Sustainability Science:
Science must go public for Sustainable Development

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Cross Cutting Challenges

The promotion of science for sustainable development requires procedures for evaluating science and technology contributions against criteria for sustainability. Neither the advance of science and technology itself nor the current widening of competitive markets can be expected to promote, as if 'naturally', a path of sustainable development. On the contrary, the short-term orientation and the mixtures of commercial, military and other preoccupations that motivate much of the science-based technology development are most often controversial to a sustainability perspective based on peace, justice and environmentally sound development (Funtowicz et al. 1999). There is an undeniable risk of undersupplying public goods essential to sustainable development when too much of the R&D talent is in private hands, and focused on delivering private value.

Table 1: Sustainable Development

Sustainable development

- **Is a phenomenon of synchronising complex systems**
- **Must focus on the interlinkages of dimensions**
- **Deals with non-linear effects, beyond cause-effect logic**
- **Regards long term and long distance problems**
- **Depends on non-scientific pre-analytical visions**

➔ **is inherently dealing with uncertainty of data, analyses, and in particular projections and prognosis.**

Sustainability is a normative objective

Sustainability politics is a societal process

Science for sustainability is a contribution to this process, embodied in it. It answers questions of society, gives hints about the consequences of proposals under discussion, warns against ignored risks.

Science for sustainability takes no decisions, but urges for them and provides the information for better decisions.

For all domains of science and engineering, sustainability science requires re-engineering of the fabric of science, its standard methodologies and institutions. However, if successfully implemented, this would significantly increase the value of science for society, enhance its credibility and provide a vast range of new and fascinating research questions. The challenge of sustainability is an opportunity not to be missed.

Table 2: Broadening the stakeholder community

Scientific disciplines to be involved

- Biology, biodiversity research, ecosystem analysis
- Chemistry, toxicity analysis, atmospheric chemistry
- Ecological economics, economy-environment interaction
- Environmental sciences, cause-effect networks
- Evolutionary economics, sustainable economic structures
- Physics and meteorology
- Political sciences, institutional analysis, governance
- Psychology, individual preferences and behaviour change
- Socio-economics, driving forces and incentive structures
- Sociology, attitudes, behavioural patterns

Non-Scientific actors to be involved

- •Trade unions, works councils, labour representatives
- •Churches and religious groups, philosophers
- •Environmental NGOs, nature & wildlife protection groups
- •Development NGOs and institutions, solidarity movements
- •Social organisations, health, homeless and poverty care
- •Business representatives of different levels
- •Media people, journalists, news makers
- •Administrators, from local to EU level, all policy sectors
- •Politicians of different parties, sustainability committed
- •Women and feminist organisations

Case studies

This section intends to illustrate how in the past we have tried to put these ideas into practice, based on a number of subsequent research projects undertaken in the Sustainable Societies Group in the Wuppertal Institute, and subsequently in the Sustainable Europe Research Institute. The research group consisted of up to 15 members from natural, cultural and social sciences, and all projects were conducted by interdisciplinary teams.

For all projects, their design was based on the insight that operationalisation of sustainability cannot be done as a top down approach of developing science-based concepts and expecting society to implement them, nor can it be achieved in a mere bottom up manner by a plurality of unlinked concepts. The integrated approach we have chosen aims at making research results usable for decision making (but not substituting for it). One preferential way of doing so is to enhance the policy relevance of the strategies and scenarios developed by stakeholder involvement in all relevant phases of the process, either in form of feedback from science and a variety of societal groups in subsequent discussions (a kind of extended peer review) or the organisation of social discourses. By including external scientific and non-scientific knowledge through such hearings, consultative processes or by means of regularly consulted societal advisory bodies (as opposed to scientific ones) one more key criterion of transdisciplinarity was met.

In order to adjust the methodology to accommodate the inherent and irreducible uncertainty of the issue, we abstained from developing models based on forecasting and extrapolation of current tends (as far as significant trends are detectable); instead we opted for a backcasting approach, where shared visions are developed and strategies towards their implementation are developed by “looking back from the future”. As far as models were used,

we opted for dynamic instead of static and for integrated co-evolutionary instead of equilibrium models.

The result of this modification of the research design is the integration of elements of "post-normal science" (Funtowicz et al. 1998, O'Connor et al. 1998) by involving practitioners and users of the information provided, integrating empirical and anecdotal evidence into the more theoretical frameworks of different disciplines, as it has been successfully demonstrated by the IPCC.

"Towards Sustainable Europe"

Being commissioned by CEAT (Coordination Européen des Amis de la Terre, Friends of the Earth Europe FoEE) in 1994 to write a study "Towards Sustainable Europe" we undertook to operationalise the concept of sustainability for governance application and to simplify it so that it could serve communication and campaigning purposes (Spangenberg 1995).

Unlike most future studies based on forecasting (understood as the extension of current trends into the future, modified by a set of assumed policy initiatives) (e.g. Meadows et al. 1972), we wrote a scenario for backcasting. Basically this means we did not describe how the world tends to be, but how it should be, based on a normative sustainability concept developed in close cooperation with the stakeholders represented in the steering group of the project, plus a few additional explicit assumptions.

The scenario includes targets taken from the international debate on environmental science and environmental policy like the goals for greenhouse gas emission reduction from IPCC (1995)and for material flows from the “factor 10” concept (Schmidt-Bleek 1994) which was used to calculate reduction targets for a limited number of key substances, providing so-called “icon indicators” e.g. for construction materials (represented by cement) or the metal industry . The resulting targets, reflecting the environmental dimension of sustainability, were then combined with a distributional justice argument, the equity principle, in order to develop sustainable development oriented reduction targets for resource use, the so-called Environmental Space (Opschoor 1994, Spangenberg 1997). Like all project results, these factors were taken to a broad public debate in more than thirty countries of Europe, but remained essentially unchanged in its course.

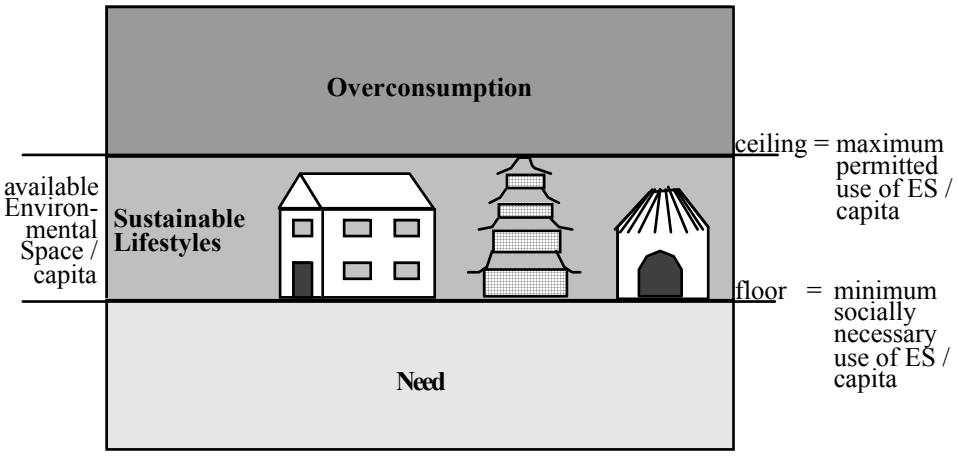
As a result of this public debate, our proposed categories of monitoring have reached the government decision-making level, and in some countries even our targets have done so.

What were the reasons for the success, what was new in our study? Some elements:

- First, it was not just a study, but a process of forming public policy networks, which in Particular did not claim any decision making capabilities, but used the study and the concepts provided by it as a common platform for conceptual debate and political lobbying and campaigning. This way we gave input to civil society dialogues in all countries of Europe and on the EU level.
- The concepts published with the study were broad, simple, operational and easily communicable. So we restricted ourselves to only three environmental categories (energy, materials and land), however with more sub-categories behind each one, giving quantified targets and time schedules, based on established scenarios, like for energy, or at least on anecdotal evidence of their potential to be realised, like for material flows. Whereas the focus on the use intensity of a few key resources made the concept easy to communicate, and the detailed sub-categories made it operational.

– We took the concept out of the environmental niche by introducing a social dimension, which we defined as the minimum amount of resources available (physical, monetary, but also in terms of education, participation rights, etc.) needed to actively participate in society which we considered a precondition for a dignified life (Milbrath 1989, Ekins 1992). This was done in co-operation with scholars from social science and labour research, and with discussion partners from the trade unions. One of the results was the "Banner of Sustainability" below:

– **Figure 1: The "Banner of Sustainability"**



– Scientifically, we extended the concept by involving experts from ecological economics, consumption and labour research. Together, we were in a position to work out the interconnectedness and importance of the interlinkages of the four dimensions of sustainability, namely the environmental, the social, the economic and the institutional one.
- We considered sustainable development as a framework concept with no ready-made blueprints available, but with linkages to many social movements, political and historic experiences. Understanding sustainability as a co-evolutionary process of search for optimal solutions for the four interlinked sub-systems made it possible to reconcile markets and sustainable development by applying an extended version (including environmental as well as the traditional social framework setting) of the ordo-liberal paradigm, effectively connecting liberal economics to ecological economics. This concept has been developed further by Hinterberger and colleagues (Renner, Hinterberger 1998).
– Finally, we developed a first draft set of sustainability performance indicators, by measuring distance to target and the progress made in the reporting period for the environmental categories, and adding to that some social aspects like income distribution and unemployment levels (Spangenberg, Boniot 1998a).

"OIPROS"

In a second project, called OIPROS, Operational Indicators for Progress Towards Sustainability but restricted to physical and economic indicators for environmental issues we tried to work out how different indicator systems can be combined (Schellemann et al. 1996). We had to learn, however, that - at least from our point of view - economic indicators based on damage cost turned out to be of little meaning, because neither for the damage nor for the cost there was a scientifically sound assessment.

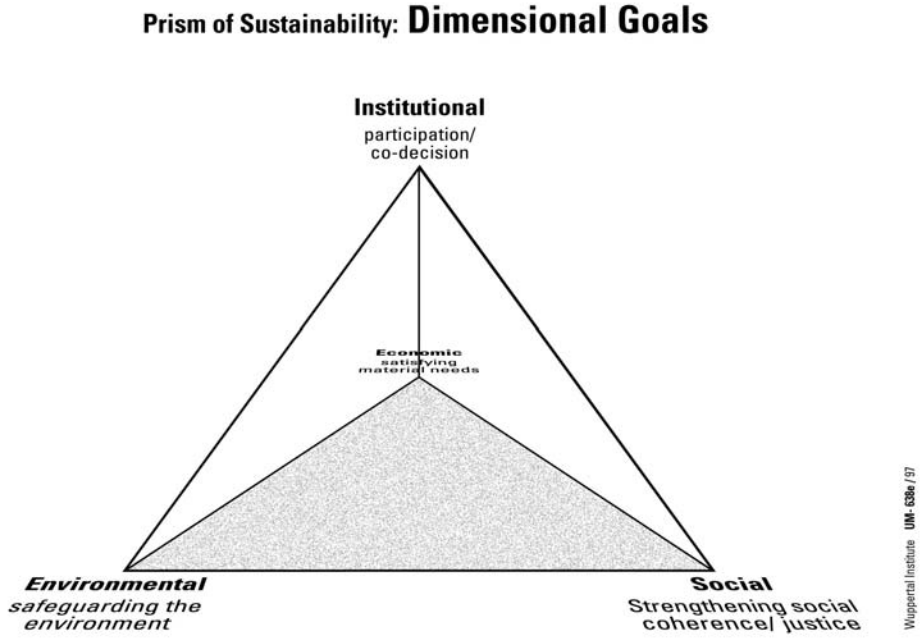
Consequently we gave up the attempt to express the total pressure on the environment in one figure, be it monetary or physical. Instead, we propose to keep energy, land and material separate as the three physical dimensions of the environment (Schmidt-Bleek et al. 1998), and to add as a biological component pressure indicators to identify possible threats for biodiversity (Spangenberg 1999).

From a communication point of view the lesson might be relevant that oversimplification, although in many cases attractive at first glance, often tends to cover relevant and substantial information. Instead we need a means of communicating trends towards sustainability, which is aggregating by expressing everything through one figure, maybe even an economic value, but to develop a structure for communication which permits transmitting the information on about a dozen of different indicators in an easily perceivable and structured way.

"The Prism of Sustainability"

Based on this insight and the understanding of sustainability as a four-dimensional co-evolutionary process, we started a project to identify goals and their corresponding indicators for all dimensions of sustainability in a coherent and structured way (Deller, Spangenberg 1997).

Figure 2: The Prism of Sustainability



Since target setting is obviously no scientific exercise but has to be a political process expressing public preferences and value judgements on the scientific information provided, we involved representatives of environmental, social (including trade unions), development women's and youth organisations in a discourse project. Unfortunately, there was no participation of the business sector since at the time of the project they generally tended to be unwilling to participate in multi-stakeholder processes - with a few honourable exceptions like the Transnational Corporations working together in the WBCSD (World Business Council for Sustainable Development), or the SME cooperating in the International Network for Environmental Management INEM). According to our experience, they preferred bilateral negotiations and voluntary agreements with governments and administrations.

The participants in the reference group agreed after intense debate on shared policy goals, necessarily on a quite abstract level, and defined some corresponding indicators. These were derived not by aggregating existing data into indices, but by selecting the most important driving forces in the discourse process, and by identifying indicators which are able to characterise their dynamics. We then developed the methodologies for calculating the indicators in an iterative process with feedback from the reference group and finally calculated the indicators as far as resource and data availability permitted us to do so.

In the meantime, this piece of applied post-normal science has had its political impacts as well: similar targets concerning energy, material and to some degree land use and transport have been accepted by the Ministry of the Environment. A change in the composition of tax revenues (by introducing eco-taxes) and regular reporting on the development of poverty and wealth in Germany, two of the indicators proposed in our exercise, have been implemented by the now outgoing government and thus the indicators we suggested.

"Modelling Sustainable Europe"

Since qualitative scenario developments tend to underestimate the dynamics of the interaction between the dimensions of sustainability, and in particular the rebound effects occurring, we undertook to develop a system dynamics model to test strategies like dematerialisation regarding their economic and social impacts. The team doing so included scholars from biology, economics, mathematics, economics, labour research, environmental sciences, engineering, modelling, and regional planning, Doing so, we were well aware that only a fraction of the characteristics of a transition towards sustainability is accessible to numerical models. Given the focus of this paper, the exact structure of the model and the scenarios runs undertaken are not reported here (see e.g. Spangenberg, Scharnagel 1998b, Spangenberg et al. 2001), but only the process of generating societal input into the model.

In an early phase of the work, we constituted a scientific and a societal advisory board, the former one consisting of economists, modelling experts, labour and social scientists, the latter one of representatives of the European industry, the European Trade Union Confederation, the European Bishops' Council and major European environmental NGOs. At two important points in time they were invited to give input to the project: first, when we designed the model structure so that they could participate in defining which kind of questions the model should be able to answer, and secondly when we began planning the scenario runs, so they could influence the definition of scenarios, assumptions, preconditions and thus the relevance of the outcome to their respective interests.

As a result, businesses as well as trade unions and NGOs considered the model relevant for their future work independently expressed their willingness– after a still pending refinement of the model – to use it for their respective policy assessments.

"Work and environment: Pathways towards a sustainable future"

Obviously a dramatic reduction of the material and energy throughput of the economies results in changes in production structures. All these changes affect the quantity and quality of paid labour as well as the relationship of the formal and informal sector of societies. Therefore, in an interdisciplinary research project (Hans-Böckler-Stiftung 2001) we have developed scenarios which assess the impact of sustainability policies on the volume and quality of labour. The goal of the project was to identify synergies as well as antagonisms,

and to propose sets of political instruments to optimise the mutual supportiveness of the different elements of sustainability strategies, with a focus on labour and employment.

The project was rather unique in a number of respects regarding interdisciplinarity and participation. First of all, it took a couple of years to be prepared. During this time intensive discussions were held amongst key persons from the Trade Union movement considering to fund the research, clarifying the demand side (What do we need? What is relevant?). Simultaneously they organised expert roundtables, and discussed with selected members of the scientific community to identify the state of the art and define what really needed to be developed through new scientific work. In the end they agreed to support the work, and despite certain diverging hopes regarding the outcome, a compromise was found defining the task of the project (identify synergies and trade offs between environmental and social concern, in particular for the sphere of labour).

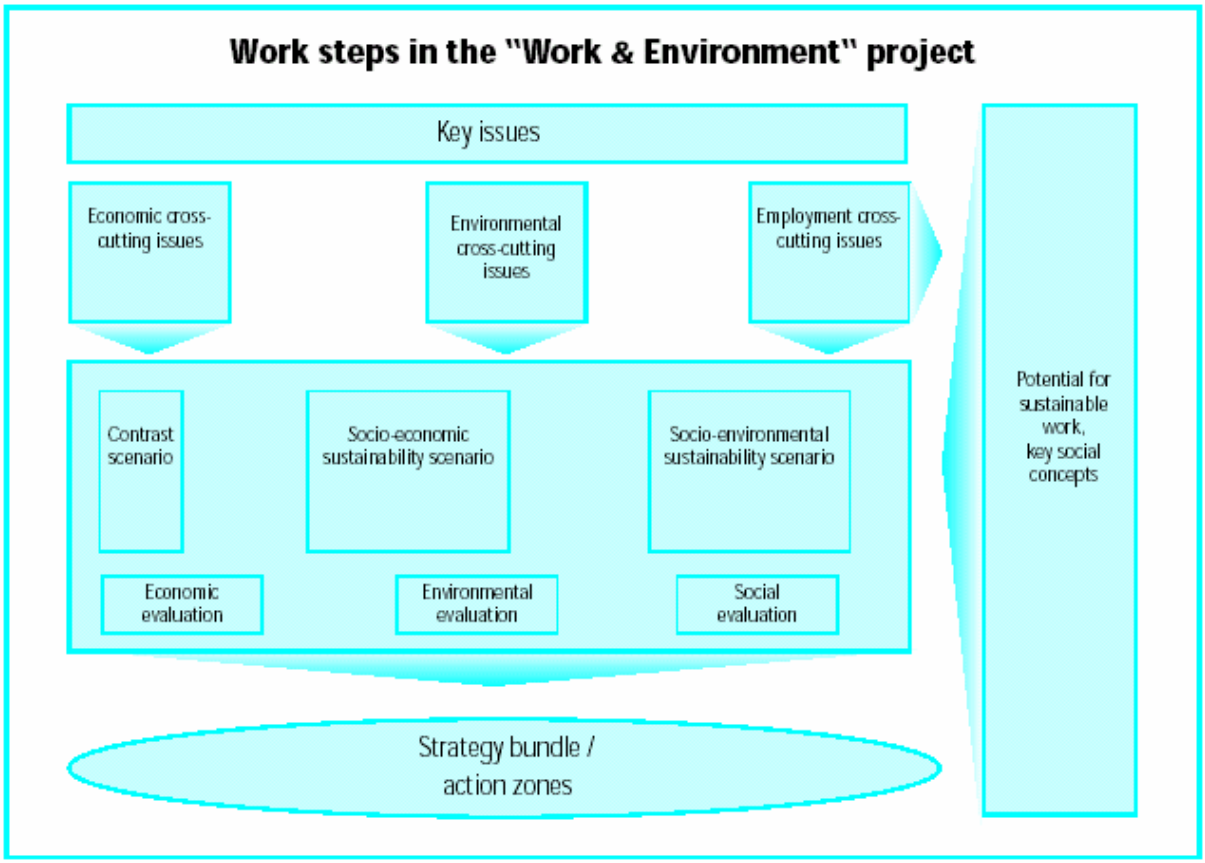
Secondly, to be able to cover the different dimensions of sustainable development with sufficient expertise, three specialised institutes (Wuppertal Institute for Climate, Environment, Energy, Wuppertal, the Science Centre for the Social Sciences, Berlin, and the German Institute for Economic Research, Berlin) had to deliver a joint project and research plan.

Finally, the project work was not restricted to literature analysis, statistics and modelling (although all this, including a macroeconomic model is included), but involved external representatives on two levels. On the one hand, the researchers reported to the advisory board of selected experts (suggested in even numbers by each of the participating institutes), environmental NGO representatives and influential trade unionists. On the other hand, in particular the socio-environmental scenario was taken to a discourse process with a number of civil society groups as well as with several political parties. The intention of this consultation round was threefold: to gain input for the scenario, to stimulate ongoing debates in the different groups with the intention to connect them amongst each other, and finally to create a (justified) feeling of ownership as a necessary precondition for political receptiveness and support once the study was published. But at least as relevant as this external feed back were the built-in internal feedback mechanisms in the process structure chosen (see figure 3).

In an early phase, a common definition of the objective was developed, and shared sustainable development criteria adopted. Although the specialised institutes had a lead role for their respective domain in this process, they could not simply set the standards but had to seek the agreement of their partners from other disciplines. This was of particular importance as the criteria developed were considered binding throughout the project, i.e. they were used to assess and to value the research contributions by all project partners. These mutual judgements were a permanent characteristic if the process, making life no way easy for the scientists involved, but providing an enormous amount of possibilities for interdisciplinary exchange and learning. As a result, a common judgement on the sustainability of a number of scenarios was achieved, despite the still remaining different preferences of researches from the different disciplines.

The discourse did not end with the project: in a subsequent transfer phase, the project results were presented (always by colleagues from all three institutes) to all major trade unions, to party conferences, environmental NGOs and religious groups. Most trade union magazines ran articles (covering some 10 million readers), as did the other groups involved. Selected results were presented to European Commission representatives (on Sept. 11th 2001), and we had the opportunity to explain or project-based point of view on the national sustainability strategy to the Chancellery staff in charge.

Figure 3: Key structural elements of the research process



A number of smaller studies was generated as spin-off from this larger one, including more detailed work on winning and loosing sectors, on qualification demand, on the role of unpaid work in sustainability scenarios, the role of consumption and the environmental impact of wealth. Each of them had a different target audience and consequently a different participation structure.

Results

Throughout all projects, the broadening of the stakeholder groups, including different forms of ex ante, project integrated and ex post involvement provided a wealth of experience regarding the benefits and risks involved in different forms of stakeholder participation.

Opening the research process to interdisciplinary co-operation has proven extremely fruitful as long as all disciplines involved were really ready to accept their limited competence and thus their role as one contributor amongst equals (an insight which always took some time to develop), and once a “common language” had emerged, the results were a richer and more differentiated view and a higher degree of political relevance of the results.

This process, however, is time consuming, and although most donor agencies consider interdisciplinarity as an added value, they are hardly ever ready to fund this extra effort, the development of understanding without any results to be presented. A new thinking on their

side will be essential to provide a level playing ground of interdisciplinary research compared to more traditional approaches.

Extending the knowledge base stepwise further, the next group to be involved is external experts. If properly chosen, they can provide valuable input, but pose a certain risk as well as they have not undergone the mutual acceptability enhancing process interdisciplinarity is all about. Some experiences are summarised in table 3.

Table 3: Expert knowledge: Extended expert consultations

Measure	***Characteristics***
Advisory boards	+: Continuous advice throughout the project, familiarity with details of the project
	-: Positive group dynamics may drive project. Conflicts (e.g. between disciplines) leads to deadlocks
Hearings	+: Situation specific advice, but out of the project context
	-: Interdisciplinarity easily achieved, but hardly integration
Internet	+: Broad access to external expertise
	-: Low selectivity of participation

The next step is to include non-scientific knowledge. As in this case, scientists are the demanding side while the non-scientists are supplying their information, they will to a large degree determine the rules of their involvement (not only time wise, but also in choosing the issues relevant to them). In other words: Involving non-scientists as a source of information requires leaving the methodological and institutional framework of science at least for some time, to talk common sense and try to understand the scientific meaning of the information provided.

In order to keep the motivation of the participants it is essential to involve them at points of the research process where their input really makes a difference, regarding future research questions or the use made of results obtained so far. This includes interim reports, reviews, consultative meeting for planning new project phases, but also the readiness to go back to what has been done and fill gaps identified by the non-scientific advisors.

For scientists, this can be a serious challenge, as the criteria applied by non-scientists may differ significantly form those used in research processes. This includes political relevance, the possibility to enact change ("If we can't do anything about it, why go into details ?") or the public sensitivity to the way insights are being presented ("this does not mean anything to me – if you emphasise that point, everybody will listen"). Obviously, there is not necessarily an immediate match between paying tribute to public sensitivity structures and the priorities derived from a research (intermediate or final). Balancing the approaches, making scientific results meaningful without loosing the scientific quality is an art of its own and requires a kind of sensitivity and diplomacy which a scientists has not necessarily gained in his/her education.

Some experiences with such processes are summarised in table 4.

Table 4: Lay knowledge: Non-scientific stakeholder participation

Measure	***Characteristics***

Steering committees	Safeguards relevance of research issues and the credibility of the methodologies applied
	Can prescribe assumptions and methodologies not suitable from a scientific point of view
Advisory boards	Selective involvement to discuss non-scientific questions like research objective and relevance
	Individual positions rather than integrated group assessment, politically heterogeneous
Consultation processes	Broad access to external expertise of selected sectors
	Not necessarily coherent suggestions

Finally, in the transfer process after a project has been concluded, the issue is no longer to involve external partners to steer the project but to present the results in a way most meaningful to the outside world (although a good discussion may always generate new research questions).

In this phase, the scientists are setting the agenda. They are inviting an audience they consider relevant (sometimes this is done by the donor rather than by the scientists), but this does not give free hand how to organise the process. To the contrary, it requires a high level of flexibility to gain the attention of the target audiences. As no opportunity exists to create a feeling ownership in a finalised product, outsiders' fascination emerges from applications rather than from content. However, as the potential applications are as different as the possible target audiences, tailor-made presentations to specific target groups are the most promising way to proceed, again a skill not necessarily learnt in the acodemic education process.

Some lessons learnt from transfer processes are summarised in table 5.

Table 5: Implementation knowledge: Transfer Processes

Measure	**Characteristics**
Mixed boards	Combines interdisciplinary scientific and stakeholder input to the project
	Can end up in deadlocks if too controversial positions; complementary boards have been more successful
Presentations	To decision makers: focus on results
	To scientists: focus on methodology
	To lay people: focus on the meaning for the everyday life – needs a rather different language
User-producer-networks	For continuous exchange, creates trust and familiarity with each others problems
	Risk of in-breeding

Outlook

Sustainability policy must comprise of target setting and policy impact monitoring for all four dimensions of sustainability as well as on different levels of society.

The complexity of the task to define sustainability targets and their corresponding indicators can be reduced by structuring them according to the prism model of sustainability, and by focussing on performance indicators for driving forces linked to this geometrical structure. This permits also the communication of diverging trends in different subsystems of society, not masking them by one aggregate index.

Applying the concept of post-normal science through multi-stakeholder dialogues for target setting is a possible, necessary and successful step to derive broadly based policy targets. Indicators can be developed the same way, creating a positive atmosphere of ownership and an increased intention and willingness to participate in the implementation of results amongst the groups involved.

Table 6: Results overview

Positive Result:
➢ Better definition of societally relevant research questions
➢ Broader definition of strategies to be pursued
➢ Improved policy suggestions due to reality check
➢ Support for proposals through feeling of ownership
Critics:
➢ Risk of short term orientation, dominated by acute problems
➢ Taboos for proposals not deemed adequate at the moment
➢ Intervention into the research process to enforce desired results

Dynamic models are an excellent tool to show interaction and rebound effects, in particular counter-intuitive effects of policy measures. Even they can be developed in cooperation with societal groups to make sure their capacity to answer questions is considered relevant by different societal actors. Again, a feeling of ownership can contribute to the shared use of the same tool by a number of different actors, thus creating common ground for policy assessment and policy request formulation, i.e. public policy networks..

Dialogues, models and indicators can thus contribute to more transparency of the policy process and the accountability of actors and consequently help steer society in a more sustainable direction. Increased accountability is of particular importance to increase the currently decreasing levels of trust in decision makers and political institutions, which tend to undermine the function of the institutional system of society.

Furthermore, all our experience confirms the need to involve stakeholders not only in the decision making processes, but already in the process of generating information for decision making. For a number of reasons like trust building, credibility of science, but also enriching the scientific process with relevant input otherwise not available , this must on equal footing, although not equally in all phases of the work (for pros and cons, see table 6, for the optimal results of specific measures taken, see table 7).

Defining the questions should be a joint exercise, deciding on the relevance should be a task in which scientist can participate in their capacity as citizens, as one person amongst equals who even often know better. However, regarding the methodology and the way of

scientific work, scientists should play a decisive role, having to justify the appropriateness of their approaches, but not necessarily doing every step in co-operation. Rather, developing the proper structure of closed and open working phases, of desktop research and discourses, providing the necessary coherence and balance will be one of the challenges for all future sustainability science projects.

Table 7: Measures and expected outcomes

Involvement in definition of research questions ➔ enhancing the relevance of researchRegular consultation during the research process ➔ opportunity to have a real impact on the researchInterim results evaluation, incorporate in research ➔ assurance of quality and relevancePre-assessment of final results ➔ ownership feelingCommon presentation ➔ credibility of the research work, enhanced outreach and acceptability Transfer process according to actors' needs ➔ significant only if decision makers accept relevance

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