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ANALYSIS

Transdisciplinarity for social learning? The contribution of the German socio-ecological research initiative to sustainability governance

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ABSTRACT

Governance depends upon inputs from science. Whereas the conventional view portrays science as advisor of policy makers, more recent understandings see knowledge creation processes and decision processes as highly interrelated and intermingled. Against this background, we analyse the new research programme on socio-ecological research set up in Germany. In doing so, we firstly discuss current conceptual approaches to redefining the role of science in society. Secondly, we identify five challenges for scientific activities and apply these as criteria for an assessment of the socio-ecological research initiative. Thirdly, we analyse the potential limits and opportunities of this programme for social learning towards sustainable development. We also indicate what can be learned for ecological economics.[2]

1. Introduction

Ecological economics sees itself as the science and management of sustainable development and claims to be more than "just science" in the traditional sense of the world — an activity that explicitly aims at changing the world. In this world, "traditional" science[3] is under attack anyway, for the conditions of the production of knowledge have

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[3] If not stated otherwise, we use the term "science" to denote both natural and social sciences.

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profoundly changed in the last decades. What is more, global problems of poverty and ecological damage have not only challenged the role of science, but of political processes as well. In this situation, "governance" becomes a central topic of ecological economics. Very obviously, ecological economics, with its explicit vision of a science that contributes to sustainability, must deal with the roles of different actors and institutions that are relevant for governance for sustainable development.[4] One crucial factor in this context is the relationship between governance and the production of knowledge — and the fact that the line between these two realms has become blurred.

In order to obtain a clearer picture of the processes of scientific knowledge production and its interaction with governance for sustainable development, a closer look is needed into the learning processes that take place on the border between the political process and scientific work. Social learning is highly interrelated with the generation, construction and representation of scientific knowledge and the openness, flexibility and variety of the governance systems of collective decision making. The political system depends upon informational and conceptual inputs and contributions from the other societal systems in the governance process — for example, the social and the natural sciences. Whereas the conventional view portrays science as an advisor of policy makers, more recent understandings of this interaction see the knowledge creation process and the decision processes as highly interrelated and intermingled (Jasanoff, 2004b; Gibbons et al., 1995). The role of science as a key societal actor that also creates realities beyond the traditional path through the policy making process, has, however, scarcely been addressed.

Building on a notion of transdisciplinarity as the inclusion of non-scientific actors into the processes of knowledge generation and implementation, a new research programme has been set up in Germany. It intends to promote sustainable development through innovative research project designs that directly involve societal actors and aim at the combined knowledge generation and at influencing societal developments into the direction of sustainable development. The *socio-ecological research programme* is funded by the German Federal Ministry for Education and Research following similar programmes in Switzerland and Austria. In the context of social learning at the science-policy-society nexus, the programme raises numerous questions that will be addressed in the present paper. We start with a description of current debates concerning the role of science for social learning in the context of sustainable development. Against this background, we sketch five specific challenges for scientific activities and apply these to the socio-ecological research programme. We analyse the potential limits and opportunities of this programme for social learning towards sustainable development. In conclusion, we also indicate the relevance of our finding for ecological economics.

[4] The fact that these actors frequently refer to time-scales different from that of scientists is beyond the scope of this paper.

2. The role of science in social learning for sustainability

2.1. Novel perspectives on science

The political system depends upon informational and conceptual inputs and contributions from the other societal systems in the governance process, among others from the social and the natural sciences. According to the conventional view as spelled out by Price (1965), science is seen as an advisor of policy makers and both spheres need to be rigorously separated. More recent understandings of this interaction see the knowledge creation process and the decision processes as a social process where both spheres closely interact and merge. The discourse on sustainable development gave a new push to this debate. Sustainable development entails highly complex challenges that include multiple problem dimensions starting from poverty eradication to safeguarding of ecosystem services and to economic development to feed the entirety of humankind. This complexity and the multi-layered scales of the problem render the relationship between governmental regulation and scientific information even more difficult than in more conventional problem arenas.

While conventional environmental problems such as air and water pollution have been somewhat successfully addressed by regulatory approaches that drew on issue-specific scientific advice, the complexities and the multiple scales and actors of sustainability governance require a different approach (Grunwald, 2004). First, uncertainties are significantly larger given the sheer number of factors involved. Sustainability addresses social, economic and ecological indicators at the same time and acknowledges the fact of their interconnectedness. Thereby, ecological processes have to be monitored and analysed in their interaction with social systems that are by nature subject to human volition. While ecological processes are already difficult to analyse, social processes are highly uncertain and unpredictable (Jasanoff, 1987; Sarewitz et al., 2000). Second, numerous new actors enter the stage of the governance process. Governments are neither the prime actors in this process nor can they prescribe distinct solutions to all problems. It is non-state actors of different kinds that are increasingly seen as crucial for the promotion of cures and innovative solutions to environmental and social problems. These include private corporations as well as non-governmental organisations, scientific communities and other civil society groups. Sustainability-related rule-setting processes can be observed that come into being entirely without government intervention. Third, the modes of governance change from conventional regulatory command-and-control schemes to different forms of interaction between actors and regulators ranging from cooperative learning circles to voluntary agreements and information requirements.

In this context, social learning has been described as the prime governance process to approach the objectives of sustainable development (The Social Learning Group, 2001; Kopfmüller et al., 2001; Board on Sustainable Development of the National Research Council, 1999; Parson and Clark, 1995). Following this strand of literature, social learning can be

understood a *process of change on a society level that is based on newly acquired knowledge, a change in predominant value structures, or of social norms which results in practical outcomes*. For the purposes of sustainable development and its implementation, it is key to concentrate on those practical outcomes that foster sustainable development. Social learning thus transcends both, individual learning and mere changes in the cognitive abilities of certain individuals. In this process, diverse social actors and groups are involved including political decision makers, activist groups and scientific communities. Social learning requires an adequate interaction of these groups and actors to generate adequate and problem oriented knowledge and to use this knowledge in practical applications.

In this paper, we intend to focus on scientific actors and their interaction with other societal actor groups in the processes of generating and implementing knowledge for sustainable development. Therefore, we will draw on the extensive debate on the changing roles of science in processes of knowledge generation and implementation in political contexts. The most prominent concepts of this debate have been Mode-2 science, co-production of knowledge, sustainability science, and the post-normal science approach.

2.1.1. *Mode-2 science*

Building on the observation that processes of scientific knowledge production are becoming more dispersed and entail a larger degree of social interaction across institutional boundaries, Gibbons et al. (1995) coined the term Mode-2 science. This form of science is concerned with problems that are characterised by irreducible uncertainties, high complexity and the need to transcend traditional boundaries of science and society. Apart from the basic empirical observations, the concept also refers to normative foundations that allude to increases in democratic legitimacy of more open and integrative forms of knowledge production. Therefore, the involvement of non-scientific forms of knowledge becomes essential to generate socially robust knowledge that is likely to be accepted by large parts of society. Nowotny et al. (2001, pp. 258f) call for a more open and constant exchange between traditional forms of scientific knowledge and other knowledge elements that might also build on other values and norm systems: "(I)t is no longer possible to establish a clear demarcation between context and core, hard layers and soft layers, the body of knowledge and images of knowledge. Many of the most promising scientific arenas combine elements of both." The clash of different varieties of knowledge should rather be seen as an encouragement for more refined research for the hidden systems of values and symbols and could prove to be highly productive. It is expected to impact on the organisation and division of knowledge generation processes as well as on the epistemological foundations of research (Gibbons, 2000).

2.1.2. *Co-production of knowledge*

In a similar vein, a number of recent publications discuss the co-production of knowledge in the interaction between science and society and in particular policy making (Elzinga, 1997; Jasanoff, 2004a; Jasanoff and Wynne, 1998; Lemos and Morehouse, 2005). The concept reflects the mutual dependence of science and societal actors to generate identity and legitimacy. Neither science nor politics can claim dominance in this interaction, it is the intermingled process of their interaction that generates knowledge and social order at the same time. What is more, both domains draw on each other and cannot proceed without the other one: "Ideas and objects are simply obliged to undergo a kind of parallel processing in order for problems to be solved in either domain: that is, nothing significant happens in science without concurrent adjustments in society, politics or culture, similarly, intransigent social problems seldom yield to resolution without changes in existing structures of knowledge." (Jasanoff, 2004b, p. 21) Even though the concept of co-production of knowledge builds in large part on empirical studies and less so on theoretical systems, Jasanoff identifies four key areas of co-production. First, identities of scientists and engineers are formed within the processes of scientific knowledge production. Second, institutions such as rules of decision making are being created through scientific debates and their interaction with society. Third, discourses are processes of the formation and creation of meaning that are mutually formed by science and society. Fourth, representations of the political and social world underlie historical, political and cultural influences that are informed through scientific concepts and theories. A clear delineation cannot be drawn between both spheres and between the norms and values that are shaped by cultural, political as well as scientific influences.

2.1.3. *Sustainability science*

In the emerging field of sustainability science which has been constituted around the problems of sustainable development, novel forms of research and science-policy interaction through stakeholder participation and the integration of their diverse forms of knowledge and expertise are called for. Sustainability science has been defined as a "new field (…) that seeks to understand the fundamental character of interactions between nature and society. Such an understanding must encompass the interaction of global processes with the ecological and social characteristics of particular places and sectors" (Kates et al., 2001, p. 641). The resulting challenges for scientists and society at large have been summarised as: "(i) span the range of spatial scales between such diverse phenomena as economic globalisation and local farming practices, (ii) account for both the temporal inertia and urgency of processes like ozone depletion, (iii) deal with functional complexity such as is evident in recent analyses of environmental degradation resulting from multiple stresses; and (iv) recognize the wide range of outlooks regarding what makes knowledge usable within both science and society" (ibid.). To address these challenges, the authors call for the integration of societal stakeholders such as the private sector and the broader public as well as diverse scientific disciplines into the process of generating knowledge.

To promote the objectives of sustainable development, science will be needed to develop knowledge in an embedded way together with societal stakeholders and policy makers (Clark et al., 2005). This knowledge relates to the conditions and transformations of ecosystems and the entire earth system as well as to incentives and institutions to provide guidance for the sustainability transition. While conventional

monitoring of the conditions of ecological and social systems might remain in scientific domains, the close interaction between society and science actors is inevitable when problem-and solution-oriented knowledge is sought, e.g. on how to create the right incentives and on which institutions will be necessary to achieve sustainable development goals. This "new paradigm" of scientific work can no longer adhere to the strict focus on objectivity but has to accept a basic normative element in any research effort. With regard to sustainable development, sustainability science can build on countless decisions of the international community to implement the different objectives as embodied in the related UN conventions and conference decisions.

2.1.4. *Post-normal science*

While "Mode 2" and "co-production of knowledge" concern the general conditions of knowledge production in postmodern societies and sustainability science brings us closer to issues of sustainability governance, "post-normal science" is clearly related not only to the issues of sustainable development, but firmly linked to ecological economics. While the idea of post-normal science arose from an analysis of problems of "normal science" in the general sense, it has become an important part of the ecological economics debate on the role of science. Post-normal science is an attempt to increase the problem-solving capacity of scientific work in a context of "soft" scientific inputs and "hard" value decisions. We are in a situation where science becomes ever more necessary, but at the same time ever less sufficient for the socially relevant definition of truth. At the same time, the stakes in scientific work and political decisions are very high (Funtowicz and Ravetz 1991, 1993, 1994).

Post-normal science is a reaction to this new situation. In the context of governance for sustainable development, there are many measures that cannot rely on exact scientific inputs but have to be based on political decisions. We *have to* decide on the basis of "soft" scientific inputs to save the "hard" values — climate change being probably the most prominent case of such a situation (albeit the scientific basis is increasingly becoming "harder"). This is clearly at odds with the usual criteria of normal science. A basis for the call for a post-normal science, then, is that "uncertainty and ignorance can no longer be expected to be conquered; instead, they must be managed for the common good" (Funtowicz and Ravetz, 1991, p. 146). In a post-normal science, "science is no longer imagined as delivering truth, and it receives a new organizing principle, that of quality. This is dynamic, systemic and pragmatic, and therefore requires a new methodology and social organisation of work" (Funtowicz and Ravetz, 1994, pp. 197f.).

In normal scientific discourses, laypersons, journalists, politicians are "outsiders". A key feature of post-normal science is that extended peer communities become important for the production of relevant knowledge. In other words, "outsiders" become "insiders". It is also important to include non-scientists into decision making processes to avoid a "scientific bias" which is often dominated by mainstream-approaches: "As long as discourse remains limited to experts who represent the mainstream of disciplinary (or interdisciplinary) thinking, the discourse process may simply reinforce biases of the status quo as familiar definitions of critical rationality remain unchallenged" (O'Hara, 1996, p. 101). When extended peer communities are to play a role in scientific endeavours concerning sustainability, science has also to find new ways of communicating with people and through institutions that are not part of what has traditionally been viewed as the scientific community.

2.2. *Resulting challenges for science for sustainability governance*

From different starting points, the aforementioned approaches to the role of science agree on a number of fundamental elements that characterise the challenges for future research in general and for sustainable development and the related governance processes in particular. Governance processes to promote sustainable development goals necessitate an enormous quantity and a novel quality of knowledge support that has to be fed into social learning processes. In an integrative perspective that also considers the fact that there are no clear demarcation lines between science, politics and related governance processes, we see the following key challenges for scientific work. They can also serve as general criteria for the chances of research programmes and projects to actually contribute to societal change towards sustainability. We sketch these criteria and will, in Section 3.2, apply them to the socio-ecological research programme.

2.2.1. *Transdisciplinarity*

When understood as the problem-focused co-operation of different scientific disciplines together with non-scientific actor groups, transdisciplinarity is a key requirement of future sustainability-related research (Max-Neef, 2005). The knowledge production process can neither remain in isolated disciplinary strands nor can it be restricted to academic research institutions. It rather has to open up to civil society groups, holders of local lay knowledge, corporations and other stakeholders. In particular, scientists have to acknowledge the fact of their connectedness to political and normative questions and thus need to address them actively by establishing forms of transdisciplinary research. These should provide room for interaction but they need to be designed carefully given the numerous pitfalls and particular interests and different rationales of the different actor groups. Participatory approaches promise to allow for the inclusion of different interests and various forms of knowledge into the knowledge generation process (Joss and Durant, 1995; Siebenhüner, 2004; Webler et al., 1995). Moreover, novel evaluation schemes will be necessary to account for the contribution of the knowledge creation process to practical solutions.

2.2.2. *Active policy integration*

Given the inevitably connected and embedded nature of scientific research in particular in the field of sustainability studies, we argue that science as one actor group in the social learning process has a distinct responsibility to become involved in political decision making processes. However, the interaction with political decision makers requires additional caution since legitimacy and saliency play a significantly higher role than mere scientific credibility

(Biermann, 2002, 2006; Cash et al., 2003; Farell and Jäger, 2006; Siebenhüner, 2003). As Mitchell et al. (2006) conclude, policy changes can only be caused through information when the knowledge generation process manages to be *salient* to the potential users, *credible* in regard to the scientific methods, and *legitimate* in the way the knowledge generation process is designed. Therefore, a prudent design of cross-boundary institutions is called for that accounts for the different rationales in the governance processes towards sustainable development.

2.2.3. *Normativity*

The traditional distinction between positive and normative statements does not hold, and this has largely been accepted in the sustainability discourse, and surely within the community of ecological economists. Normativity has, in this context, at least two dimensions. First, science is full of normative statements even when statements dress as purely scientific arguments. Since this cannot be avoided, modern knowledge generators are better advised to explicitly acknowledge this fact, rather than (unsuccessfully) trying to avoid the problem. Secondly, the goal of sustainable development is explicitly normative. Sustainability is about justice (more specifically, about inter-and intragenerational justice). Ecological economists emphasise the special nature of nature and accept and attempt to analytically grasp the embeddedness of the economy and society in the natural environment. In addition, ecological economics has always insisted on the normative dimension of scientific inquiry. Many contributions from the ecological economics community share an explicitly normative stand.

2.2.4. *Learning*

The very nature of sustainable development as an open concept and the need to involve societal stakeholders into decision making processes necessitates a learning approach to governance. Policy processes need to actively integrate various forms and contents of knowledge to be socially accepted and to account for the changed governance structures in domestic and international domains (Kopfmüller et al., 2001; Müller and Siebenhüner, in press). Under these conditions, innovative approaches are called for that bridge the needs of democratic decision making and the new requirements for knowledge management in sustainability governance processes. Moreover, once decisions have been reached, policy processes need to be open for new knowledge.

2.2.5. *International approach*

Knowledge generation processes for sustainable development need to be interconnected on different levels. One of these levels is the cross-national and global level of interaction. Sustainable development is characterised by its global approach that is linked to all other geographical scales including regional and local scales. Isolated national approaches make only limited sense in this context. In particular when addressing problems of international scale such as climate change, poverty, or globalisation, knowledge generation processes need to reach out to the knowledge of others in other domains and national contexts.

3. The socio-ecological research initiative in Germany

3.1. *The current state of the socio-ecological research initiative*

Building on a notion of transdisciplinarity as the inclusion of non-scientific actors into the processes of knowledge generation and implementation, a new research programme has been established in Germany under the auspices of the Federal Ministry of Education and Research (BMBF). It intends to promote sustainable development through innovative research project designs that directly involve societal actors and aim at the combined knowledge generation and at influencing societal developments into the direction of sustainable development. The socio-ecological research programme is funded by the Federal Ministry since 1999 and should run for about 10 years. All projects under this initiative have to include researchers from the natural and the social sciences and should include practitioners to ensure the practical applicability and impacts of the research project. The spectrum stretches from projects with advocacy objectives to research designs that adhere to the more conventional approach of scientific analysis that is discussed with societal actors at a later stage. Socio-ecological research is explicitly normative in that it is intended to actively contribute to sustainable development. It is part of the national sustainability strategy of the German federal government.[5]

We have already indicated a few characteristics of socio-ecological research, and it is obvious that it shares many features with approaches such as ecological economics or sustainability science. Socio-ecological research is explicitly designed to go beyond disciplinary boundaries, a basic idea being to overcome a technical orientation of environmental policy and research. It is an attempt to go beyond an environmental focus towards an integrative approach that takes into account the social, economic, cultural and political dimensions of sustainable development and the societal transitions related to it. Socio-ecological research explicitly aims at scientific activities that contribute to the solution of practical problems concerning sustainability. With this emphasis and a focus on issues at the interface of nature and society, its projects cover a broad range of problems and methods, reaching from material flow analysis and regional studies to issues concerning transportation and agriculture and social learning processes and its contribution to sustainable development.

Socio-ecological research was established in 1999 under the auspices of the German Federal Ministry of Education and Research. Altogether, it funds about 30 research projects which range from analyses of infrastructure systems, such as electricity, water or food, via regionally oriented studies of (un)sustainability to projects that focus on certain policy fields such as mobility or nutrition. Disciplines involved include

[5] For an overview of the programme see http://www.sozial-oekologische-forschung.org. Initial research results are summarised in Balzer and Wächter (2002).

virtually all social and natural sciences. Until 2005, about seven million Euros have been spent. Socio-ecological research has three instruments of funding. Project network funding relates to the funding of research projects on specific issues such as strategies for sustainable consumption or transformations for regional sustainability. These project teams have to consist of individuals from different research institutions as well as from societal actors such as corporations, public authorities or non-governmental organisations. Within the funding for young scientists, junior scientists that want to develop their inter-and transdisciplinary qualification are supported. At the moment, this instrument supports nine research groups. Finally, infrastructure funding is designed to strengthen non-profit environmental research institutes. Six institutions have so far received funding. The goal is to prepare and develop specific knowledge in inter-and transdisciplinary research.

The several projects can be clustered according to the topics of their research. One group of projects works on networks of supply and disposal systems (e.g., water, energy, waste) and the impacts of demographic and economic change on these networks. The goal is to develop innovative instruments and strategies that contribute to the sustainability of supply and disposal systems. Sustainable food systems and agriculture is another field of socio-ecological research. It encompasses the whole supply chain of food production and investigates alternative methods of agriculture or specific life styles and their relevance for sustainable agriculture. Another group of projects focuses on urban and regional development, analysing alternative means of the reconstruction of urban districts or planning for sustainability. Other projects that do not fit into this clustering include, among others, work on innovations concerning information society, benchmarking in companies, and the evaluation of transdisciplinary research. Following its cross-cutting approach, socio-ecological research has three problem dimensions that are, with different emphases, considered in all projects: (i) societal needs and flows of materials, energy, and information; (ii) basic problems and development of methods; (iii) gender and environment. Moreover, the socio-ecological research structure includes working groups on cross-cutting issues such as basic questions of interdisciplinarity, transformation, the inclusion of social partners in research, gender, or the role of economics in socio-ecological research activities.

3.2. *Discussion of the initiative*

Socio-ecological research is explicitly designed to contribute to "transformation knowledge" that improves society's ability to induce changes that allow better governance for sustainable development. If successful, socio-ecological research will help to reassess and redesign the triangular relationship between society, politics and science and promote an institutional learning that results in new institutional arrangements that better address the challenges of sustainable development than the current system of research informing politics. But how does this initiative meet the aforementioned challenges to scientific research in relation to sustainability governance? In this section, we will discuss the initiative with regard to these items and give an assessment of the potentials and limits of socio-ecological research.[6]

3.2.1. *Transdisciplinarity*

It was a fundamental requirement for all project proposals within the socio-ecological research initiative to have a transdisciplinary component. This relates first to staffing questions where teams had to consist of scholars from both fields, natural and social sciences including humanities. A view on the actual teams reveals, however, that the social sciences clearly dominate most projects. Secondly, all projects had to include practitioners or a practical application that is apt to contribute to socio-ecological transformations. In particular the issue-specific projects are forced to put a strong emphasis on this element while the groups of young researchers are given more freedom to also focus on their academic work.

3.2.2. *Active policy integration*

Participation of non-scientific experts and lay citizens play a prominent role in many research projects of the socio-ecological research programme. In this sense, socio-ecological research as a programme serves as a boundary-spanning initiative (Gieryn, 1995). The programme also aims at the integration of aspects such as theory development or gender issues. However, most research projects focus on local and highly selected actor groups, e.g. farmers or politicians in one specific region, to be included in the knowledge generation process. Only very few projects address current domestic or even international policy issues where they could actually have an impact on governance. Exceptions to this rule address the current reforms in agricultural policy in Germany and to some extent a project on climate policy. None of the projects deliberately addresses the adequate combination of saliency, legitimacy and credibility. However, it is the objective of the programme to support independent non-profit research institutes that have a political aspect in particular on research policy. These institutes, such as the Öko-Institute or the Institute for Ecological Economic Research (IÖW), warrant an independent voice among the research institutions in Germany and are generally well respected in the public. They also attempt to influence environmental policy decision making in several areas.

3.2.3. *Normativity*

Nearly all project partners accept the basic normativity of their work that is targeted at the general guidelines of the concept of sustainable development. As part of the notion of transdisciplinary research, they intend to bring about practical solutions towards more sustainable outcomes. The price several projects have to pay for this often explicitly stated normative approach is the jeopardy of not being accepted in the conventional scientific communities. This is a serious problem that points to the general tension between "norma-

[6] Data for this analysis is drawn from the personal experience of the authors as project leaders in the programme analysed here as well as from a constant oral and written exchange with other projects and the programme co-ordinators.

tive", issue-oriented research and "classical" ideas of science as a neutral and non-political exercise—a situation that ecological economists are well familiar with. Academic communities rarely acknowledge the open normativity of research and raise concerns about the scientific credibility. In this respect, researchers—and, we should add, especially young scientists who still have the need to promote their work within a specific scientific community—in the socio-ecological research initiative have taken on a difficult communication task to explain the intrinsic normative aspects of every academic work and the specific and deliberate normative choices they make.

3.2.4. *Learning*

The socio-ecological research initiative came into being as a learning endeavour. From the outset, it was clear to most proponents of the programme inside and outside the Ministry that the programme will need to evolve over time and will need to be responsive to new insights and new challenges. It could not have been designed as a conventional research programme with standardised funding rules and procedures. Since many design elements and administrative features of the programme also challenged conventional funding structures inside the Ministry, learning was often used as an excuse for overt difficulties in implementing the ambitious plans and projects. However, institutions such as a strategic advisory board and external review committees give feedback to the organisers of the programme and give them the opportunity to learn from the experiences in the implementation of the projects. For instance, a review on the groups of young researchers criticised the over-complexity of the multiple tasks these groups have to fulfil in conducting excellent research projects while ensuring transdisciplinary designs and allowing all group members to pursue their individual qualifications. Programme organisers reacted in reducing some extra burdens of the groups.

3.2.5. *International approach*

With regard to the international approach, the socio-ecological research initiative has, so far, a bad record. It is closely linked to similar preceding programmes in Switzerland[7] and Austria[8], but it is hardly connected to international debates, e.g. on sustainability science, on ecological economics or on the human dimensions of global environmental change. This deficiency seriously limits the impacts the programme might have since it picks up key topics of international interest and could very well be internationally interlinked. However, the set-up as a research programme of a national federal ministry has so far precluded it from a more international scope. In this respect, the programme could learn from similar programmes in Denmark or in the Netherlands that start to open up their national research competitions for applicants from other countries.

[7] For the Swiss Priority Programme (SPP) Envrionment see http://www.sppe.ch. A synthesis of the programme can be found in Häberli et al. (2002).

[8] The Austrian Programme on Landscape research is described in greater detail at: http://www.klf.at.

4. Conclusions

Science faces challenges that cannot be met by doing "normal science". "Mode 2", co-production of knowledge, sustainability science and post-normal science are all keywords of discourses reflecting this situation, the latter two being directly related to questions of sustainability governance. Drawing on these concepts, we have sketched criteria concerning the role of science for governance: transdisciplinarity, policy integration, normativity, learning approach, and the international dimension. We have described the programme "socio-ecological research" as an activity with an explicit mission concerning its contribution to the (political) goal of sustainable development. Since most projects within the socio-ecological research initiative are ongoing, it would be premature to judge its actual impact on governance. What we have done here is to evaluate key characteristics of the programme according to our five criteria which delivers insights about the *potential* impact on actual processes of governance. As for transdisciplinarity, socio-ecological research, albeit its bias toward social sciences, can be viewed as a success, since it actually brings together researchers from an array of different disciplines. Concerning active policy integration, the programme has not a strong record with regard to national and international policy issues.

Obviously, normativity of socio-ecological research raises serious problems that are well known from other areas of research concerning sustainable development. We have shown that scientists are faced with an important and difficult communication task. Towards this end, it might be helpful to take up the distinction between "internal" and "external" rhetorics of science (Luks, 1998, 1999). When scientists try to convince each other about the usefulness of their theories or paradigms, this can be called "internal rhetoric". However, scientists do not only produce science, they also communicate with the rest of the world: "external" rhetoric. This external rhetoric has two dimensions (Luks, 2005, pp. 53f.): When science wants to communicate with non-scientists in order to improve its quality, for example addressing extended-peer-communities in the context of post-normal science, it has to use a language different from intra-scientific language. This could be called *explicit* external rhetoric. An external dimension is, however, also present if communication with non-scientists is *not* the explicit goal — scientific communication plays a role in political discourse. This could be called *implicit* external rhetoric. These rhetorics and the different emphases related to them will not solve the problem of sustainability scientists of "getting involved" — but it might help them to communicate their findings in a manner sensible to different audiences that are relevant in the sustainability governance discourse.

The criterion of learning was, from the start of the programme, of crucial importance to socio-ecological research. This learning process was at times rough and tough for all participants involved, but after a rocky road, learning processes started to and still do have an impact on the practice of socio-ecological research. As a tool for social learning, the programme might also serve as a promoter of sustainable development in Germany, even though its actual policy impacts will probably

remain limited. We have shown that the international orientation of socio-ecological research is far from optimal. Indeed, this field is a weak point of the programme that should soon be overcome.

On the whole, ecological economists and socio-ecological researches have a lot to learn from each other (see also Luks et al., 2006). Ecological economics sees itself as a post-normal science of sustainability, approaching problems with a plurality of methodological perspectives and reaching beyond the borders of scientific disciplines. In addition, ecological economics is explicitly normative in that it is intended to contribute to societal change in a specific direction: sustainable development. Socio-ecological research, which also originated from an explicitly "transformative" version of scientific work, is based on the intention of overcoming disciplinary boundaries and integrating the work of social and natural scientists. With regard to the notion of transdisciplinarity, the approach of socio-ecological research and ecological economics follow different concepts (see also Höhler and Luks, 2005). The interpretation in ecological economics relates to the transcendence of intra-scientific boundaries, and the one in socio-ecological research strives to overcome the border between science and "practice". In other words, the two interpretations of transdisciplinarity refer to either the "internal" or "external" rhetorics of science. Ecological economics as a post-normal science and the social ecological research programme thus emphasise different aspects of transdisciplinarity, but in the final analysis, they *share* the vision of science as an activity that transcends disciplinary boundaries and dares to get involved in "practical" processes relevant for sustainable development.

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