This set is intended as one thoroughly tested deliverable of EFORWOOD.

4.2 Case analysis: EFORWOOD between transfer and transaction

Based on this short description of the development process of the EFORWOOD indicator set we are now able to discuss the underlying model of science/policy interface applied according to the criteria outlined in chapter 3.

Starting with the mode of interaction used, we observe in the EFORWOOD indicator development process, a two-sided knowledge transfer. This means that besides natural scientists, also social scientists and various stakeholders internal to the EFORWOOD project are involved. The knowledge transfer process happens simultaneously between social scientists that lead the process and natural scientists as well as stakeholders that are asked to provide input for the first indicator set via five distinguished email rounds and consortium meetings. On the other side the exchange of information, points of view and knowledge between EFORWOOD members partaking in the stakeholder meetings and interest associations as well as policy-makers taking the opportunity to participate in the discussion process is supported (for a detailed list see Gamborg, 2006). Their opinions and views on the proposed indicator list are included in the development process and have an impact on the further refinement of the set. In that regards it needs to also point out that stakeholders play a double role in this indicator development process. On the one side they are part of the project and comment on indicators as other scientists and on the other side they assume their political roles in stakeholder meetings. They act in their capacity as boundary spanners as they “translate” each other’s views to the science and to the policy world. Generally spoken it can be said that the major input in the discussion- an estimated 70% of all participants input – was provided by natural scientists. About 25% of the input came from social scientists and here especially from the indicator development group. Only about 5% of the input was provided by stakeholders and policy-makers. This 5% stakeholders input is not ideal, but seems to reflect the realistic options in a FP6 project. Regarding the selection criteria applied to the development process two of the selection criteria for the EFORWOOD indicator set are rather oriented at scientific accuracy (indicator relevance and technical feasibility), while the other two (data availability and cost of indicator application) qualify with a view to the practical application of the EFORWOOD indicator set. The selection of those criteria was thus aiming at supporting boundary spanning activities.

Secondly, with regard to the type of output, we observe that in the present indicator development process scientists did not present a technical product to policy-makers that should then be used by them, but the EFORWOOD indicators are being developed with a clear focus on the process dimension and the product (output), and not on producing a ready-made product alone. Several rounds of interaction between all EFORWOOD members as well as policy-makers external to the project have led to a first set of EFORWOOD indicators. Here they engaged in the discussion over the indicator selection (e.g. include/exclude the indicator called "red tape") and definition (e.g. how to measure investment and research activities in the forestry wood chain). The first indicator set has also been tested empirically as scientists started to collect indicator related data. This first application of the indicator set led to further refinements of the indicators both with regard to definitions applied, practicality and further political relevance. The indicator development process is thus conceived as long-term interaction that evolves over time and is based on practical application.

Thirdly with regard to the integration of facts and values, the EFORWOOD indicator development process involved a complex intermixture of values and facts: Natural scientists had to compromise with social scientists, stakeholders and policy-makers on the indicators. For example in the revision process (after the first data collection) all members (all of which were scientists) of the Task Force on Indicators[ii] were asked to formally approve (by consent) the individual indicators, forcing experts to discuss with and listen to non-experts in a specific field, and non-experts to act as "informed citizens". The development of sustainability indicators is more complex as in the case of environmental indicators only. Here not only natural scientists, but also social scientists (e.g. economists and political scientists) are involved putting forward different ideas on what to include and what to exclude. For example some natural scientists supported by social scientists wanted to include the indicator “use of hazardous chemicals”. Stakeholder considerably opposed this idea as they feared that a related data collection and use would harm the image of the wood industry.

With regard to the boundaries between science and politics established, we could see that those were blurred and fuzzy in the EFORWOOD case. Already in the project itself, not only researchers, but also stakeholders such as e.g. CEPI, CEPF, CEI-BOIS are involved. No clear delineation can be ascertained. The EFORWOOD indicator set aims at being accepted by the scientific as well as by the political domain.

Finally the type of knowledge use can be characterised as reflexive, because the EFORWOOD set is first of all based on already existing indicator sets and thus aims at taking in existing ideas on sustainability. Secondly, the iterative approach applied to the development and testing phases of the indicator set allows for a continuous refinement of the indicators and admit to ingrate experience over time. Scientists, stakeholders and policy-makers involved in the practical testing of the EFORWOOD indicator sets see directly success and failures attached to the indicators. For example from the first application test it turned out that some indicators and especially their sub-classes need further refinement (e.g. resource and material use). It showed also that when using the indicators to collect reference data, many more questions arise, that previously nobody thought of (e.g. where are the system boundaries between indicators, data quality and assurance etc.). In addition it showed that not only the development of the indicators itself, but also the development of a data collection protocol needs a boundary spanning activity and it cannot be left to scientists alone.

5 Discussion and conclusion

This article posed the question how the development of sustainability indicators works in particular in the context of science-driven assessment projects. The analysis showed that the transfer model can be rather dismissed, while the transaction model by and large proved to be more realistic. The transfer model proved to be an ideal-type model that is possibly not expected to be found in reality. The idea that the science and policy domain can be held apart so easily has not only been questioned by sociology of science and policy analysis communities, but in reality very often policy-makers and scientists have different understandings of a science/policy interface. This model does thus primarily serve the development of the transaction model. The transaction model nicely helps to show that EFORWOOD sustainability indicator process design was aimed at boundary spanning activities by the science and politics domains alike. In addition a team of social scientists acting as *boundary spanning actors* was tasked with the implementation and coordination of the process. They actively translated concepts and ideas underlying the selection of indicators, respective definitions and related sub-classes to the involved actors, both scientists and policy-makers alike.

The analysis of the EFORWOOD indicator development process therefore partly verified our hypothesis: We could ascertain a two-sided knowledge transfer between social and natural scientists on the one side and policy-makers on the other side that were supported by continuous face-to-face contacts and email exchange. In addition participating stakeholders are asked to communicate the selection of indicator to their members. Secondly, the indicator development process involved several rounds of interaction within the four-year life span of the project, both by engaging scientists and stakeholders internal and external to the project. Thirdly, the development of indicators involved compromises by both, natural and social scientists as well as stakeholders, as their consensus was a requirement for the approval of indicators, a form of interaction and negotiation scientists may not be as used to as policy makers or stakeholders. This consensus-led procedure requires the application of normative value judgments. Fourthly, the boundaries between science and politics proved blurred within EFORWOOD as stakeholders assumed a kind of double role; some stakeholders had already been actively engaged in the project itself; however they did also assume an outside role in so-called stakeholders meetings, where the preliminary indicator selection was discussed with a wider group of stakeholders. Finally, the analysis showed that a reflexive type of knowledge use was followed as the sustainability indicators were based on already existing sets as well as an iterative approach was followed through the development and testing phases that allowed for a continuous refinement over time. The factors of analysis characterizing the transaction model described in chapter 3 are thus more or less met by the design of the sustainability indicator development process in the EFORWOOD project. However, analysing the degree of interaction and type of *boundary spanning activities* between science and politics as well as the way how values and facts are integrated is not conceptualized in the models used.

Even so the transaction model is more likely to be found in practice, the design of indicator processes following the transaction model and applying it as a prescriptive model is likely to be restricted by additional constraints: Firstly, the indicator development process and its intended results such as an indicator set may be one, and not the most important "product" expected from a scientific project. For the EFORWOOD project this implied that at least one draft set of sustainability indicators was needed at an early stage of the project. This means that already by design scientific indicator development processes within a larger project are likely to be restricted in terms of means to reach out and to include many policy makers in the development process, both financially and time-wise.

Secondly, it proves difficult to actively engage those policy-makers in an indicator development process that is not explicitly political. This may be explained by the missing perceived "political necessity" to take part in a scientific project paid by government or other funding agencies and contracted out to scientists to perform. A more active role of policy-makers engaging with scientists as well as scientists that take economic feasibility and political relevance into consideration supports knowledge transaction and improves the acceptance of the final sustainability indicator set. In the EFORWOOD project the exchange with policy-makers on indicators beyond some few "stakeholder meetings" has been rather negligible.

Thirdly, stakeholders being part of a scientific endeavour are constrained by their policy role. In other words they are used to interact with policy-makers in decision-making and implementation in order to impose their interests, but they are not regular actors in the scientific domain. Hence also supporting the scientific enterprise they import their policy ideas and assume their stakeholder role inside the project environment. The way they export scientific ideas is kept in the dark as the EFORWOOD case shows.

Finally even so our initial hypothesis could be partly verified, it turned out that some aspects could not be covered entirely by the enlisted factors of analysis of the transaction model in chapter three: science-led indicator processes tend not to attract enough attention to enhance the participation of policy-makers and thus the transfer of knowledge and policy-learning remains limited. Value judgements are performed, but it is less because policy-makers and scientists exchange views regarding the development of the indicator set. Those value judgments are made, because scientists compromise on indicators and indicator sub-classes they presume as politically relevant. Also it should be emphasised that this case analysis may only be seen as plausibility probe and in order to prove this point more thoroughly a higher number of cases need to be used that provide compelling answers.

Participation in indicator development processes (see also Turnhout *et al.,* 2007: 225-226) is important. Here not only scientists and policy-makers should be part of the development group, but also stakeholders, interest associations and concerned citizens may take part directly and indirectly. An iterative approach (such as the one followed in the context of the EFORWOOD project) based on the results of other previous or related processes supports the meaning making process and gives all actors involved also the chance to voice concerns if necessary. The (real-world) testing of the indicator set may be used for the refinement process. However actors need to understand and accept that the indicator development process is not a technical process, but has to be conceived as social process, where negotiation and exchange of views happens and sometimes may also involve power. This may also involve that arbitrary and non-scientific decisions are made. Hence it needs to be assured that actors accept indicators.

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[i] About 100 researchers and stakeholders (from 38 research institutes and organisations) all over Europe and from outside Europe (Congo, Costa Rica) are involved in the EFORWOOD project.

[ii] A Task Force on Indicators has been established in the framework of the EFORWOOD project. This Task Force comprises of 12 + 4 members (all selected from the different work packages of the project).

6 Literature

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Abbreviations:

CEI-BOIS European Confederation of woodworking industries

CEPF European Family Forestry

CEPI Confederation of European Paper Industries

CSD Commission for Sustainable Development of the United Nations

EEA European Environmental Agency

EFORWOOD Sustainability Impact Assessment for the Forestry Wood Chain

FWC Forestry-Wood Chain

MCPFE	Ministerial Conference on the Protection of Forests in Europe
OECD	Organisation for Economic Co-operation and Development
SEAMLESS	System for Environmental and Agricultural Modelling; Linking European Science and Society
SENSOR	Sustainability Impact Assessment: Tools for Environmental, Social and Economic Effects of Multifunctional Land Use in European Regions