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1 Introduction: The idea of programme-based research and the Helmholtz-Programme *Sustainable Use of Landscapes*

For the solution of modern-day problems concerning the interface between ecological systems, the economy and society technological solutions alone are no longer sufficient. Instead, new ideas, concepts and proposals are required: On the one hand, they have to encompass physical, ecological, technical as well as economic, cultural, legal and political aspects and, on the other hand, they must be socially acceptable and politically enforceable. Because of this, science and research institutions are confronted with new challenges. Society and the general public expect science to offer relevant and durable contributions for the protection of the natural, economic and social basis of life:

> "The current and growing extent of human dominance of the planet will require new kinds of knowledge and applications from science – knowledge to reduce the rate at which we alter the Earth systems, knowledge to understand Earth's ecosystems and how they interact with the numerous components of human-caused global change, and knowledge to manage the planet." (Lubchenco 1998: 495)

However, up to now the natural and social sciences within traditional universities are by no means prepared to meet these challenges. Orientation and organisation of research and teaching is guided by rather specialised and narrow disciplinary viewpoints in the framework of the traditional university institutions:

> "The present scientific institutions and organisations have become alarmingly complex. On the one hand, there is a growing particularisation of disciplines, on the other hand, there is diminishing ability to think in encompassing interrelationships beyond the disciplines." (Mittelstraß 2003: 7, our translation)

According to Lawrence (2003: 260), science in its present state offers strong incentives towards "an antiscientific culture in which pushiness and political skills are rewarded too much, and imaginative approaches, high quality results and logical argument too little."

In contrast, the Helmholtz-Gemeinschaft as the biggest German research institution outside the university structure has made decisive steps towards a re-orientation and re-organisation

of research, when it fundamentally changed the principles of research funding in such a way that it considers the great challenges in nature, society and politics: Research funding is no longer based on the funding of research *institutions* but primarily of research *programmes* (Kröll 2003, Mlynek 2005). Thus, the Helmholtz-Gemeinschaft adopts the principle of programme-based research ("Programmforschung").

Programme-based research means that research institutions and teams have to subordinate their activities to a certain research programme. As a rule, the core of such a programme cannot solely be determined by the internal dynamics of one specific scientific discipline. Rather it is demand from outside one specific discipline, or even from outside the scientific realm, which determines the contents of a research programme of this kind: Scientific research and theory building are oriented and organised in such a way that they contribute to the solution of ecological, economic and social problems of society. Programme-based research, in most cases, is essentially problem-oriented and interdisciplinary.

Against this background, the UFZ Umweltforschungszentrum Leipzig-Halle in 2003 developed its Programme-Proposal 5, *Sustainable Use of Landscapes,* (P5) within the Helmholtz Research Field "Earth and Environment". An international team of evaluators from different disciplines considered this programme to be promising and recommended it for funding. At the same time, acknowledging the innovative character of the programme, the evaluators invited the UFZ to formulate standards and measures by which scientific research corresponding to the aims of P5 could be evaluated. This challenge has been met by the book "Herausforderung Programmforschung. Konzeption, Organisation und Evaluation problemorientierter Umweltforschung" (Schiller et al., 2006).

This book deals with the conception, organisation and evaluation of programme-based environmental research on different levels of abstraction: Detailed proposals concerning the organisation and evaluation of research in the framework of an interdisciplinary research centre like the UFZ are developed against the background of a general analysis of important traits of integrative environmental research within the dynamics of present natural and social sciences and humanities. After an Introduction in Chapter 1, Chapter 2 deals with general circumstances and perspectives of problem-oriented environmental research. Present debates in the philosophy and the politics of science are summarised with special attention to the organisation and evaluation of environmental research. This provides a basis for the development of the required evaluation criteria. The nature of Programme 5, "Sustainable Use of Landscapes" is the focus of Chapter 3. From the general aims of this programme four essential characteristics and nine corresponding features of problem-oriented environmental research are extracted, which, at the same time are guidelines for the implementation of research of this kind. Difficulties concerning this implementation are discussed and ways to overcome them are formulated. Particular importance is given to the philosophical principle `power of judgement´ ("Urteilskraft"), which has been developed in the tradition of political philosophy. Chapter 4 then transforms the characteristics of problem-oriented environmental research into guiding criteria within operational procedures of evaluation. It turns out that evaluation procedures have to take into account not only the *results* of research activities, but at the same time have to consider the corresponding research *processes*. The discussion of evaluation procedures includes remarks on desirable qualifications of the evaluators, on the composition of the evaluation group, and on particular occasions for evaluation. For two occasions, specific evaluation procedures are developed. Details of these procedures (questionnaires and checklists for the evaluators) are included in an appendix. This chapter, as a whole, shows how the general idea of programme-based research may be linked to the particular situation of research centres like the UFZ.

Outline of the book: "Herausforderung Programmforschung. Konzeption, Organisation und Evaluation problemorientierter Umweltforschung (Schiller et al., 2006)"

In the remainder of this paper, central issues are addressed that are discussed in detail in Schiller et al. (2006). In Section 2 we formulate the challenge to be met by an account of important sections of the programme proposal 5 which implicitly contain the nature of problem-oriented environmental research. Based on this excerpt, in Section 3 we derive four characteristics and nine related features of problem-oriented environmental research. In Section 4 we scrutinise the significance of this kind of research in the context of the present overall research system. In particular, typical shortcomings and traps as well as ways to overcome them are discussed. Section 5 deals with some essential aspects of an evaluation of problem-oriented environmental research – such as the group of evaluators and the evaluation process.

2 Programme Proposal 5 – Aims and Perspectives

The Helmholtz Research Field "Earth and Environment", and in particular Programme 5, can be seen as paradigmatic for the character of programme-based environmental research in general. "Earth and Environment" formulates some objectives which form the general frame for the approach of P5:[1]

> The definition of the upcoming tasks, the identification of knowledge gaps und the development of solutions for the Grand Challenges ahead of us require a significant advance in understanding the functionality of the Earth system and the interconnections between society and nature. A knowledge-based platform in the political arena is required to which R&D of the Helmholtz Research Field "Earth and Environment" contributes. The synergetic combination of expertise and viewpoints from the natural sciences, the earth sciences, the social sciences, the medical sciences and engineering is urgently asked for. Understanding the implications of far-reaching, complex changes of the Earth and the environment to a degree that allows the provision of guidance to policy makers and the public is a daunting task.

Within this framework, the guiding question of P5 "Sustainable Use of Landscapes" is: How can we develop concepts and decision support for sustainable use of landscapes in the context of global change? The relevant statements can be summarised as follows:[2]

> A balanced, sustainability-oriented development of landscapes is a highly complex management and governance problem, which can only be solved by concerted action in the fields of politics, economy, society and science. Science will play a key role by providing problem-oriented knowledge. The research approach should be suited to the analysis of the interdependencies of different subsystems of landscapes (such as the water cycle, biodiversity, matter flows, and the socio-economic system) in a single complex framework. To achieve this aim, inter- and transdisciplinary research is required. This approach transcends the isolated and fragmented analysis of individual eco-systems, often based exclusively on natural sciences. The objective is not merely an increase in scientific knowledge but particularly the integration of this knowledge within the framework of a problem-oriented approach. Problem-oriented research means that different disciplines work together in order to understand and develop solutions. Social sciences, in particular, add an interaction-oriented research perspective in order to overcome implementation barriers in the fields of politics and society. This makes science leave its ivory tower and encourages the dialogue between science and society. At the same time, the programme aims to provide

[1] The following is extracted from Helmholtz-Gemeinschaft 2003: 7.

[2] The following extract is taken from Helmholtz-Gemeinschaft 2003: 12-15.

direct policy advice. An innovative and future-oriented research approach of this kind will influence national and international environmental research. The aim of the programme is to develop into a nodal point of interdisciplinary environmental research within the European and international research scene. The long-term vision is an integrated research approach within the social sciences and between social and natural sciences. This will require a process of mutual adaptation in problem definition and solution.

The corresponding challenge is to develop and organise problem-oriented environmental research that is at the same time interdisciplinary and integrative and meets the highest national and international standards. To this end, the first task is to clarify the character of this research.

3 Characteristics and Organisational Features of Problem-oriented Environmental Research

As the first step to the operationalisation of Programme 5, essential and distinct aspects of the requested research are extracted from the general statements of the programme proposal. Considering Programme 5 as paradigmatic for problem-oriented environmental research, the resulting four main characteristics – and nine associated features – can be regarded as central attributes of problem-oriented environmental research as an ideal. Although it seems unreasonable to expect that all research performed in a large research institution like the UFZ fully complies with these standards, it can be expected that at least research performed within the programme is oriented towards those characteristics.

Characteristic A) Problem-orientation

Feature 1) Problem-oriented Research Design

In problem-oriented research, the starting-point for research design is to be found in problems that are observed within society and are worth public discussion. In the environmental sciences, problems of this kind, as a rule, originate from outside the realms of science. As a consequence, a scientific problem is not primarily determined by axioms, methods or theories of particular scientific disciplines, but by which methods and theories are appropriate for the understanding and solution of the underlying societal problem. It is, in short, a task of problem-oriented environmental research, to transform the observed problems at the interface “ecology-economy-society” into a set of scientific questions, and also, by means of the obtained scientific results, to contribute to their solution.

Feature 2) Application-oriented Fundamental Research

Problem-oriented environmental research encompasses both, scientific theory-building, i.e. fundamental research, and applied research directed towards concrete problem resolution. Both elements are interlinked: On the one hand, scientific insights gained from fundamental research are necessary for innovations in problem solving, and they have to be suitable for this kind of application to the ecological, economic and social realms. On the other hand, problems that stem from the areas of application can trigger further development of theoretical approaches in science. Through this, scientific concepts, methods and theories can be developed which are universal in the sense that they can be used in several application fields.

Feature 3) Social Responsibility

Environmental research, as related to the protection, the regeneration and the sustainable use of landscapes, has to be seen under certain obligations. As far as the state of society is associated directly or indirectly with the results of their research, researchers share responsibility for this state. Beyond the direct responsibility of researchers for the immediate effects of the technological or social-technological procedures they have proposed, this implies the obligation to reflect also seemingly remote consequences of their research and of the actions based thereon.

Characteristic B) High Scientific Quality

Feature 4) Compliance with High Scientific Standards

As a rule, clear and verifiable relationships should exist between research and the state of the art of the involved sciences. In its disciplinary aspects, the results of problem-oriented environmental research have to face comparison with parallel research within the respective disciplines. This comparison is the place for the “classical criteria” of scientific evaluation. Furthermore, it seems desirable that widely acknowledged standards for integrative interdisciplinary research emerge. In addition, forms of publication like monographs and textbooks, which give room for an encompassing presentation of the approaches of integrative research, should be taken into account far more than presently.

Feature 5) Innovation

High-quality research is characterised by creative elements that foster innovation. Innovation may, on the one hand, contribute to disciplinary scientific progress or, on the other hand, to shifts in paradigms. Classical progress in science implies: Innovative theories and methods have to be developed within a given paradigm. Challenging problems from reality outside the scientific realm are transformed in such a way that they can be treated within the existing scientific paradigms. As a consequence, important aspects of the original problem may be neglected if they are not accessible within given paradigms. Problem-oriented research, in contrast, may necessitate the creation of new concepts, methods, theories and even paradigms. The measure for the necessity of such radical innovations is the original problem itself.

Characteristic C) Integration

Feature 6) Interdisciplinary Research

Problems at the interface between ecological systems, the economy, and society feature manifold aspects and, hence, as a general rule transcend the limits of any particular scientific discipline. When starting problem analysis, it is by no means clear which scientific axioms, methods and even objectives should be employed. These problems have to be answered by a kind of research that systematically leads beyond disciplinary concepts, definitions and methods and that avoids potential one-sidedness and reductionism of any individual disciplinary approach. For that purpose disciplinary approaches have to be synergetically combined and “translated” into the framework of the other disciplines involved. In addition, several forms of non-scientific knowledge, e.g. forms of practical knowledge in application

fields or forms of everyday-experience, have to be taken into account. The feature "interdisciplinary research" refers to the *research process*.

Feature 7) Integration of Results

For the integration of research results, an integrative framework and a language that can be communicated across all involved disciplines is needed. Such a framework, as a rule, need not be an encompassing theory. In addition it may be a common perspective upon the societal problem. The framework facilitates, on the one hand, scientific access to the problem stemming from outside the realm of science and, on the other hand, a synergetic account of all obtained research insights related to the problem. It is important that the process of integration does not exclude essential aspects of the societal problem: Within the integrative framework, the problem should be covered in all its relevant characteristics (natural scientific, technical, economic, and social, including aspects of political feasibility, barriers of implementation, interests of stake-holders etc.). The feature "integration of results" refers to the *results of research*.

Characteristic D) Knowledge Transfer

Feature 8) Transfer between science and society

Research results are made accessible to the public. In general, the public of problem-oriented research is not limited to the *scientific community* of any particular discipline – in addition, transfer into the interdisciplinary field should take place so that the results can be debated by the relevant audience. Additionally, transferring knowledge to the general public and to decision-makers is requested (politics, administration, organisations, stake-holders). However, knowledge transfer is also required in the direction from society to science: Non-scientific practical knowledge stemming from actors and citizens in politics, economy and society may contribute significantly to adequate problem understanding and solution in the field of problem-oriented research.

Feature 9) Consultancy of Decision Makers

In principle, researchers are willing to provide decision-makers in economy, administration and politics with concepts and tools helping them to take adequate decisions. For this to be possible, results of research often have to be restated and put into context with regard to the specific conditions of a concrete decision situation. As the case may be, even central research questions may have to be tailored with regard to decision support. By taking into account which solutions may be feasible and which ones not however, research must not be obliged to any particular interests of individuals or groups.

4 Organising Problem-oriented Research – Difficulties and Potentials

Difficulties

The present state of the scientific system features disincentives for interdisciplinary research (Mittelstraß 2005: 21). In this line, Kostoff (2003: 3) concludes: "The author's observation, from examination of many science and technology sponsoring agencies and performing organizations, supplemented by a wide body of literature (…) is that strong cross-disciplinary disincentives exist at all phases of program/project evolution, including selection, management and execution, review, and publication." The same holds, of course, for the evaluation of such kind of research. Some of these disincentives are mentioned in the following.

Lack of reputation of interdisciplinary and integrative research within disciplinary organised scientific communities: Until now, there has been a severe lack of interdisciplinary publication organs whose reputation and ranking is comparable to that of acknowledged disciplinary organs. In the eyes of a high-performance researcher who is oriented to any citation index, disciplinary publications will be, as a rule, weighted far higher than interdisciplinary ones.

Less output of interdisciplinary research of a high standard compared with disciplinary research: For example, the evaluators of NERI in their evaluation of the field „Environment and Society" and in particular of the „Department of Policy Analysis" (NERI 2003: 78-79) came to the result that "the publication rate is lower than what is seen for research within natural science and pure discipline-oriented science" (ibid.). To a great extent, this is due to the circumstance that interdisciplinary communication and cooperation takes much more time and effort than disciplinary cooperation.

Lack of obvious methodological or theoretical "surplus" of problem-oriented research (Defila, Di Giulio 1999: 7): "One should usually not expect generalized theory building in problem-oriented research" (Conrad 2002: 13). The reason for this is that there exist basic methodical discrepances for instances between natural and social sciences. Integration of results across both of them will, as a rule, not lead to an encompassing and consistent meta-theory beyond existing theories.

Lack of standards for the quality of problem-oriented environmental research with an interdisciplinary and integrative character: Due to this lack, researchers are uncertain concerning the evaluation criteria of their research. As long as current indicators for the usual evaluation of research are based exclusively on traditional disciplinary measures it is difficult to stimulate high-standard integrative and interdisciplinary research.

Lack of time for interdisciplinary research on the side of the researchers: From the analysis of some interdisciplinary projects, Conrad (2002: 10) concludes: "To achieve a common detailed theoretical and analytical framework which was shared by all projects, participants obviously would have required much more time for debate and reflection than was actually available." However, time and resources spent for interdisciplinary cooperation and transfer activities is not available for progress in disciplinary research and the respective publications.

Lack of interest for viewpoints outside the usual perspectives of one´s own discipline: To successfully organise research beyond disciplinary limits it is not sufficient to bring together different approaches, theories or results from different sciences. Within interdisciplinary discourse, each expert has to develop the ability to express his/her positions in ways that are accessible to participants from other disciplines. On the other hand, each expert has to show willingness and openness to follow the arguments of scientific discourses which seem to be rather strange from within the framework of her/his profession. This task is rather challenging.

Lack of psychological expertise concerning group dynamics: This makes interdisciplinary discussions and decision processes complicated and unpromising. Thus Naiman (1999: 293-294) states: "Most serious problems arise within the group. A lack of patience, understanding, trust and respect, or unspoken jealousies and perceived threats to someone's position or authority can be devastating. (…) Invalidation of individual initiative will occur if the leadership is too controlling or does not seek out the views of others in a way that is nonthreatening."

Ways to overcome the difficulties

"The most effective change by far would be if the organizations that award grants and manage research programmes were to place much less trust in a quantitative audit that reeks of false precision" (Lawrence 2003: 261). This statement holds in particular for the organisation of problem-oriented environmental research. Researchers involved in such research have to trust that their results are not measured by standards which may be apt to disciplinary research, but not for their interdisciplinary work. Instead, it should be the consensus of all participants that the broader range of characteristics (and features), such as the one developed above, should serve as general guidelines for an evaluation of problem-oriented environmental research.

Additionally, some other measures can help in encouraging this kind of research:

Room for creativity: In an ideal situation, the leadership of problem-oriented interdisciplinary research groups is entrusted to scientists of high reputation. The groups should then be given enough room for creative work and should be shielded from the rituals and administrative restrictions of normal research operations.

Willingness to trust and to take risks: True innovative research always bears the risk of failure. From the beginning of an interdisciplinary research project on, all involved institutions, groups and persons (including the executive board as well as the researchers themselves) have to articulate their willingness to take risks of this kind. Thus, researchers receive the necessary trust to go in new directions.

Reflections on principal questions of the research programme beyond the limits of a particular project: Opportunities (seminars, workshops, conferences) should be provided to researchers so that they become able to embed their research into the horizon of the whole programme and to reflect on the significance of the programme for their particular work.

Reflection on the significance of results: Special emphasis should be given to processes of reflection. In particular, the feature "social responsibility" requires that researchers reflect on the scope and limits of their results as a well as on possible consequences. Workshops and

meetings between scientists and politicians and other stake-holders may further these processes.

Importance of "soft" factors related to individual researchers. Interdisciplinary cooperation requires communication not only via the internet and telephone, but also and primarily in personal meetings. In this line, Röbbecke et al. (2004: 74) stress the significance of individual-related factors in interdisciplinary cooperation. In particular, they conclude that the workplaces of the researchers should be situated within rather small distances so that frequent meetings can easily take place.

5 Evaluation – Viewpoints and Processes

In normal disciplinary science, researchers, as a rule, are well informed on the standards and criteria they have to meet with their research. As this is, by no means, clear for interdisciplinary research, a clarification of the criteria and procedures for the evaluation of problem-oriented research is not only helpful for the respective evaluators but in particular for the researchers themselves. In Germany, the debate on how to evaluate problem-oriented environmental research shows two different tendencies:

1. One tendency is represented by the Wissenschaftsrat (2002a, 2002b, 2002c; cf. Einhäupl 2003 and NERI 2003). Environmental research is, to a large extent, evaluated within the realm of traditional criteria of disciplinary science, though it is acknowledged that citation indices and quantitative indicators are not sufficient. Einhäupl (2003: 78) remarks the necessity of "special modalities for recruiting (…) experts with interdisciplinary backgrounds".
2. The other tendency, represented, e.g., by Defila and Di Giulio (1999), Bergmann (2003) and Bergmann et al. (2005) is characterised by the attempt to elaborate new criteria and procedures that are appropriate to the nature of problem-oriented environmental research. These authors stress that environmental research has to be conceived more in categories of processes than in those of results. As a consequence, non-quantitative approaches to evaluation are explicitly taken into account. However, in their attempt to completely cover all details of environmental research, the respective catalogues of criteria tend to be over-complex. The advice to the evaluators to choose between the criteria and indicators somehow opens up the door for arbitrariness.

In this final section, we report on some important features of our approach to evaluating problem-oriented environmental research which incorporates aspects of both mentioned tendencies, but at the same time differs from both in some points. For the following argument, the characteristics and features of problem-oriented environmental research (see Section 3) are interpreted as *guiding criteria* ("Leitkriterien") for the evaluation of this kind of research. On this basis, some requirements concerning the evaluators, the composition of the evaluation group and some aspects of the evaluation process are discussed.

Judgement

An evaluation of problem-oriented research will certainly include traditional criteria and indicators to test scientific standards in a normal context. However, this is not sufficient. *Beyond citation indices and quantitative measures*, evaluators have to assess and to evaluate, at least in selected extracts, the contents and the concrete results of problem-oriented research.

For this, it is required that the evaluators dispose of *the power of judgement* in applying the guiding criteria.

The origin of the concept "power of judgment" is to be found in the tradition of political philosophy (cf. (Aristotle 1908: Book VI, Kant 1790/2001, Vollrath 1977, Arendt 1981, 1985, Wieland 2001). In the present discussion, this concept is related to the handling of uncertainty (cf. Heidbrink 2003: 290). Judgement has to take place in a situation in which a decision cannot be derived (more or less) automatically from given information, methods and norms. In the situation of evaluation, judgement is required, in particular, if the interdisciplinary integration of heterogeneous approaches has to be evaluated. A competent judgement presupposes that the evaluators are acquainted with the standards of all participating disciplines. As a single person will only rarely fulfil such a requirement, the evaluation of problem-oriented research should be carried out by a group of evaluators with different scientific backgrounds.

Results and Processes

An evaluation of problem-oriented environmental research should not be restricted solely to the results, but should also encompass an assessment of research potentials by incorporating the research processes. This can be achieved by, e.g., process-accompanying advice to integrative projects given by (external or internal) mentors. To this end, selected scientists of high reputation should be invited on a regular basis, who are familiar with the perspectives and approaches of the research programme as well as with the character of the research institute. Additionally, potential mentors should have experience in interdisciplinary research – including its potentials but also difficulties and shortcomings. In regular meetings between those consultants and the research group, objects, approaches and methods of the research as well as group and communication structures can be reflected and challenged. Mentors' knowledge of the research process resulting from these consultations can then be fed into the evaluation process.

Key Integrative Projects

As a rule, not all departments and research groups etc. at an existing research institution can be subordinated to the claims of problem-oriented research in the same way. Structures and capacities that are given at any point in time have to be respected when implementing a problem-oriented research programme. One way to overcome problems in the initial phase of a problem-oriented integrative research programme is to develop *key integrative research projects* that are paradigmatic for the research approach of the programme as a whole. Based on the example of such projects tools and methods for integration can be developed and such projects in particular demonstrate the characteristics of problem-oriented interdisciplinary research: social relevance, necessity of interdisciplinarity, integration of results, demand for transfer of knowledge into public and politics etc. An important criterion for the selection of a key integrative project is that a high scientific potential for the adequate treatment of the subject has to exist at the research institution. In a mixture of a "bottom-up" and a "top-down" procedure, existing research capacities have to be bundled under a set of unequivocal research questions and, at the same time, an existing societal problem has to be transformed into such a set of scientific questions.

Final remark: Overview on Large Research Programmes

From a purely ex-post perspective, large research programmes like Programme 5 can hardly be evaluated as a whole. To achieve a general view, a combination of two elements should be applied:

1. An overview of the whole programme in its breadth should be achieved – e.g. by reports of the participating researchers on the research processes combined with an examination of an aggregated set of qualified quantitative performance data.
2. In addition to the overview, exemplary research projects should be examined in a detailed way. Some of the projects to be investigated should be suggested by the participating researchers according to their relevance, others should be picked by the evaluation group.

Within both elements, the basis of the evaluation is made up by the four guiding criteria with their nine features of problem-oriented integrative environmental research, albeit in different implementations. The application of the guiding criteria ensures that the horizon of the whole programme is present in any occasion of evaluation.

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