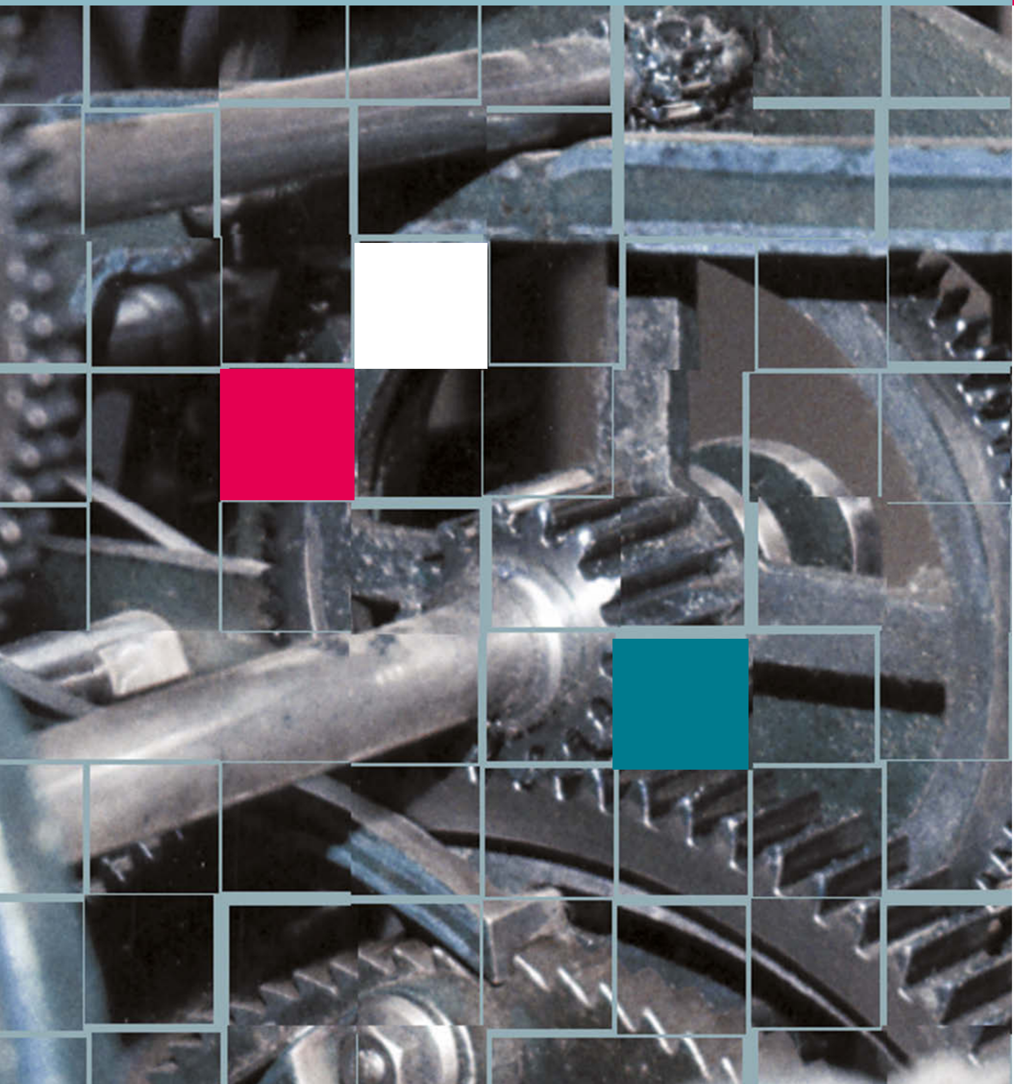
Christian Pohl, Gertrude Hirsch Hadorn

Principles for Designing Transdisciplinary Research

Proposed by the Swiss Academies of Arts and Sciences



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Christian Pohl, Gertrude Hirsch Hadorn
Translated by Anne B. Zimmermann

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Foreword to the English Edition

Research workers are increasingly being asked to tackle important but messy problems in the everyday world. These problems may be both difficult and require several disciplinary skills if they are to be effectively addressed. Perhaps consequently, interdisciplinary research is currently fashionable with research funding organizations, but it does not take long to discover that no two agencies have the same picture of interdisciplinarity: For some, to get a crystallographer and a materials scientist to work together is the limit of their ambition, while for another agency a proposal might need to include not only a climatologist, a hydrologist, a fish physiologist and an economist, but also a fishmonger and an ethnic minority consumer! What is special about interdisciplinary and transdisciplinary work? What is its power and what are its demands and optimal methodology? The agencies are driven by various forces. Certainly, new fundamental discoveries are often at the intersection of two existing disciplines, but more frequently now the aim is to tackle the large problems of life: poverty, malnutrition and climate change, for example.

Any reasonable person will see the necessity for both natural and social scientists to solve problems of malnutrition, for example. For some research workers, it seems that the difficulties involved in interdisciplinary research only become clear when they receive a grant and start work. Charles Darwin said that it was often harder to formulate the question in biology than it was to subsequently answer it. Social and natural scientists faced with the same problem will ask very different questions. It becomes clear that there is more to combining disciplines than at first meets the eye. If we go one step further and involve the people affected by the problem as well (transdisciplinary research), things get still more complex.

Anglo-Saxon researchers tend to choose what we feel are the relevant disciplines and try to get on with the research, struggling with the problems of interdisciplinary working as best we can. I had social anthropologists and molecular biologists, along with several other disciplines, in the same department in 1979; and detailed consultation with what now would be called stakeholders was a feature of the rapid rural appraisal work of Robert Chambers, which is quintessentially transdisciplinary, at about the same time. But we had little insight into what we were doing.

But our continental colleagues have been more thoughtful about the process, and have tried hard to sort out what is going on in the activities of transdisciplinary research. They have thought rigorously about it, which is very helpful, as all sorts of transdisciplinary research activities are currently appearing: 'sustainability science' in the USA, participatory rural appraisal from the UK, Ecohealth in Canada, recherche-intervention from France. Are these identical? No, but perhaps they are similar responses to a widely perceived need for scientists to get to grips with the messy important problems of the world? Some scientists will decide this is not the business of science; others will try but flounder in the complexity; yet others will prescribe a particular research process that will somehow unlock the problems. Most of us will have doubts about all these attitudes.

Our Swiss and German colleagues have been concomitantly struggling with real transdisciplinary research applied to environmental problems in Switzerland (Swiss Priority Programme Environment) and global change-related issues worldwide (most notably in the Swiss NCCR North-South multi-university programme). They have also created a forum within the Swiss Academies of Arts and Sciences to think about what they are doing. The most accessible output of that thinking is this little book. It first sums up their best experiences in transdisciplinary research so far, and describes the process that it entails, providing a framework and a broad philosophy of how to do it. It aims to describe this framework as precisely as possible and has struggled for precision and clarity, remarkably successfully. That does not make it a rapid read, as it requires us to think in new ways, but it does face up to the scientific challenges which arise when messy transdisciplinary problems come up against what Medawar memorably called 'the art of the soluble'. One may not agree with this book at every point, but the Swiss work view is put clearly, and progress in science is more likely to come from error than confusion. We have the feeling of mastering a complex map; rather than of swimming in pea soup, which so much other writing on transdisciplinarity does. Equally useful is the second part of the book (called an annex) which reviews the different definitions and usages of 'transdisciplinarity' and helps us to see some order in the chaotic literature.

The original German version of the text has been translated into English with great care and perception. This book brings a whole area of research and reflection to English-speaking readers. Anyone whose research takes them beyond a single discipline, and who seeks to tackle how to understand the major problems of society in a scientific way, will gain new insights on how to set about it.

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& Zoology Department, University of Oxford.

Translator's Note

Translating is an act of mediation between cultures and currents of thought. To produce their German version of the *Principles for Designing Transdisciplinary Research*, Christian Pohl and Gertrude Hirsch Hadorn "translated" a first time, so to speak: in a major effort, they succeeded in mediating between numerous different debates, each characterised by a scientific community's distinctive approach to the problem of making science speak *with* rather than *for* society. This is a remarkable achievement. My work was much easier and less perilous; it benefited from the authors' willingness to answer question after question and discuss versions of sentences that were not really appropriate translations of their original thoughts. I take the opportunity of this "Translator's Note" to thank them for having allowed me to learn so much about transdisciplinary research in the process of translating their work. Let me add two technical remarks.

First, it is a common experience for translators to find that some concepts in the source language exist in their own right, with no equivalent in the target language – a reflection of the cultural specificity of a current of thought. In such cases, translators like to stick to a literal translation of the words, as this signals that the concepts come from "elsewhere", not from the cultural world of the target language, in our case English and the English-speaking world. In the present text, this was the case for the following terms: *Problemfeld, Rekursivität,* and *Lebenswelt.* These terms therefore occur as literal translations. A "problem field" is explained by the authors as "an area in which the need for knowledge related to empirical and practice-oriented questions arises within society due to an uncertain knowledge base and diffuse as well as controversial perceptions of problems" (see endnote #10). The key concept of "recursiveness" means about the same as "iterativeness": however, "iterative" is defined by the *Oxford English Dictionary* as "characterized by repeating or being repeated", while its denotation for "recursive" – listed as first occurring in English in 1904 – is: "involving or being a repeated procedure such that the required result at each step except the last is given in terms of the result(s) of the next step, until after a finite number of steps a terminus is reached with an outright evaluation of the result." The difference is a fine one but it is relevant in the context of the present publication, where "recursiveness" is used in the sense of this second OED definition. As for "life-world", which could be approximated by the more English-sounding "everyday-world", the authors point to the origin of the philosophical concept in Husserl's work and its use in constructivist thinking (see endnote #3).

The second and final technical remark concerns the translation of quotations from other authors. Wherever English translations of quotations originally in German or French were found, I transcribed them, with a reference to the source of the published translation; in all other cases, a note indicates that a citation was translated into English specifically for this publication. Whenever possible, I asked authors of the original quotation to correct my draft translations.

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National Centre of Competence in Research (NCCR) North-South
Bern, Switzerland
January 2007

Foreword by the td-net Scientific Advisory Board

The mission of transdisciplinarity-net (td-net, www.transdisciplinarity.ch) is to develop the means of supporting exchange and learning among researchers dealing with the various "problem fields" in which transdisciplinary research takes place. The present *Principles for Designing Transdisciplinary Research* (TR) constitute a first supportive element of this kind. A second element is a *Handbook for Transdisciplinary Research* based on these *Principles*, to be published in 2007. To effectively meet concrete challenges in the fields of health, valorisation of technological innovations, North-South collaboration, environmental change, social dynamics etc., and engage in sustainable development, the private sector, public agencies and civil society rely on collaboration with the scientific community. Within this context, transdisciplinary research plays an important role, complementary to basic research. The aim of transdisciplinary research is to help solve societal problems and develop knowledge about how to fashion adequate solutions for specific problems in fields as diverse as sanitation, pollution, equal rights, poverty alleviation, epidemiology etc. These solutions need to take into account systemic processes and social perspectives in order to be embedded in concrete contexts. Transdisciplinary projects also advance science and the humanities by developing an understanding of complex relationships, by discovering new ways of asking questions, and by elaborating unusual methods.

For those engaged in transdisciplinary research, its aims, content and practices constitute a major challenge. What transdisciplinary research requires is mutual respect, reciprocal learning, and constructive collaboration between different academic cultures, between research and "life-world" perspectives, as well as between different institutions. Only in this way can the tasks of research – identifying and structuring problems, analysing them, and bringing results to fruition – be adequately fulfilled. It is obvious that successful transdisciplinary collaboration is not an easy undertaking, given the need for crossing boundaries between disciplines as well as between research and practice. To be successful, transdisciplinary research requires systematic procedures, which have so far been significantly lacking. The present *Principles for Designing Transdisciplinary Research* intend to fill this gap.

The development of excellence in research depends on continuous debate, critique and innovation among experts regarding research questions, concepts, methods and results. Typically, transdisciplinary research groups work on a wide range of themes and display a high degree of mobility. Adequate networks therefore need to be developed, with communication structures capable of promoting the advancement of transdisciplinary research through exchange and learning among researchers in the different problem fields. The transdisciplinarity-net (td-net) of the Swiss Academies of Arts and Sciences was created in 2003 to support and promote transdisciplinary research in the engineering, natural and social sciences and in the humanities.

The *Principles for Designing Transdisciplinary Research* were elaborated within the framework of a td-net project. The td-net Scientific Advisory Board considers these *Principles* as a key element for supporting transdisciplinary research. The *Principles* highlight the special challenges that have to be met by transdisciplinary researchers when they conceive their projects, and suggest how to tackle them.

The committed response of the Swiss Federal Office for the Environment (FOEN) provided both the impulse for and the means of developing the present *Principles*. With great insight and understanding, Christian Pohl formulated a first draft of the *Principles*, based on an analysis of publications on transdisciplinary projects and transdisciplinary research. This draft was edited on the basis of feedback collected in a broad review process, after presentations given to many different audiences, and following experimental implementations. The latter were made possible through collaboration with projects of the National Centre of Competence (NCCR) North-South and an expert appraisal for the Berlin-Brandenburg Academy of Sciences and Humanities.

If the scientific community succeeds in revising and further developing the present *Principles*, this document will have fulfilled its true purpose of supporting a form of research currently in the process of defining itself.

The td-net Scientific Advisory Board: *Susette Biber-Klemm, Beat Butz, Sandro Cattacin, Martin Grosjean, Walter Grossenbacher, Bernd Hägele, Gertrude Hirsch Hadorn, Patrick Hunziker, Dominique Joye, Othmar Käppeli, Ingrid Kissling-Näf, Margrit Leuthold, Arthur Mohr, Michael Nentwich, Rainer Schweizer, Martine Stoffel, Thomas Teuscher, Urs Wiesmann, Elisabeth Zemp*

1

Introduction

The conditions for transdisciplinary research (TR) are given when knowledge about a socially relevant problem field is uncertain, when the concrete nature of problems is in dispute, and when there is a great deal involved for those concerned by these problems. TR copes with such problem fields in a process that integrates a variety of disciplines and actors from public agencies, civil society and the private sector, in order to identify and analyse problems with the aim of developing knowledge and practices that promote what is perceived to be the common good (see the definition in Chapter 3.1).

The content of a TR project is defined by the problem field, the disciplines and the groups involved, as well as the local circumstances that characterise a project. What is often forgotten is that in spite of this dependency on very specific contexts, transdisciplinary projects also have many common features and are constantly confronted with the same challenges, be it in the health sciences, in peace studies, technology assessment, or sustainability research.

The *Principles for Designing TR* outline the particular challenges of designing a project that must have a transdisciplinary orientation. They also suggest how to deal with these challenges with a view to elaborating knowledge of immediate social relevance and encouraging researchers to work creatively. The present publication is primarily intended for transdisciplinary researchers. While it aims to help them plan and implement transdisciplinary research projects, it does not claim to be a methodological handbook. By outlining the particularities of TR, the *Principles* underline aspects that can be referred to when there is a need to assess and promote TR adequately. Institutions that support research are therefore a further audience for the present publication – which does not, however, claim to be a concrete evaluation instrument.

In the past few years, a whole series of publications focusing on management, evaluation and the specific challenges of inter- and transdisciplinary research has emerged.[1] These studies mainly discuss the organisational and communicational challenges that can be met – with the help of group processes – by researchers and actors from different fields who work in the same project and with the same aim. Given the different interests, views, working methods and timeframes, the task of those involved consists of building a culture of productive and reliable collaboration. By focusing mainly on the *conceptual* challenges of TR, the *Principles* draw attention to another task: readers are encouraged to ask what the specific objectives of TR are, under what conditions it can be conducted, what the objectives and conditions are for formulating and working on research questions, and what needs to be taken into account in order to bring research results to fruition.

The *Principles* are based on a first draft entitled "Guidelines für die transdisziplinäre Forschung: 1. Vorschlag September 2004 zum Peer Review und zur Vernehmlassung"[2] ("Guidelines for Transdisciplinary Research: 1st Proposal for Peer Review and Consultation, September 2004") and on the results of the ensuing process of consultation. The experts who actively took part in the process and thus made the current version possible are listed in Annex A3.

In the German-speaking world, the past ten years have seen a growth of TR, mainly in the fields of environmental research and sustainability research. As the present *Principles for Designing TR* primarily rely on experience gained in these fields, they are a first step in a learning process that will help correct the bias that might result from this context. The *Principles* do not claim to be complete and authoritative: as a "real-world experiment" (see Chapter 4.4.1), they aim to trigger a recursive or iterative process (see Chapter 4.1). The ideal case would be for them to be used extensively, before being modified and made practical and diversified on the basis of feedback from researchers in a variety of fields.

Structure

This publication is divided into four chapters. In the following chapter (Chapter 2), the principles are presented in brief. The rest of the text explains them. Chapter 3 elucidates the understanding of TR on which the principles are founded and explains basic concepts. Chapter 4 presents the specific challenges of TR for each of the three phases of the research process, i.e.: 1) problem identification and structuring, 2) problem analysis and 3) bringing results to fruition. The summary in Chapter 2 is based on conclusions about general principles for designing research, drawn from the presentation of TR in Chapter 3 and the description of the research process in Chapter 4. Finally, Annex A presents various definitions of TR and its "modes of operation". This overview shows the whole gamut of understandings of TR and thus makes it possible to situate the present *Principles* in the context of the debate on such forms of research.

In order to make the text as reader-friendly as possible, references to the literature as well as many detailed explanations and clarifications of terms are listed as endnotes as of Chapter 3.

2

The Principles in Brief

Transdisciplinary Research (TR)

There is a need for TR when knowledge about a societally relevant problem field is uncertain, when the concrete nature of problems is disputed, and when there is a great deal at stake for those concerned by problems and involved in dealing with them. TR deals with problem fields in such a way that it can:

a) grasp the complexity of problems,
b) take into account the diversity of life-world and scientific perceptions of problems,
c) link abstract and case-specific knowledge, and
d) develop knowledge and practices that promote what is perceived to be the common good.

The transdisciplinary research process

The transdisciplinary research process consists of three phases:

1. Problem identification and structuring
2. Problem analysis
3. Bringing results to fruition

The importance of each of the three phases must be taken into account when allocating time, finances and personnel. TR does not necessarily progress through the phases in the order mentioned above. For example, identifying and structuring problems can lead to the insight that no further research is necessary because enough knowledge is available to develop suggestions for feasible solutions. In other cases, problem analysis and bringing results to fruition may lead to the conclusion that problem identification or structuring needs to be revised and adapted.

At the stage of analysing a problem field, trying to meet all of the four requirements of TR – which are: (a) to come to terms with complexity, (b) to take into account diversity, (c) to develop case-specific and practice-oriented knowledge that can be transferred and (d) oriented towards what is perceived to be the common good – is risky, as this might overload the project with prerequisites, as if it were supposed to become the proverbial "all things to all people". To avoid such overburdening of projects, it is important to take into account the following four principles when shaping the research process.

1st principle: Reduce complexity by specifying the need for knowledge and identifying those involved

When trying to come to terms with the complexity of problems, it is crucial to consider only those relations relevant to practice-oriented problem-solving. TR deals with empirical questions (systems knowledge); it also aims to ascertain and explain better practices (target knowledge) and reflect on the practicability of goals and feasibility of proposed solutions to problems (transformation knowledge) (see Table 1, p. 36). With this in mind, two means of adequately reducing complexity are to specify the particular need for knowledge and identify the people involved. Specifying the need for knowledge implies discerning what research questions need to be addressed by a project and determining the corresponding conditions. To this end, it is necessary to find out what kind of systems perception underlies a project, what normative targets it has set itself, and what potential societal transformations it aims at (see Tool 2, p. 40). Identifying the people involved implies coordinating the tasks of societal actors and disciplines in relation to the four requirements that need to be fulfilled (a–d, see above), e.g. by determining which actors and disciplines need to be involved and in what manner, with a view to taking into account the diversity of relevant perspectives (see Tool 1, p. 30).

The principle of specification is important in all three phases of TR, but it is particularly significant when identifying and structuring problem fields.

2nd principle: Achieve effectiveness through contextualisation

TR aims to develop knowledge that helps solve "life-world" (or everyday-life) problems concretely. Knowledge in this context comprises empirical knowledge, as well as knowledge that enables people to shape practice-oriented opinions and creative skills that open up possibilities for action in specific life-worlds. Research must therefore pay particular attention to the impact-related contextualisation of a project. One way of achieving this is to elaborate an impact model at the stage of problem identification and structuring that shows the social impacts projects may have when bringing results to fruition. Projects must therefore assess the state of knowledge not only in relation to the research questions identified, but also with regard to concrete societal practices and issues in the life-world (existing technologies, regulations, practices, power relations and potential for change). In order to make research results accessible to those concerned, it is essential to reformulate them: Scientific insights must be summarised and assessed for specific target groups; they must be translated creatively into products useful to these groups; and it is necessary to reflect on how these products will fit target groups' current practices and agendas (see Tool 4, p. 65).

But the effectiveness of TR relies just as much on its being embedded in the scientific context. This can be achieved by linking current efforts to the state of the art in the relevant disciplines, by learning from transdisciplinary work on similar problems (even in other thematic realms), and by systematising and publishing experiences garnered in a project (see Tool 5, p. 67).

While the principle of contextualisation is relevant to all three phases of TR, it is particularly significant when problems are identified and structured, and when results are brought to fruition.

3rd principle: Achieve integration through open encounters

The most important principle for successful collaboration between disciplines and with various social groups is to be open to encounters. This implies perceiving one's own perspective as only one among several others, and accepting other views as potentially just as relevant as one's own. Only thus can constructive discussions about the potential of the various perspectives to contribute to the common undertaking take place and be further developed.

Collaboration can take various forms (common learning as a group, negotiations among experts, integration through the project leader), and be based on different modes of integration ("boundary objects", glossary, everyday language, models, transfer of concepts, mutual adaptation of concepts, developing bridge concepts) (see Tool 3, p. 59). Depending on the form of collaboration and mode of integration, the intensity of reflection about one's own and other actors' perspectives can vary. Moreover, every form of integration structures the relation between the perspectives involved in a specific way. This is why it is important to determine the mode and concrete process of integration in a common and open procedure, in order to ensure that it is adapted to problem structuring and questions that have been defined above.

The principle of open encounters is relevant to all three phases of TR.

4th principle: Develop reflexivity through recursiveness

Fulfilment of the requirement that TR must, in the phase of problem analysis, (a) encompass the complexity of a problem field, (b) take into account diversity, (c) develop knowledge that is both relevant to specific cases as well as transferable, and (d) develop practice-oriented solutions for what is perceived to be the common good, often seems to be possible only to a limited degree. This can jeopardise the quality of results and stall TR. One means of preventing this is to shape the research process recursively (or iteratively). Recursiveness (or iteration) implies foreseeing that project steps may be repeated several times in case of need. The possible limitation or uncertainty of a preliminary result thus becomes a means of targeted learning. Recursiveness is important in all three phases of the research process. With regard to bringing results to fruition, this implies introducing recursiveness not just at the end but already in the course of the research process, so that recursive adaptations are possible. Every effort in the phase of bringing results to fruition becomes a "real-world experiment" that must be observed and from which something may perhaps be learned for problem identification and structuring, for problem analysis, or for the next time results are brought to fruition. Reflexivity thus means to correct assumptions on which the production of knowledge is based, in case the real-world experiment reveals that these assumptions need to be corrected.

The principle of recursiveness is relevant to all three phases of TR.

When planning a project, it is necessary to decide how the four TR principles need to be implemented. Tools 1–5 are designed to help make this choice: they summarise the aspects that need to be taken into account and show very different ways of shaping TR.

3

Transdisciplinary Research

At first sight, it seems rather difficult to define TR based on the literature. But a closer look reveals that existing definitions have recurring elements. Several definitions available in the literature are presented in Annex A1. They are grouped according to how they prioritise the following four characteristics of TR:

- Transcending and integrating disciplinary paradigms;
- Doing participatory research;
- Relating to life-world[3] problems;
- Searching for unity of knowledge beyond disciplines.

By transcending disciplinary paradigms,[4] the limitations of disciplinary specialisation in the process of structuring and analysing problems can be corrected. Participatory research[5] means that actors[6] from public agencies[7], the private sector and civil society can help shape the research process. The motivation for focusing on life-world problems is the wish to take into consideration the accountability of science[8] vis-à-vis society and to meet the scientific challenges of dealing with empirical and practice-oriented issues[9] in public agencies, the private sector and civil society. The present *Principles* refer to a form of TR that has such an extra-scientific motivation. Other forms of TR begin with a search for fundamental metadisciplinary structures of knowledge.

3.1 Starting point, goal and requirements

The starting point for TR is a *socially relevant problem field*.[10] A problem field (e.g. violence, hunger, poverty, disease, environmental pollution) refers to a life-world area in which empirical and practice-oriented issues call for knowledge. Problem fields are socially relevant when those involved have a major stake in the issues and when there is a societal interest in improving the situation. This does not mean that there is always general agreement about the need for action, nor about the type of strategy required. The aim of TR is to develop empirical and practice-oriented knowledge that can help solve, mitigate or prevent life-world problems. When pursuing this goal and identifying, structuring, analysing and dealing with concrete problems in a problem field, it is necessary to consider four fundamental *requirements*.

a) *TR takes into account the complexity of problems:* TR must include relevant relations between the social and natural factors that constitute a problem and might influence possible solutions. To this purpose, it is necessary to grasp the dynamic interdependencies of empirical insights, technical options, value orientations and policy options.
b) *TR takes into consideration the diversity of scientific and life-world perspectives on problems*: Actors in science and the life-world do not have the same perception of what factors induce a problem; nor are these two groups homogenous: Perceptions of the relevance of factors differ within the groups as well. This multiplicity of perspectives is the result of individual disciplinary viewpoints and particular relations to action in the life-world, coupled with the specific social and natural conditions of concrete situations. This diversity and complexity must be taken into account when identifying and structuring problems, by establishing relations between the perspectives with a focus on how to deal with the given problems in the life-world. Often, the various perspectives that are considered in this manner are not complementary: They may actually contradict one another, in which case they require reciprocal correction.
c) *TR links abstract and case-specific knowledge*: In order to help find solutions that can become effective within a specific problem field, TR must build a bridge between scientific knowledge produced under idealised conditions and processes in a concrete situation.[11] It must establish relations between different forms of relevant, case-specific and transmissible knowledge.
d) *TR develops knowledge and practices that promote what is perceived to be the common good*:[12] By dealing explicitly with the question of whether proposed solutions serve the common good, TR enables those involved to achieve a consensus about solutions – an important condition given the fact that actor groups in the private sector, public agencies, and civil society can hold controversial positions. The question how to define the concept of the common good with regard to a specific problem field can be one of the research questions pursued by TR.

Participatory research involving non-scientific groups and research that crosses the barriers between disciplines – both of which are characteristics of TR – are a *means* to fulfil the above-mentioned requirements. Thus, the aim of involving social groups is often primarily to integrate various life-world perspectives and interests into TR (requirement b). But beyond this, participatory research is also a means of grasping the complexity of a problem with the help of local knowledge (requirement a), of testing the situational relevance and transferability of results (requirement c), or of finding solutions for what is perceived to be the common good, and improving the practice-oriented effectiveness of results (requirement d)[13] (see also Example 1 below). Several disciplines are often involved in efforts to grasp the complexity of a problem (requirement a). This, however, can also help integrate different or even contradictory disciplinary perspectives (requirement b); alternately, when analytical and technical disciplines are brought together, a bridge may be built between abstract academic reflection and case-specific knowledge (requirement c)[14] (see also Example 2, p. 29).

Example 1 — **The "Popular Theatre" Approach**[15]

This example shows how requirements a), b), c) and d) can be met with the help of participatory research.

In Tanzania, a UNICEF project uses theatre practice as a means for conducting research on HIV/AIDS. The reason for this is that 60% of new infections affect 16 to 24–year-olds. Theatre practice is conceived of as a form of participatory research aiming to provide insights into the sexual practices of this risk group and generate a debate among them about these practices and their consequences, in order to find possible solutions.

In a first step, one woman and one man who belong to the risk group in a specific region are given training in participatory research using "popular theatre". Apart from gaining knowledge about HIV/AIDS, they learn how to collect and interpret data, write a play about it, and lead a discussion. These candidates then train further theatre practitioners in their district. The choice of theatre practitioners lies in the hands of the risk group. Because it is believed that differences between gender roles are a key factor in understanding sexual behaviour, the same number of women and men are trained as theatre practitioners.

With the support of the person in charge of training, the theatre group conducts data collection and analysis with the population in the region, as well as a brainstorming about possible solutions (requirement c). In Tanzania, data collection showed that there is a series of culturally founded beliefs and practices which incite young people to have sexual contacts with many different partners, thus leading to a high rate of infection in the age group (requirements a and b). By performing results in a play, themes that are not usually openly debated become public and are discussed within a community context (requirement d).

Example 2 The Syndrome Approach[16]

This example shows how requirements a), b), c) and d) can be fulfilled by using various disciplines.

The syndrome approach classifies problems of global change on the basis of characteristic indicators (symptoms), by analogy with disease patterns or syndromes. It attempts to understand how these syndromes function in order to suggest prevention and healing measures. Over-cultivation of marginal land (Sahel syndrome) and environmental degradation through uncontrolled urban growth (favela syndrome) are examples of such patterns. The syndrome approach was developed by the German Advisory Council on Global Change (Wissenschaftlicher Beirat der deutschen Bundesregierung Globale Umweltveränderungen, WBGU). This approach uses a conceptual framework that is well-known in medicine and successfully used for diagnosing and treating diseases. By adopting an approach developed in another discipline, the syndrome approach meets requirements c and d.

The functioning of syndromes of global change is being investigated with the help of systems analysis and modelling at the Potsdam Institute for Climate Impact Research. Modelling serves the purpose of grasping the large number of natural and social factors and their mutual dependence (requirement a). The multiplicity becomes apparent by taking up insights from the natural and social sciences in the modelling process (requirement b). On the basis of syndrome modelling, the acuteness of a syndrome in regions around the world where it has been diagnosed, and therefore the urgency of measures in these regions, can be forecast (requirements c and d).

When dealing with controversial perspectives and interests, relating practice-oriented problem-solving to the common good as a fundamental ethical principle in society and state (requirement d) functions as a regulative idea.[17] The transdisciplinary research process should clarify how to understand the concept of the common good and its implications as a normative principle for dealing with problems in the life-world. For example, promoting the common good can mean striking a balance between everyone's individual interests, i.e. searching for a win-win situation.[18] Another understanding of the common good is that of a specific good, e.g. human rights that are shared by and beneficial for the members of a community. An explicit debate about the concept of the common good and its implications for dealing with problems in the life-world should help prevent an actor in science or the life-world from taking over the research process.[19]

▷ *The starting point for TR is a socially relevant problem field. Within this field, TR identifies, structures, analyses and deals with specific problems in such a way that it can:*
a) grasp the complexity of problems,
b) take into account the diversity of life-world and scientific perceptions of problems,
c) link abstract and case-specific knowledge, and
d) develop knowledge and practices that promote what is perceived to be the common good.
Participatory research and collaboration between disciplines are the means of meeting requirements a)–d) in the research process. The fact that transdisciplinary researchers have referred to a certain competition between both means is evidence of how important it is to coordinate the use of both means[20] (see Tool 1, p. 30). The explicit description, structuring and attribution of various roles will prevent unexpressed differences between those involved from blocking the transdisciplinary research process.[21]

Tool 1: Identifying the actors involved with regard to TR requirements

Actors involved / **Requirements of TR**	Actor A	Actor B	Actor ...	Discipline A	Discipline B	Discipline ...
a) Complexity of problems						
b) Diversity of perceptions						
c) Abstract and case-specific knowledge						
d) Knowledge and practices that promote what is perceived to be the common good						

Tool 1 serves the purpose of coordinating participatory research and collaboration between disciplines, and ensuring their relation to the problems so that they can best fulfil the four requirements of TR. Taking requirement d) as an example, the table can be read in the following manner: "What actors and/or what disciplines need to be involved in the project in order to ensure that knowledge and practices will be produced that promote what is perceived to be the common good?"
As the Tool is a matrix, it becomes clear that the requirements can be met through various constellations of actors and disciplines involved (see also Examples 1 and 2, pp. 28–29).

3.2 Identifying and structuring research questions

The requirements of TR make it especially challenging to identify and structure research questions. Applied research and basic research reduce the complexity of a problem field with the help of disciplinary criteria that allow them to identify concrete problems and structure them into research questions that can be processed scientifically. TR has to meet special challenges in this area. This is explained below in a comparison between the research modes of basic research, applied research and TR. To point out the relevant differences, all three forms of research are conceived of as "ideal types".[22]

Differences between the three forms of research are due to the ways in which academic disciplines and actors in the life-world interact when identifying and structuring research questions in problem fields. The following figure presents the elements that are needed to compare basic, applied and transdisciplinary research:

Scientific disciplines	***Problem fields***	***Actors in the life-world***
Economics	Poverty	Private sector
Ethics	Disease	Civil society
Molecular biology	Land degradation	Public agencies
Ecology	Hunger	
etc.	etc.	

Research questions: ...

Figure 1: Chart for comparing basic, applied and transdisciplinary research

The sciences are structured by disciplines and research areas,[23] as exemplified in the figure's left column. Examples of various possible problem fields are listed in the middle column. In the right column, three societal "policy cultures" are distinguished as different "actors in the life-world": public agencies (which include international public institutions), civil society, and the private sector. In the knowledge society, scientific disciplines, the private sector, civil society and public agencies are four interacting "policy cultures".[24]

Identifying and structuring problems in a problem field to determine research questions means to distinguish relevant aspects from irrelevant ones. Diversity and complexity are reduced by referring to existing knowledge. This reduction is done from a different perspective in basic research, applied research and TR, as each form of research deals in a different way with the different types of questions in relation to specific problem fields. In the figure below, the arrows symbolise these perspectives.

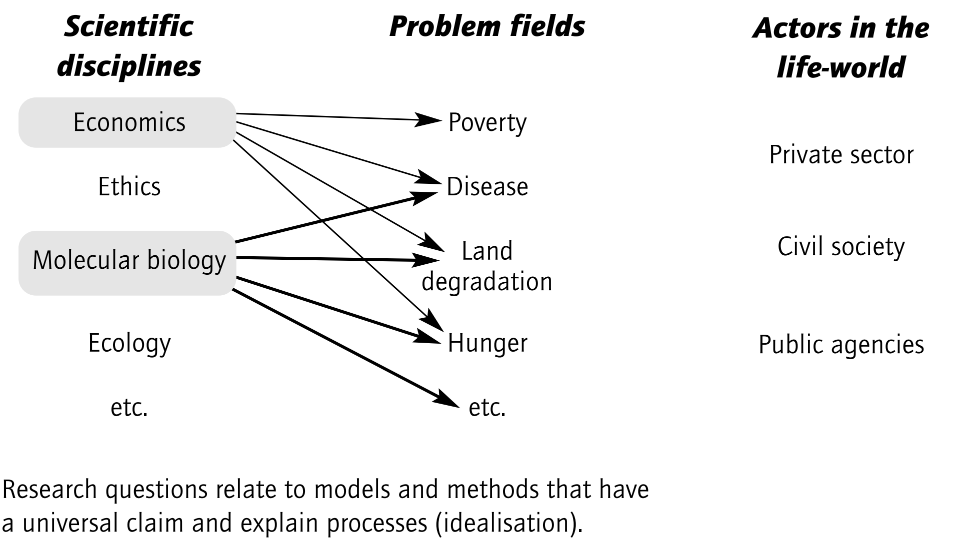
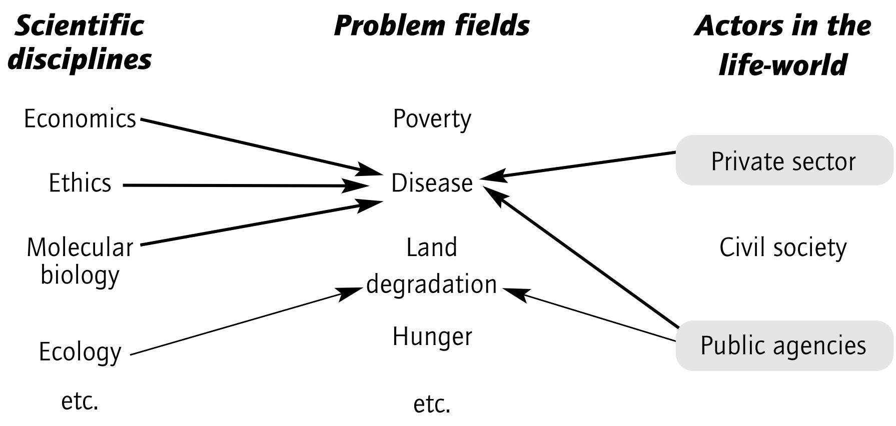


Figure 2: Identifying and structuring research questions in basic research

Basic research aims at enhancing the state of the art in a discipline, e.g. economy, molecular biology etc. Problem fields such as disease harbour difficulties related to empirical data collection and theoretical interpretation of specific processes. Research questions are structured with the help of the conceptual and methodological tools of a discipline: In the case of the "disease" problem field, for example, one can address molecular biology processes, economic processes etc. The research methods and conceptual frameworks of a certain discipline – e.g. molecular biology – are supposed to be valid for molecular processes in all problem fields, i.e. independent of historical time and geographic space. In order to achieve this, idealisation, i.e. the abstraction from a multitude of possible influencing factors, is necessary. Research is expected to improve the general models of a discipline by which processes are described, analysed and explained.

When studying a specific process in different problem fields and under various conditions, research may be confronted with processes behaving in unexpected ways and thus challenging the present explanations and the state of knowledge of a discipline. Innovation in basic research can be triggered by interdisciplinary collaboration between disciplines,[25] leading to new special fields. This is how biochemistry emerged: It is the result of a combination and transfer of concepts and methods from other disciplines – in this case chemistry for research on biological processes – with the aim of finding new methods and models for investigating specific processes. Because such unexpected processes can always occur, each discipline is subject to change over time.

In basic research, reduction of the complexity of phenomenological diversity is based on a disciplinary paradigm, i.e. on its specialised language, underlying theoretical assumptions, values, forms of communication and institutional structures, as well as on the state of research that can thus be achieved. The progress of knowledge in basic research can open new ways of dealing with problems in the life-world, but it is applied research and TR that develop the means required by actors for improving practices in the life-world.



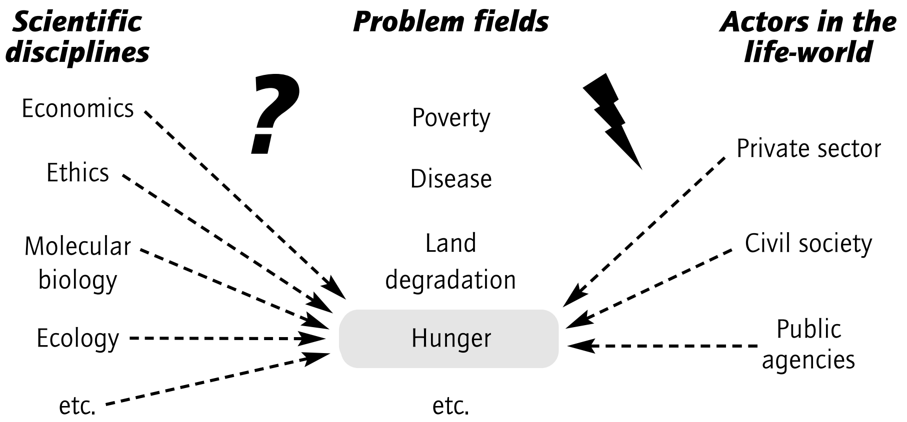
Research questions relate to the variability of processes in a problem field and the different measures required for specific actors.

Figure 3: Identifying and structuring research questions in applied research

In *applied research*, research questions relate to the variability of processes in problem fields. Disciplines have to specialise on a certain problem field in order to describe and explain the variability of processes, as is the case for instance with agricultural ecology or educational psychology. The diversity of factors influencing processes in a problem field and their complex interaction often call for specialised interdisciplinary collaboration in a specific field. Conservation biology, food sciences and specialised disciplines in the field of material sciences are examples of such applied research disciplines.

Applied research often directly relates to dealing with problems in the life-world and may be designed to improve the practices of specific actors. To this purpose, applied research is often funded by clients from the private sector or public agencies. Research activities in this case may be conducted by a tandem of scientists and practitioners.

Reduction of complexity is made possible through disciplinary and interdisciplinary models adapted to specific problem fields. It is also the result of focusing on the goals and interests of specific actors in the life-world, be it in public agencies, the private sector or civil society.



Research questions relate to the complexity of a problem field, of its interpretations, and of the measures aiming to improve practices for what is perceived to be the common good.

Figure 4: Identifying and structuring research questions in transdisciplinary research

In *transdisciplinary research*, problem fields such as hunger and poverty are studied as complex controversial issues. Knowledge about such issues is uncertain and the stakes people and institutions have in finding solutions are high. Because of empirical diversity and complexity, there is debate about which parameters are relevant, how they are connected in concrete processes, and what disciplines therefore need to be involved. This is indicated in Figure 4 by the dotted arrows between academic disciplines and a problem field, and by a question mark symbolising uncertainty. Uncertainties exist regarding the description and explanation of the genesis and possible further development of such problem fields. Disputes inevitably exist in the life-world regarding whether and how certain actors' practices need to be changed, because the groups directly or indirectly involved have a variety of interests, most of which are often incompatible.[26] Further dotted arrows and a question mark in Figure 4 illustrate this. Following the four requirements of TR, the research questions need to refer to: developing knowledge and practices that promote what is perceived to be the common good (requirement d) while taking into account the complexity of the problem (requirement a) and the diversity of life-world and scientific perceptions of the problem (requirement b), and connecting abstract and case-specific knowledge (requirement c).

TR is different from basic research and applied research in that it does not initially seek to reduce the diversity and complexity of problem fields from the perspective of a certain discipline or of a certain actor in the life-world. However, to be able to formulate research questions that can be dealt with, TR needs instruments to reduce the complexity symbolised in Figure 4 by multiple arrows, by adequately distinguishing between what is important and what is not.[27] The design of the research process presented in Chapter 4 is such an instrument. Another one is the positioning of research needs with regard to systems, target and transformation knowledge (see Tool 2 p. 40). To avoid possible misunderstandings, several points need to be clarified before presenting these instruments in greater detail:

- Basic research, applied research and TR are three different forms of research (ideal types) that complement and enhance one another. They do not compete for the overall title of "best research form". It is therefore important to specify which form of research will constitute the scientific approach to the problem field and under what conditions. This must be decided according to the kinds of problems and research questions about which there is a need for research.
- Basic research is not directly in touch with actors in the life-world. This does not mean, however, that such research is fundamentally independent of values and practices in the life-world. Basic research is an important prerequisite for applied and transdisciplinary research and thus indirectly connected with what is perceived to be important in the life-world. But if values and practices in the life-world are uncontested they are often not debated, which, however, does not mean that basic research and life-world orientations do not influence one another.

- Applied research often directly refers to life-world actors' practice-oriented issues. However, this does not necessarily imply that it serves only individual interests.
- TR develops knowledge and practices that promote what is perceived to be the common good. This does not imply, however, that TR is the only form of research that addresses common good issues. Applied research mandated by government authorities is expected to focus on the common good. In ethics and economics, basic research questions deal with theories of the common good. But what is specific to TR is the combination of the four requirements: developing knowledge and practices that promote what is perceived to be the common good while taking into account the complexity of a problem and the diversity of perspectives on the problem, and by linking abstract and case-specific knowledge.

3.3 Systems, target and transformation knowledge

TR addresses three kinds of research questions: (a) questions about the genesis and possible development of a problem field, and about interpretations of the problems in the life-world; (b) questions related to determining and explaining practice-oriented goals; and (c) questions that concern the development of pragmatic means (technologies, institutions, laws, norms etc.) as well as the possibility of transforming existing conditions. In their vision of research for sustainability, Swiss researchers defined three different types of knowledge which are also often used to characterise TR: systems, target and transformation knowledge.[28]

Table 1: The three forms of knowledge

Form of knowledge	Research questions
Systems knowledge	Questions about the genesis and possible further development of a problem, and about interpretations of the problem in the life-world
Target knowledge	Questions related to determining and explaining the need for change, desired goals and better practices
Transformation knowledge	Questions about technical, social, legal, cultural and other possible means of acting that aim to transform existing practices and introduce desired ones

The difference between TR on the one hand and basic and applied research on the other is a gradual one: TR does not start with specific disciplinary paradigms and action perspectives. Instead, in order to meet its research objectives in the best possible way, TR takes into consideration a large array of potential disciplinary paradigms and life-world perspectives, and it explicitly narrows down its focus to a few of them in the phase of identifying and structuring problems. TR takes into account that knowledge about problem fields is uncertain and social groups' stakes are high. Moreover, TR takes into account the fact that the definition and analysis of problems constitutes disputed ground. Therefore, the production of the three forms of knowledge faces *particular challenges*:

- Systems knowledge confronts the difficulty of how to deal with *uncertainties*. These uncertainties are the result, on the one hand, of transferring abstract insights from a laboratory, a model or a theory to a concrete case underlying specific conditions. Furthermore, empirical or theoretical knowledge about a problem may be lacking, and depending on the interpretation of a problem, these uncertainties may be assigned different degrees of importance, which leads to diverging assessments of the need for action and of target knowledge and transformation knowledge. We subsume all these aspects under the term "uncertainties". If systems knowledge is uncertain, this can be used as an argument to block attempts to transform a problem situation.[29] Therefore, TR faces the challenge of finding a transparent way of dealing with uncertainties in order to avoid blocking the research process.
- In the case of target knowledge, the question is what *the multiplicity of social goals* means for research, for society's practice-related problems, and for transdisciplinary collaboration between science and actors in the life-world. TR faces the challenge of clarifying a variety of positions and prioritising them in the research process according to their significance for developing knowledge and practices that promote what is perceived to be the common good. This is necessary not only when the need for action has to be identified and objectives have to be determined, but also when describing the systems to which they refer and the possibilities of inducing change (see Tool 2, p. 40).
- In the case of transformation knowledge, *established technologies, regulations, practices and power relation*s must be taken into account.[30] This is the mere consequence of pragmatism, since options for change have to rely on existing infrastructure, on current laws, and to a certain degree on current power relations and cultural preferences, in order to have any chance at all of being effective. When these social, cultural and technological givens are not considered, this leads to the often criticised discrepancy between knowledge and practice.[31] For TR, the challenge here is to learn how to make what is established more "flexible".

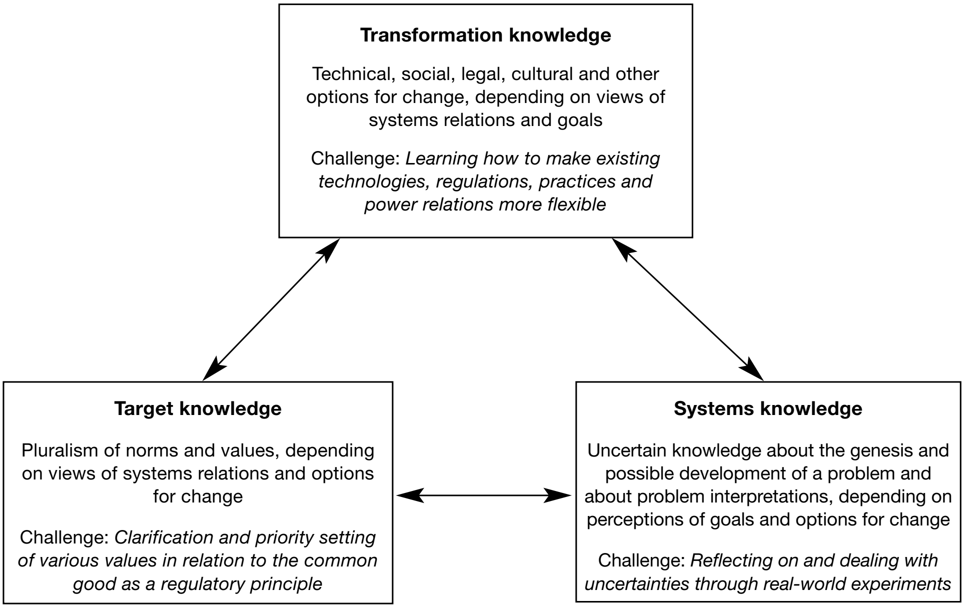


Figure 5: Interdependencies between the three forms of knowledge

TR aims to develop knowledge and practices that promote what is perceived to be the common good. Therefore, TR must consider systems and transformation knowledge. The resulting *interdependencies between the three forms of knowledg*e are the main viewpoint from which the need for knowledge must be identified and structured. Research questions relating to systems, target and transformation knowledge are not isolated in TR; instead, they can only be answered by referring to the other two forms of knowledge (see Figure 5). Thus, an empirical analysis of systems relations will refer to a particular means of transforming a specific social practice and to a specific idea of a better practice. (In the process, a new kind of systems knowledge may be necessary, as illustrated in Example 4, p. 48.) When research questions refer to target knowledge, they are examined based on specific assumptions about systems relations and with a view to particular options for transforming existing practices. For example, when a comparative life-cycle assessment of two products is made, it is based on specific models of natural and economic processes; moreover the assumed transformation is that a positive assessment will allow the product to be distributed more widely. Finally, studies of possible change options are based on specific assumptions about systems relations, goals and better practices, and address the question of what can be done to establish these as standard practices under the given circumstances.[32]

▷ *TR is sometimes referred to by trans-disciplinary researchers in the German-speaking world as an "*eierlegende Wollmilchsau*", i.e. as beset by the quandary of being "all things to all people".*[33] *This is an expression of the experience that projects are often confronted with unrealistic requirements and expectations. For researchers, such excessive demands can easily lead to overburdening. Provided one does not believe that TR will become "all things to all people", it can be useful to reduce complexity by positioning research questions with regard to systems, target and transformation knowledge, while taking into account both the interactions between these forms of knowledge and the particular challenges that characterise each of them (see Tool 2, p. 40). Research questions may focus on systems, target or transformation knowledge, each with its particular challenges. Positioning the need for knowledge with regard to the three forms of knowledge ensures that their interdependencies are taken into account, even if only one of these forms of knowledge is aimed at.*
Reduction of complexity by specifying the relations between forms of knowledge is an instrument that is often implicitly used, but has until now seldom been explicitly connected with this purpose.

*Karl Herweg **

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Tool 2: Positioning the need for knowledge with regard to the three forms of knowledge

	Research questions	Particular challenge	Questions to help with positioning
Systems knowledge	Questions about the genesis and possible development of a problem and about life-world interpretations of a problem	Reflecting on and dealing with uncertainties with the help of real-world experiments	② ③
Target knowledge	Questions related to determining and explaining the need for change, desired goals and better practices	Clarifying and prioritising diverse perceptions of targets and values, taking into account the common good as a regulatory principle	① ③
Transformation knowledge	Questions about technical, social, cultural, legal and other possible means of acting to transform existing practices and introduce desired ones	Learning how to make existing technologies, regulations, practices and power relations more flexible	① ②

① *To what understanding of the genesis and possible development of a problem and life-world interpretations of it does the research question refer?*

② *To what kind of need for change, desired goals and better practices does the research question refer?*

③ *To what technical, social, cultural, legal and other possible means of acting does the research question refer?*

Tool 2 helps to position TR vis-à-vis the three forms of knowledge. Using the example of systems knowledge, it can be read as follows: "TR about systems knowledge deals with questions about the genesis and possible development of a problem and about life-world interpretations of the problem. The particular challenge is to reflect on and deal with uncertainties with the help of real-world experiments. TR that produces systems knowledge must answer questions 2 and 3 when tackling problem identification and structuring, because of the interdependencies between the three forms of knowledge relevant to TR."

4

The Transdisciplinary Research Process

The requirements of TR (see Chapter 3.1) imply not only that different disciplines and actors should be included in the research process, but also that the research process ought to be shaped accordingly. A division of the research process into three phases is commonly found in the literature on managing and evaluating both TR and applied research.[34] We refer to these three phases in the following way:

- Problem identification and structuring
- Problem analysis
- Bringing results to fruition

It is not necessary to go through the three phases in this order. In some cases, identification and structuring of problems may lead to spending the remaining time on dealing with this specific task. But it might also reveal the need for a concrete analysis that may have to be conducted either in a transdisciplinary way or by using applied research, depending on the complexity of the problem.[35] Problem identification and structuring may also reveal that there is primarily a need for bringing existing knowledge to fruition, in particular when the state of the art in research makes it possible to examine and deal with the problem in a far more differentiated manner than the state of knowledge about the problem in the life-world.

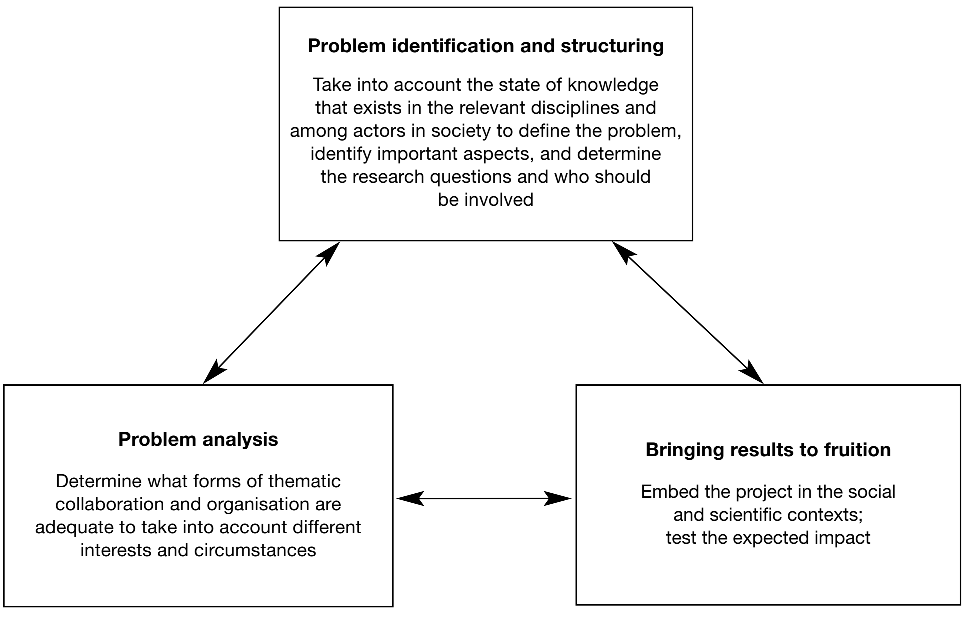

Figure 6: The three phases of research

Depending on the form of collaboration (see Chapter 4.3.2), those involved in TR take part in the process with varying intensity in the course of time, in particular because some have the role of carrying out the research and are paid for this. Alternation of times of intense participatory research, exchange among researchers from different disciplines, and moments of individual work are illustrated in Figure 7. The adjectives "inter-" and "transdisciplinary" characterise the phases in which mutual adaptation between disciplines and with actors in the life-world is achieved.

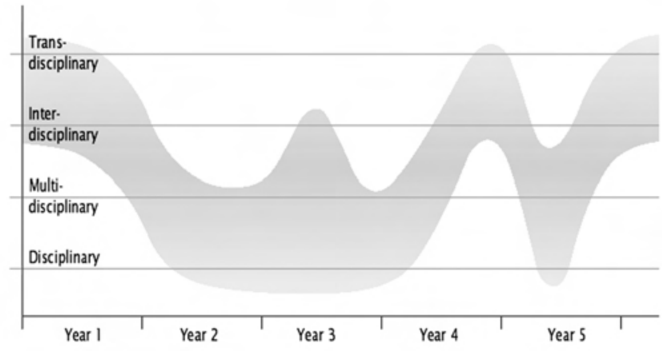

Figure 7:
Phases of a transdisciplinary research process (Hurni and Wiesmann 2004, p. 40)

4.1 Recursiveness

Recursiveness is a general principle of TR. It points to the iterative procedures that characterise both the entire research process and its individual phases. This implies that the research process has to be shaped in such a way that concepts and methods can be repeatedly tested, and that underlying assumptions can be modified if they are found to be inadequate.

Within the individual phases, a recursive design is a meaningful pragmatic way of working with intermediary results and further developing them with the help of critical assessment. Recursiveness between the phases implies that initial problem identification and structuring can be corrected based on the outcome of problem analysis or bringing results to fruition. A recursive design of the research process thus also serves the purpose of adequately reducing the complexity of problem identification and structuring.

4.2 Problem identification and structuring

4.2.1 Identifying actors and specifying the need for knowledge

In TR, the question of how problems in a problem field should be identified and structured is in fact the keystone of research. This implies making fundamental decisions about whether and to what extent aspects relevant to concrete practices and circumstances will be included. These aspects determine whether and how the project results will have the desired impact. To this purpose, TR must build on existing disciplinary and life-world perspectives of the problem, and then structure the problem in a manner that enables exploration of the complexity relevant to practice-oriented solutions for what is perceived to be the common good.

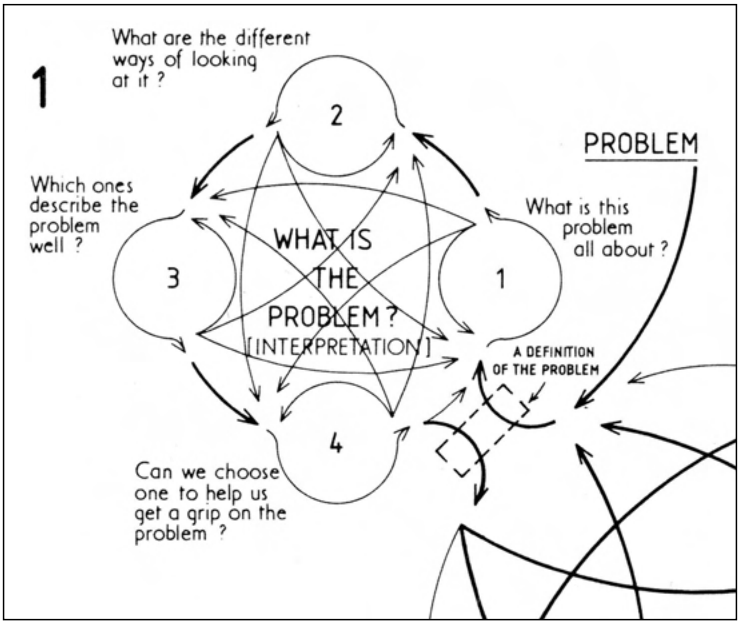

*Figure 8: Problem identification and structuring portrayed as a recursive process (Extract from Hickling 1982, p. 284)**

Figure 8 illustrates the recursive process of problem identification and structuring. The process must be recursive because relevant disciplines and actors in the life-world can only be identified on the basis of a preliminary perception of the problem. Participation of life-world actors and scientific disciplines, however, may modify the perception of the problem to such an extent that further actors and disciplines need

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to be consulted, leading to yet another perception of the problem. According to Figure 8, the challenge of this process is to develop an interpretation of the problem that helps to grasp it and differentiate between dimensions relevant to the actual research question. The (German-language) literature on managing TR emphasises how important it is in this phase to include life-world actors.[36]

In Chapter 3.1, participatory research with life-world actors and collaboration beyond disciplinary borders was described as a means of adequately fulfilling the four requirements of TR. Tool 1 was introduced as a means to help *identify the actors involved with regard to TR requirements* (p. 30). As a first step in problem identification and structuring, project leaders can use this tool to present their perception of what disciplines and actors are relevant. With a view to fulfilling the requirements of TR, project leaders will then have to assess and correct this perception based on the knowledge and concerns of those involved, in a recursive process of problem identification and structuring. Depending on the result of this re-assessment, the process will either end here or have to be repeated.

A second tool to support this process helps *position the need for knowledge with regard to the three forms of knowledge* (see Tool 2, p. 40). The differentiation between the three forms of knowledge and their specific challenges provides a structure for purposefully acquiring state-of-the-art knowledge and identifying research needs. The questions listed in Tool 2 to help position the need for knowledge ensure that the interdependencies between the three forms of knowledge are taken into account when differentiating between them. These questions reveal the assumptions that have to be made before research questions can be formulated regarding one of the three types of knowledge. This helps researchers remain aware of the fact that if a particular understanding of a problem in a problem field is modified, this will also change the perception of what can and what cannot be considered an adequate solution to the problem.[37]

4.2.2 Contextualisation: embedding TR in science and the life-world context

It is important to take into account the phase of bringing results to fruition (discussed in Chapter 4.4 in greater detail) already when dealing with problem identification and structuring. TR aims to link abstract knowledge to results that are relevant to specific cases, in order to contribute to practice-oriented problem-solving. This requires firm embedding of TR both in science and in the life-world. TR can achieve this by establishing relations both to the life-world and to the scientific context during the phase of problem identification and structuring, through the involvement of relevant actors and disciplines.

Contextualisation within the sciences requires, on the one hand, linking research to the state of knowledge in the relevant disciplines (see Example 3), and on the other, learning from transdisciplinary research already conducted on similar problems. Such research can have taken place in various problem fields. As long as no categorisation of existing TR according to types of problems is available in the literature, the search for relevant TR projects is likely to take time. It is therefore useful to consider that TR has various "modes of operation" which appear under other names in the literature (see Annex 2). Moreover, it is necessary to check carefully whether the manner in which problem identification and structuring, problem analysis, and bringing results to fruition is conducted in other projects can really be carried over to the present project, and what lessons can be learned from the experience of other projects. To ensure that TR results have an impact on research, it is important to systematise research experiences – thinking about how they could be transferred to other situations and problem fields – and publish these results in scientific journals (see Tool 5, p. 67).

Example 3 — **"Collaborative Planning"[38]**

The example shows how researchers carried out a theory-based process in which they planned the redevelopment of a future suburb in collaboration with its inhabitants.

A suburb in Quebec was growing old: both the buildings and its inhabitants. For several years, the suburb had been the object of research by a group of sociologists, architects, urban planners, environmental psychologists and other researchers. When the town council decided to integrate the suburb into the town limits, the research group suggested carrying out a participatory planning process for its development. The researchers established a problem identification in collaboration with the inhabitants, as well as a plan and strategy for the redevelopment of the suburb.

The research group based its practice on Habermas' theory of communicative action, according to which the key to collaborative planning is intense exchange of ideas and arguments among those involved. During such an exchange, empirical, instrumental, ethical and aesthetic knowledge flow into the process, eventually resulting in "making sense together". The elaboration of a development plan and strategy for this suburb in Quebec was thus the result of a process that lasted several years and involved a multitude of interactions.

In order to contextualise or embed TR within the life-world, it is necessary to inquire into the status of life-world practices in the problem field, analogous to inquiring into the state of research in a scientific discipline. The life-world actors who are involved in recursive problem identification and structuring offer a variety of perspectives as well as conflicts of interest and claims to power. Embedding TR in the life-world is therefore also a means of relating the target and transformation knowledge that needs to be developed in the course of the project to existing needs and interests, technologies, regulations, practices and power relations (see Chapter 3.3 and Tool 4, p. 40).

In the literature, the "policy sciences" (see Annex 2) suggest how to "map the context"[39], i.e. how to structure the life-world context and, in particular, its dynamics. "Mapping the context" implies not only checking on the status of life-world practices in the problem field, but also finding out what current social trends influence the problem, how one can deal with them, what the causes of these trends are, and what their significance is for the evolution of the problem situation in future.

4.2.3 Reformulation of the questions in relation to life-world actors

TR aims to help solve socially relevant problems in a manner that will serve the common good. It tries to build a bridge between science and the life-world. During the phase of problem identification and structuring, this means that problems previously identified from a scientific perspective need to be related to the actors involved and to specific circumstances, possibly leading to reformulation of the problem or adding of elements. This can be achieved by rephrasing the research question from the perspective of the life-world actors (see Example 4, p. 48). Another possibility is to examine transformation knowledge to find out what it is that makes actors change their behaviour or keeps them from changing it.

Example 4 — **The "Menu"**[41]

This example shows how a problem can be reformulated in relation to life-world actors, and how this leads to a new systems perspective.

The process of reformulation begins when a life-world problem *("*problème identifié sur le terrain") is rephrased, eventually leading through transdisciplinary research[42] to new questions for applied research. Hubert and Bonnemaire illustrate this process with the help of three examples from agronomy. In the following example of how to graze pastureland invaded by shrubs, reformulation is a five-step process.

1. First, the life-world problem that TR will deal with is formulated (in this case by the researchers). In our example, the question is: "How can livestock producers be motivated to graze pastureland threatened by shrub invasion in such a way that both agro-economic goals (livestock fattening) and ecological ones (pastureland management) can be achieved?"
2. In the next step, the problem is related to specific practices and reformulated. The aim is to find instruments that will enable the livestock holders to influence how their animals feed on the pastures so that grazing serves both to fatten the animals and maintain the pastureland.
3. Thus, TR will focus on how to encourage livestock to eat the shrubs and how to stimulate fattening by making animals feed on different plants in a specific sequence.
4. The product of TR – the new instrument – is a "menu". This "menu" sees the grazing area as a spatial set of "courses" which have to be eaten in such a sequence that both the ecological goal of grazing shrubs and the agro-economic goal of fattening are achieved. The "main course" or target zone consists of the plants that livestock do not like eating but which have to be decimated by grazing. Apart from the main course there are "starters", "trimmings" and a "dessert" at the end. The starters and trimmings have an appetising effect.[43]
5. The new instrument and the grazing strategy thus generated lead to new disciplinary topics and research questions. Apart from analysing the organic composition of plants, research will now also explore the constellation in which plants occur in pastureland, the influence on the fattening process of the sequence in which animals feed, and the appetising functions (dessert, starter) of plants for animals.

Example 4 illustrates once again how interdependent systems, target and transformation knowledge are (see Chapter 3.3). The definition of the problem comes from the field of transformation knowledge. The main question is: "What will encourage livestock holders to graze pastureland threatened by shrub invasion in such a way that both agro-economic goals (livestock fattening) and ecological ones (pastureland management) can be achieved?" Seeking to prevent shrub invasion by combining an agro-economic production goal with an agro-ecological one implies a preliminary assumption concerning target knowledge. The aim is to bring both goals into a win-win relationship and avoid a conflict of objectives. The "menu" is based on a new way of perceiving pastureland as a spatial sequence of "courses" that needs to be optimised to fulfil both goals. New kinds of questions thus emerge for livestock production science. In order to improve the instrument, there is a need for *new systems knowledge*, which is only worth knowing in view of the desired transformation.

The example is so illustrative because it is so simple. A conflict of objectives is prevented, the immediate addressees of knowledge are the animals and the livestock producers, and the animals are directed by the producers. The "menu" is a suggestion that may or may not be used by the livestock producers. On the other hand, the example also demonstrates in an exemplary manner how a bridge is built between science and practical relevance – a bridge that encourages connecting things rather than remaining stuck at either end of the bridge: There are new questions for livestock scientists and a new instrument for livestock producers. Both are based on a way of perceiving things that was not known before, either among the scientists or among the livestock holders, as it only emerged as a result of the reformulation of the problem in relation to actors in the life-world. This building of bridges is one of the spaces where TR needs to be creative and original, in order to be able to connect academic knowledge and practical relevance without getting lost in one or the other. Such creativity and originality also characterises Example 5, in which analytical and applied researchers developed a new perception of agglomerations.

Example 5 **The "Netzstadt" project**[44]

This example demonstrates how a "bridge concept" makes collaboration between the analytical sciences and applied sciences possible.

The main concern of the "**Netzstadt**" ("net city") project was the development of a region in the Swiss central lowlands that is a typical agglomeration. The concept of the "net city" offered the researchers a new way of perceiving this agglomeration: as a city organised like a net, with no centre but with many knots or nodes connected to one another.

The researchers who worked together in the "**Netzstadt**" project came from material flow analysis and settlement planning. In both disciplines, it is common to perceive regions from a bird's eye perspective and divide them for analysis and development into areas according to activities (leisure, work, living etc.). The expert knowledge from both disciplines is combined so that a material flow analysis is made of the drafts developed by settlement planning, and suggestions are made to improve material flow, which planning then takes up.

The bridge concept of the "net city" introduced a way of perceiving things that was new for both disciplines and harboured potential for development. The settlement planners used it as a regulatory idea for their draft. Their challenge was to transform the agglomeration into a net city. For the material flow analysts, the challenge was to improve material flow in a region by giving it a net structure.

▷ *Problem identification and structuring is the heart of TR. Complexity can be reduced by identifying those involved in relation to the requirements of TR (see Tool 1, p. 30) and by specifying the need for knowledge in the three forms of knowledge (see Tool 2, p. 40). The decisions made on this basis may need to be modified in a recursive procedure.*

To create a bridge between science and practice, the problem identified can be reformulated in relation to actors in the life-world. This is one of the areas where TR can develop creativity and originality, for example by finding a new way of perceiving things, which works like a bridge between fixed viewpoints.

In this phase, the project must already be contextualised: first, by embedding it in science, which is achieved by referring to the state of the art in the relevant disciplines, and by learning from transdisciplinary research on similar *problems (see Tool 5, p. 67); and second by embedding it in the life-world, which is achieved by considering existing needs, interests, technologies, regulations, practices and power relations that TR will have to take into account (see Tool 4, p. 40).*

Although problem identification and structuring is the keystone of TR, there is very little literature on this phase and it is unusual to plan the necessary means for it. This is an important starting point for promoting TR; increased support for this phase will have a great leverage effect.

4.3 Problem analysis

4.3.1 The structure of problem analysis

Figure 9 is a schematic representation of the possible course that problem analysis can take. The step of problem identification and structuring is not explicitly shown here. Within the logic of the present publication, it would flow from the "recognition of the real-world problem" to the "identification and analysis of main questions", before leading into the finding of a "solution of the sub-problems".

According to Figure 9, problem analysis consists of three steps:

- The research question is divided into sub-questions or "sub-problems".
- The sub-questions are dealt with and answered while keeping them interrelated.
- The sub-answers ("results") are integrated.

What are the implications of analysing sub-questions while keeping them interrelated? What does it mean to integrate the sub-answers? This can be explained by looking at the various forms of collaboration and modes of integration (see Tool 3, p. 59). Recursiveness, here, will require working through the three steps several times.

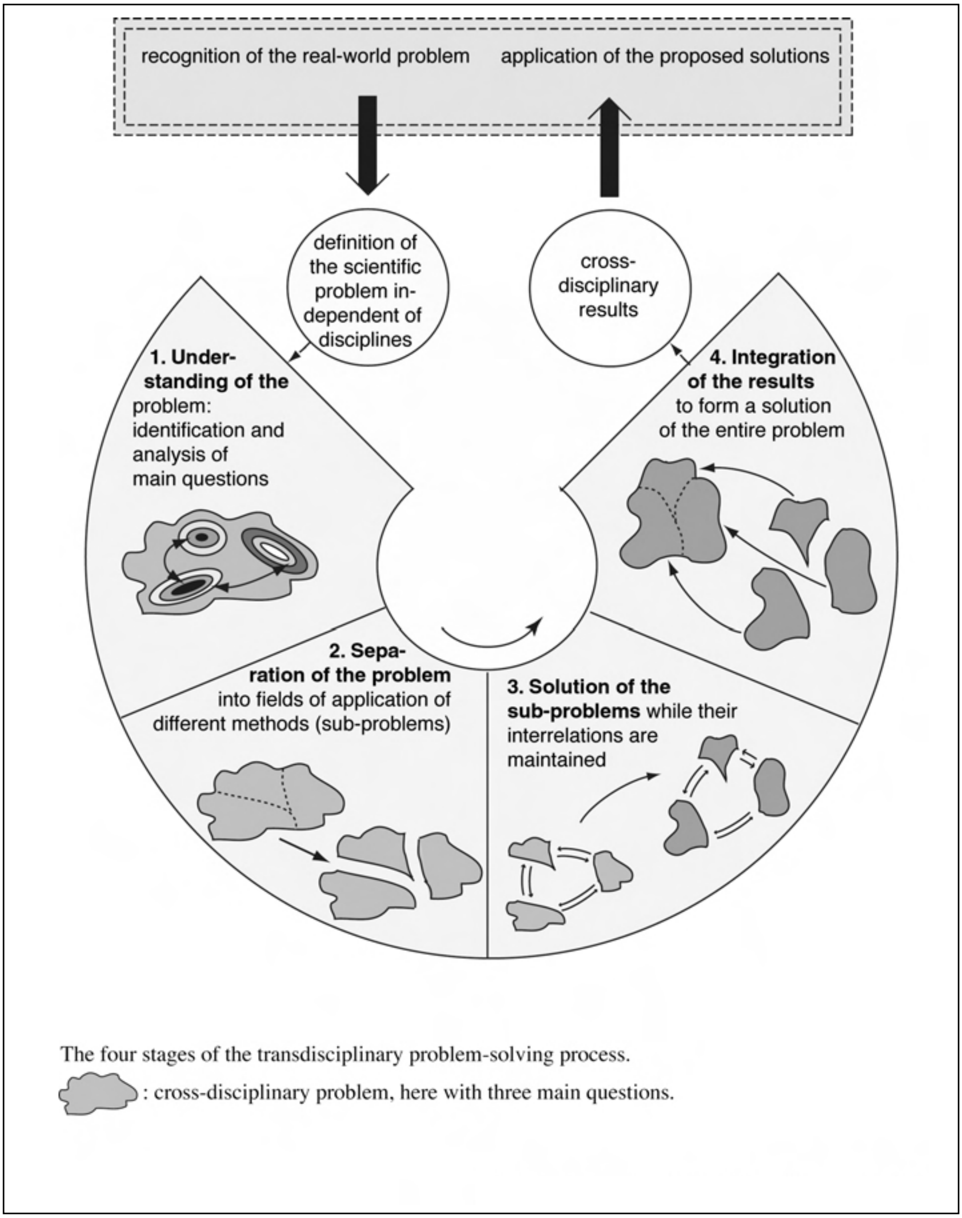

Figure 9: Transdisciplinary problem analysis (Jaeger and Scheringer 1998, p. 19; translated)

4.3.2 Forms of collaboration

In an older, empirical study of the organisation of group work in technology assessment, a distinction is made between four forms of collaboration; this distinction has been taken up in the German-language literature on TR.[46] The four

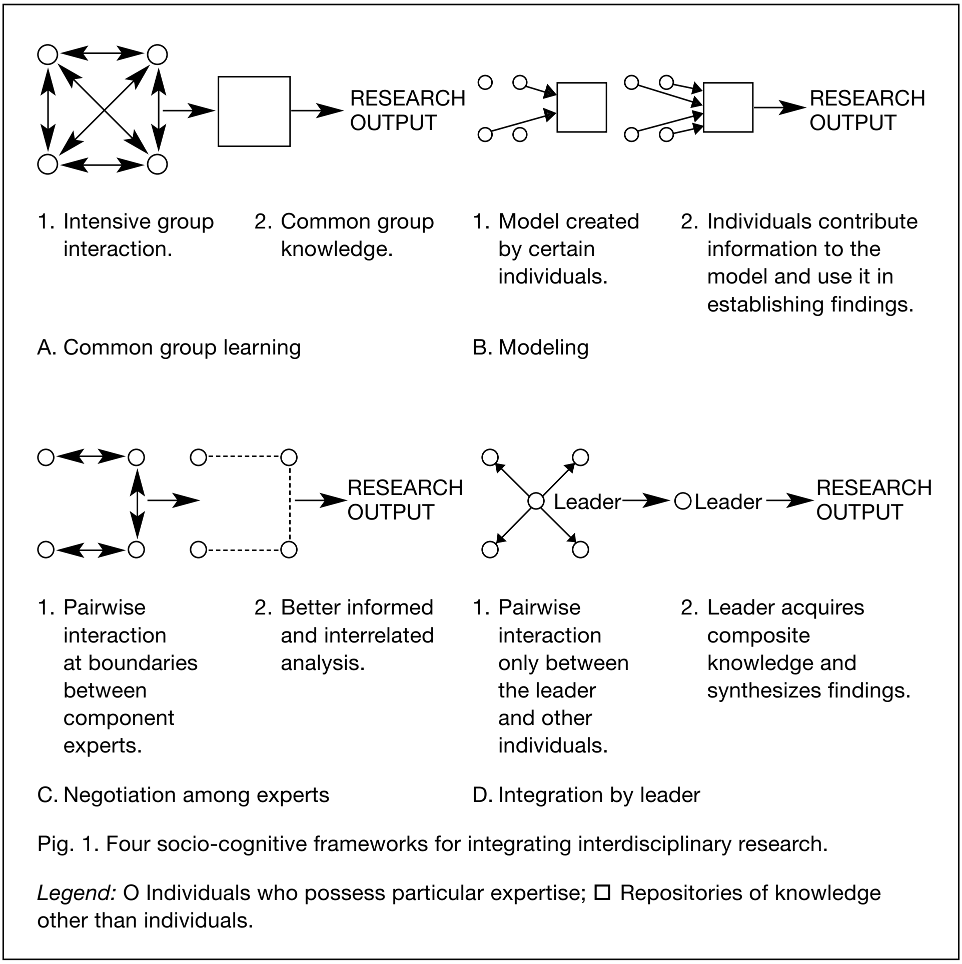

*Figure 10: Forms of collaboration (Rossini and Porter 1979, p. 74)**

forms, which are conceived as ideal types, are referred to as "common group learning", "negotiation among experts", "integration by leader" and "modelling" (see Figure 10).

The dots in Figure 10 stand for "individuals who possess particular expertise". In TR, this refers to the experts both from science and the life-world.[47]

In *common group learning*, all those involved in a TR project go through a common recursive learning and research process. In the first round, the sub-questions are distributed to those members of the group who are felt to be the

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most appropriate ones on the basis of their interests and expert knowledge. After their individual analyses, the results are discussed by the whole group and related a first time to the overall question. Subsequently, the responsibility for the sub-questions changes, and further analysis is no longer in the hands of those who have the greatest level of expertise on, or the greatest interest in, the matter. The process of analysis is repeated until the group decides that an adequate answer to the overall question has been found. The recurring group discussions and the work on the different sub-questions enable the group to learn together. In this manner, individual responsibility for sub-answers decreases, to the benefit of the responsibility of the group as a whole.[48]

Negotiation among experts begins in the same way as common group learning: The sub-questions are distributed among those participating in the research process according to their expertise. Each sub-problem is then analysed individually by the relevant expert. The experts engage in bilateral exchange, while working on the sub-results wherever this is useful for dealing with their own sub-questions. Mutual adaptation of answers and sub-questions is thus achieved. In contrast to common group learning, however, the responsibility for the sub-answers remains with the corresponding experts. A final stage of negotiation leads to a synthesis. The responsibility for the sub-questions and sub-answers, as well as for ensuring that these are adequately represented in the synthesis, lies with each individual expert.[49]

In the process of *integration by a leader*, there is no immediate exchange among the participants. Exchange is mediated by a leader, who is also responsible for integrating all the sub-results at the end.

The process of collaboration referred to as *modelling* often focuses on a (usually quantitative) model. This model is introduced and managed by some participants. The other participants deliver knowledge and assessments that are fed into the model. The relative importance of the model for the process can vary a great deal. It can be a pragmatic tool with which a common understanding of systemic relationships can be developed and represented. In this case, the structure of the model is also the result of a group process. In other cases, the model is developed and modified only by a few participants, and the role of the other participants is to determine certain input variables. In the present publication, modelling is not considered to be a fourth form of collaboration but a mode of integration that can be used in various ways in each of the three forms of collaboration (see Tool 3, p. 59).

Example 6 — "Collaborative Design"[50]

This example shows how a model can be used to lead to a common understanding of a problem, and to develop and discuss possible solutions.

The Collaborative Design concept presupposes that the knowledge needed for understanding a problem in a world characterised by specialisation is distributed in various places. A so-called symmetry of ignorance requires that knowledge be externalised, as well as collected, connected and further developed on the basis of one common object.

The "Envisionment and Discovery Collaboratory" was developed to this purpose at the University of Colorado (USA). The common object used in this case is a horizontal surface that works like a touch-screen. On this working space, spatial conditions can be represented, e.g. the public transport system provided in a neighbourhood. The idea is that inhabitants of the neighbourhood who participate in the project can represent their environment, enter important road stretches, and say how frequently transport services should be offered. The touch-screen is linked to a quantitative model that can, for example, predict how full the buses will be on the basis of general information about local traffic. Participants can shift the location of stops, introduce new bus lines, and change the frequency of services. Thanks to the quantitative model, they find out about the impact of suggested changes on the spare capacity of buses and on the costs involved.

A great deal of new approaches to modelling have emerged and been further developed in the past few decades. Amongst them are methods and procedures as diverse as the syndrome approach (see Example 2), collaborative design (see Example 6) and approaches developed for integrated assessment.[51] Models may also constitute just one part of a more elaborate project design, as is the case with formative scenario analysis in the embedded case study method (see Example 7).

Example 7 — **ETH-NSSI Case Studies**[52]

This example shows that models can be parts of a more elaborate project design.

Since 1993, the Chair of Natural and Social Science Interface (NSSI) at the Swiss Federal Institute of Technology (ETH Zurich) has been conducting annual transdisciplinary case studies on sustainable development.[53] Within the context of the case studies, transdisciplinary research is defined as a scientific activity that produces, integrates and analyses knowledge. Moreover, it:[54]

- deals with relevant and complex social problems,
- complements disciplinary and interdisciplinary research by integrating actors from outside the academic institution, and
- organises a process of mutual learning between science and society.[55]

The ETH-NSSI case studies can be understood as examples of a transdisciplinary laboratory that enables a dialogue between the academic institution and society.[56] Scholz and Marks use the concept of the laboratory to refer to a workshop in which a set of methods and techniques are available to use and further develop transdisciplinarity.[57] The entire project is a methods-based analysis: integration of knowledge and complex problem-solving are organised with the help of a set of methods that are acknowledged and have proven to be successful (Formative Scenario Analysis, System Dynamics, Multi-Attribute Utility Theory, Integrated Risk Management, Mediation: Area Development Negotiations, Future Workshops, Experiential Case Encounter, Synthesis Moderation, Material Flux Analysis, Life Cycle Assessment, Bio-Ecological Potential Analysis).[58] In recent years, transdisciplinary case studies were conducted according to the ETH-NSSI model at other European universities. The International Transdisciplinarity Net on Case Study Teaching (ITdNet)[59] is an international network that enables researchers and teachers at these institutions to have an exchange of experience.

The forms of collaboration are characterised by different hierarchies between those involved and therefore between the areas of knowledge that participants can offer. In common group learning, participants are on equal terms. All of them bring their own expert knowledge, deal with information from other areas of knowledge, and search for an understanding and related procedure that satisfy the group. This can be described as *searching for something new in common*. In negotiations between experts, every expert is responsible for a specific part of the whole. The sub-questions are attributed to sub-sections of the whole. Work on the sub-questions is mutually adapted through bilateral exchange. This procedure can be referred to as a *give and take*. In integration by a leader, the leader names the experts and gives them mandates, determines what is expected from them, and carries out the integration. This form of collaboration can be called *give or take*.[60] In the case of modelling, all three above-mentioned variants are possible; the characterisation of the hierarchy will depend on whether the model is used for the purpose of participatory research (see Example 6, p. 55) or whether a specific modelling approach exists for which knowledge is needed (see Example 2, p. 29). Accordingly, modelling is a mode of integration that can be used in the different forms of collaboration. This is explained in the following section.

4.3.3 Modes of integration

Different aspects of a problem field are relevant to each discipline and each actor (see Chapter 3.2). Normally, aspects considered to be relevant by those involved are perceived in a very differentiated manner, while those considered irrelevant are very undifferentiated.[61] To ensure that best use is made of the potential harboured by differentiated perceptions, the most important principle for collaboration in TR is certainly that of *open encounters*. What is essential here is that participants ask themselves about the significance of other perspectives in relation to their own perspective. This requires relativising one's own perspective and accepting that other viewpoints may also be relevant and should be related to one's own.[62] It is only on this basis that participants can constructively determine the significance of the different perspectives for their common undertaking.[63]

The various perspectives on problems and ways of structuring them may be complementary, which will make collaboration easier. But they may also overlap and compete, making concerted clarification necessary.[64] Many different theories exist that try to explain how different perspectives emerge within science and the life-world and how they can co-exist. Amongst these are the concepts of scientific paradigms (see Chapter 3.2), academic tribes and cultures, thought styles, social worlds, and social sub-systems.[65] These approaches differ a great deal from one another when it comes to details; they also draw completely different conclusions regarding the possibility of communicating between perspectives, the most extreme view being that no such communication is possible.[66] Despite these fundamental divergences, the approaches all agree on the pluralism of perspectives and reject a uniform, all-encompassing perspective – the "view from nowhere"[67]. This, however, does not conflict with the idea that perspectives endeavour to expand the area for which they provide explanations. This is underlined by the concept of academic tribes and cultures, which are said to possess cognitive authority over a specific cognitive territory, as proven by their competence regarding issues in this area. The term "boundary work" is used to designate insistence on this authority or attempts to expand its influence, be it among various disciplines or between science and life-world actors.[68]

A first means of – or rather a pre-condition for – integration is to grasp the multiplicity of perspectives conceptually. To this purpose, it is useful to use one of the above-mentioned pluralist concepts or any similar one. Explicit representation of diversity offers the possibility of productive work with multiple perspectives, instead of letting the latter be unexpressed and unrecognised differences that lead to tensions. TR tends to deal with this pluralism in a rather pragmatic way,[69] as the motivating and centripetal force of collaboration is mainly founded on the claim that it will develop knowledge and practices that promote what is perceived to be the common good.[70]

To support the need for reciprocal relations between perspectives in the phase of problem analysis, it is necessary to go through some form of integration. Several ways of doing this exist; we refer to them as *modes of integration* (see Tool 3, p. 59). Methodologically speaking, the different modes of integration can follow many different paths:

- Integration can be achieved through a *boundary object*, i.e. an object to which all those involved refer based on their specific interest (in shaping things), and which does not require explicit communication between the perspectives.[71]
- A *glossary* leads to integration through clarification of the different concepts and definition of what common concepts should be used, at least for the project.
- Integration can take place through *everyday language*, which "belongs to everyone" (yet is not understood in the same way by everyone). Everyday language is used for example in the "Popular Theatre" approach (see Example 1, p. 28). Some research programmes also recommend the use of everyday language as a means of integration.[72]
- *Models*, in the sense of formal structuring, constitute another mode of integration, as illustrated by the "Syndrome" approach (Example 2, p. 29) and the "Collaborative Design" approach (Example 6, p. 55).
- A further mode of integration is *mutual adaptation of concepts*. This happens when researchers from different disciplines share their specific methods and key concepts in relation to common research questions, and then adapt and further develop them.[73]

- Integration can also take place through metaphorical *transfer of concepts* from one discipline to another. This enables the emergence of new ways of looking at and differentiating between things, and new possibilities for action. The original meaning of the concepts is often modified in the process. Metaphorical transfer is illustrated by the attribution of "momentum" to large technical systems,[74] or by the use of the concept of "syndromes" to describe environmental problems (see Example 2, p. 29).
- Another possibility of achieving integration is through *bridge concepts*. This is a deliberate search for concepts that establish a link between different perspectives by introducing a concept that is useful for collaboration and new to all those involved. The "Netzstadt" (Example 5, p. 50) and the "Menu" (Example 4, p. 48) are examples of such bridge concepts.[75]

Tool 3: Forms of collaboration and modes of integration

	Form of collaboration		
Modes of integration	Common group learning *(search for something new)*	Negotiation among experts *(give and take)*	Integration by a leader *(give or take)*
Boundary object			
Glossary			
Everyday language			
Models			
Mutual adaptation of concepts			
Transfer of concepts			
Bridge concepts			

Tool 3 offers an overview of the forms of collaboration and modes of integration that can be used to deal with problem analysis in TR. It lays no claim to completeness. Every cell represents one possibility. For example, collaboration can take place in the form of negotiation among experts who use everyday language. Or a project leader can perform the integration of perspectives based on a model. The form of collaboration and the modes of integration determine how intensely participants will interact.

▷ *To analyse a problem, the problem statement is divided into sub-questions. These are dealt with and answered in relation to one another, after which the answers to the sub-questions go through a process of integration. Various forms* *of collaboration and modes of integration can be used to this purpose (see Tool 3). As a principle of utmost importance, those involved must encounter one another openly before choosing the form of collaboration and modes of integration. Moreover, the principle of recursiveness requires that decisions already taken can be reconsidered.*

▷ *The form of collaboration and the mode of integration determine the structure and intensity of exchange between those involved. Intense exchange requires a deeper knowledge of one another's positions and a flexible attitude with regard to one's own position.*
There is no debate about contents in the case of integration through a "boundary object". The intensity of debate is low when integration takes place through a project leader or through negotiation among experts. In both cases, there is a clear distribution of tasks and those involved are mainly expected to make statements from their own specialist perspective, without having to reach a deeper understanding of the other perspectives. Exchange becomes intense in common group learning, and even more intense when a new bridge concept is jointly developed. To be able to discover bridge concepts, those involved must first have found out what their perspective allows them to perceive in a very differentiated manner, and what it does not allow them to perceive at all. It is only on this basis that participants will be able to recognise a common potential and search for a concept that will enable this potential to be realised. To reach such intense familiarity with a concept, many years of teamwork may be necessary within a favourable institutional context.[76]

4.4 Bringing results to fruition

Various terms are used to refer to the third phase of the research process, e.g. "implementation", "use", "dissemination of results", "valorisation", or "bringing results to fruition" ("In-Wert-Setzung" in German, "mise-en-valeur" in French).[77] We name this phase "bringing results to fruition". This phase should already be thought of at the stage of identifying and structuring problems, i.e. when TR is embedded in the life-world context or when the problem is reformulated from the perspective of the life-world actors (see Chapter 4.2.2 and 4.2.3).

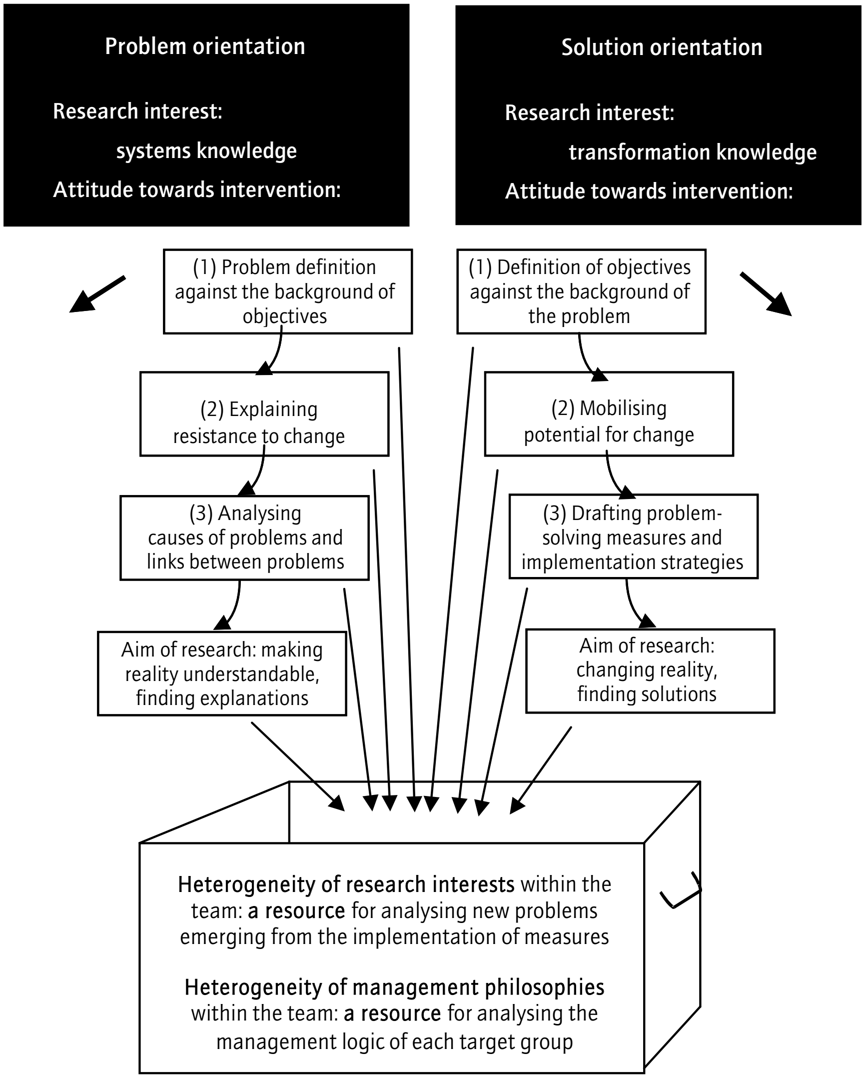

Figure 11: Problem orientation vs. solution orientation
(Loibl 2005, p. 141; translation by A. Zimmermann)

What is particularly important for the phase of bringing results to fruition is that TR builds a bridge between abstract research and concrete problem analysis. The schematic comparison between "problem orientation" and "solution orientation" in Figure 11 offers an overview of the heterogeneous demands that need to be related creatively and productively in the third phase of TR.[78]

4.4.1 Recursiveness in the phase of bringing results to fruition

During the phase of bringing results to fruition, application of the principle of recursiveness requires thinking of the phase not as the final stage of TR but as a part that enables learning processes. The key reason for such recursive shaping is the requirement of TR that the complexity of problems and the diversity of perspectives be adequately taken into account. During the phase of bringing results to fruition, this complexity is articulated in unexpected side-effects, in particular when such side-effects run up against the actual objectives of the project.[79] A recursive design of this phase makes every instance of bringing results to fruition an experiment that needs to be observed in order to learn something for the next instance of bringing results to fruition. In the English-speaking scientific community, the terms used to describe this and similar processes are: "single- and double-loop-learning", "muddling through", "adaptive management", "sophisticated trial-and-error". The French-speaking debate features the term "recherche-intervention", and German TR has coined the terms "experimentelle Implementation" (experimental implementation) and "Real-experiment" (real-world experiments).[80]

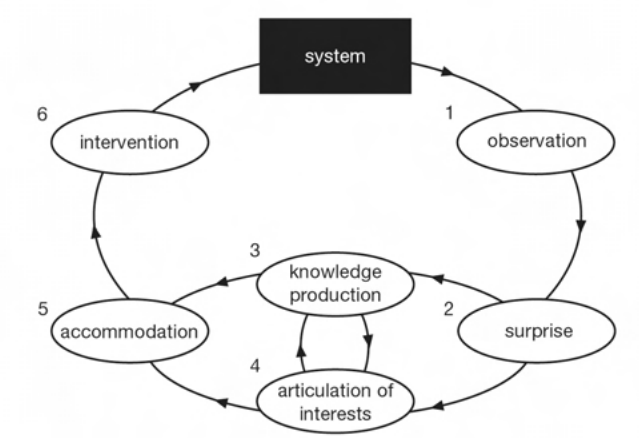

Figure 12:
*Recursive application of the phase of bringing results to fruition: the real-world experiment (Gross et al. 2005, p. 275)**

Figure 12 illustrates the recursive application of bringing results to fruition in the form of a "real-world experiment". The effects of a project are observed, with a view to finding surprises (unexpected impacts). As a result, the assumptions, models and explanations developed in the project are revised in such a way that they can explain these surprises (increase of knowledge). New instances of bringing results to fruition are then planned and conducted etc.

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4.4.2 Explicit and detailed development of impact models

For quite some time, authors in science studies have been discussing the mutual shaping of technology, research and society.[81] This mutual influence is significant because TR aims for contextualisation and impact-orientation. The relevance of TR will depend decisively on how subtly it succeeds in interacting with the life-world.[82] One means of discussing and planning such interaction is the use of an *impact model* to make the assumed interrelations between TR and the life-world explicit. In this context, evaluation research for socio-political research programmes has introduced the concept of the "implicit programme model".[83] What this refers to is the unexpressed but nevertheless influential understanding of how a research programme interacts with life-world processes, and how research can contribute to shaping social change. Several very different implicit programme models can exist within a project. By making them explicit in the form of impact models, their inherent potential to become a source of conflict is transformed into an element of TR that can be shaped.

The impact model can be used as a basis for recursively bringing results to fruition. This requires distinguishing between the *results* of TR, the *use* of results and the *effects* of TR (see Figure 13).[84]

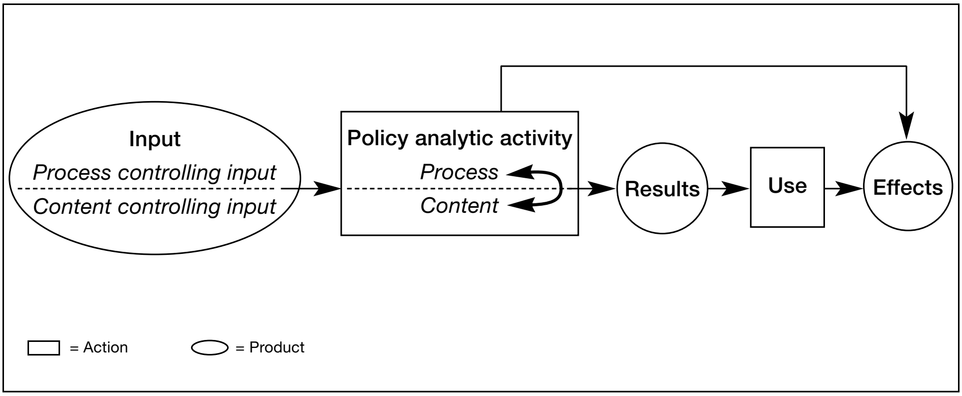

*Figure 13: The diversity of impacts (Thissen and Twaalfhoven 2001, p. 629)***

Differentiation between results and their use underlines the fact that actors in the life-world interpret the same results in different ways and use them for different purposes. A distinction must also be made between this use of results and the effects that the results and their use (or the project itself) may have. Thus, a

** Reproduced with permission from Elsevier project may have an impact through its mere existence, e.g. by making a theme relevant because research is being conducted on it, or by preventing action in a thematic area until initial results are available.

Basically, impacts are numerous and occur at various levels; they can be intended or unintended, e.g. TR may influence a decision-making process or may generate new knowledge of problems and possible solutions. But a project can also lead to changes in the perception of the problem itself, or to new responsibilities.[85] Conceptual frameworks for assessing the impacts of research on different areas of the life-world can deliver methodologies for adequate description of this multiplicity of impacts.[86] Further development of TR in this field will depend on expanding systematic observation and recording the multiplicity of impacts. For the recursive phase of bringing results to fruition, this implies that TR should be creative in searching for surprises and must by no means limit itself to impacts that are expected according to the impact model.

4.4.3 Cognizance of the context of life-world problems

To determine how TR should interact with actors in the life-world, it is important to gain *detailed knowledge of the state of life-world problem identification and analysis*. As already mentioned in Chapter 4.2, life-world actors involved in problem identification and structuring bring in a multiplicity of perspectives, conflicting objectives, and their claims to power. An impact model for a TR project must therefore take existing needs, interests, technologies, regulations, practices and power relations as a starting point, and include consideration of procedures and timeframes to which they are bound. To date, no fully developed conceptual framework and corresponding procedures seem to exist for systematically describing and improving the role of a project in life-world problem analysis.[87]

4.4.4 Tailoring results for the target groups

Theories of thought styles, social worlds and social sub-systems (see Chapter 4.3.3) in particular insist on the fact that every viewpoint is informed by its own logic and has its own procedures and timeframes. Politicians follow the rhythm of legislation processes, topical issues and the next election. Businesspeople base their decisions on quarterly statements and keep an eye on future markets. Bringing results to fruition in TR therefore depends on *tailoring results for target groups*. This is particularly necessary if problems have not been structured in a practice-oriented manner and the relevant life-world actors have hardly been involved in the research process.

When the impact model determines specific social groups as targets (e.g. politics, administration, the education system, the private sector, the media or public opinion), tailoring results requires adapting them to the perceptions of target groups as well as to the procedures and schedules to which they are bound.[88] As Luhmann and Langrock show in the case of politics, the following challenges have to be met:[89]

- Scientific discourses need to be bundled and assessed from the point of view of politics.
- They have to be creatively translated into products useful to politicians.
- The scheduling of product dissemination must fit the current political agenda.

These challenges can be transferred to contexts with other targets, simply by replacing the word "politics" with the terms "private sector", "administration", "the media", or "public opinion". Success will depend on a sound search for knowledge about, and conceptions developed by, these target groups and the way in which they deal with the academic world.[90]

Tool 4: Embedding TR in the life-world

Questions about the impact model	**Area of impact**		
	Private sector	Civil society	Public agencies
What impact is intended?			
What existing needs, interests, technologies, regulations, practices and power relations need to be taken into account?			
What causal relationships are initially assumed?			
In what form and at what point in time can results be introduced in a way tailored for the target group?			
What are likely unintended impacts, and what "probes" may reveal them?			

Tool 4 summarises the questions that need to be answered in order to embed TR in the life-world. For example, if TR is to have an impact on public agencies, there is a need to clarify not only the intended impact and the assumed impact mechanism, but also what existing needs, interests etc. need to be taken into account, and in what form and at what point in time the results should be presented in a way tailored for the target group, and what "experimental tests" may reveal potential unintended impacts.

4.4.5 Embedding TR in the scientific environment

TR should also help science gain new insights by providing an understanding of complex relations, discovery of new research questions and developing new methods. To this end, when TR projects formulate research questions during the phase of problem identification and structuring, it is important that they refer to the state of the art in research within the relevant disciplines (see Chapters 3.2 and 4.2.2) as well as to the state of the art in the development of problem-related integration (see Tool 3, p. 67). The significance of scientific progress in problem structuring and knowledge integration that transcends disciplinary boundaries was underlined by Rosenblum as early as the 1990s in his analysis of research proposals for interdisciplinary projects.[91] This constitutes the specific conceptual and methodological challenge for TR.

To support the impact of TR on developing scientific insights, it is important to determine the corresponding contents, target groups and forms, and to plan their realisation in the various phases of the research process. Thus, after formulating the research questions in the phase of problem identification and structuring, it is useful to clarify what thematic and methodological issues have a potential for further development or innovation in the phase of problem analysis. Results must then be brought into the relevant disciplinary or transdisciplinary debates. This can be done, for example, in the form of contributions to journals and other publications[92], through information channelled through networks, or by means of presentation of results at conferences (see Tool 5). These activities can be fruitful already at the stage of problem analysis, as embedding in the scientific context can lead to recursive adaptation of questions and methods.

TR has virtually no stable institutional foundations, as problem-specific research groups are characterised by disciplinary and institutional heterogeneity; moreover, they are highly mobile due to the limited duration of projects. This is why the embedding of TR in the scientific environment should also be linked to science policy goals. Amongst these are the initiation of research programmes, and the ensuring of academic capacity development and career opportunities. In this context, it is important to inform the relevant science policy actors about the need for and the successes of TR.

Tool 5: Embedding TR in the scientific environment

Strategic elements	Project phase: Problem identification and structuring	Project phase: Problem analysis	Project phase: Bringing results to fruition
Goals (scientific/science policy)			
Contents (state of the art in relevant disciplines/state of the art in transdisciplinary research/future research areas/need for institutional action)			
Addressees (disciplines/transdisciplinary groups/science policy actors)			
Forms (publications/organisation of conferences/initiation of research programmes/development of networks/writing of official statements)			

Tool 5 lists four strategic elements that are important for embedding TR in the scientific environment. These strategic elements can be used at different phases of the research process. Thus, the reference to the state of the art in research is especially useful for the identification and structuring of the problem, as well as for the interpretation of research results during problem analysis. On the other hand, the planning of publications is most appropriately done in the phase of problem analysis while the writing is a part of bringing results to fruition.

▷ *According to the principle of recursiveness, bringing results to fruition is a phase of research that does not occur at the end of TR: It takes place in the course of the research process in order to enable learning processes. Bringing results to fruition is achieved in the form of a real-world experiment, so that its impact can be observed and lessons can be learned for the following phase of bringing results to fruition. To this end, it is important to consider the following aspects:*

- *Already during the phase of problem identification and structuring, it is necessary to develop an impact model that clearly reveals what ideas exist about the impact to be achieved by TR.*
- *To achieve an impact-oriented embedding of TR in the life-world, it is necessary to take into account existing needs, interests, technologies, regulations, practices and power relations that are relevant to the impact model.*
- *If problems are not formulated in a way related to practices in the life-world, and if problem analysis is conducted mainly from a scientific point of view, the results must be specifically processed for the target group. This means that scientific discourses need to be bundled and assessed specifically for the target group. They require creative translation into products that are useful to the target group and can be handed on to the group at a time that suits its agenda.*
- *To promote the effectiveness of TR within the scientific community, it is important to foresee activities at all stages of the research process. With regard to scientific goals, it is necessary to clarify what thematic and methodological results of TR should be integrated into the scientific debate, which research groups are the relevant target groups and what forms of communication are the most adequate (publications, conferences, network). The initiation of projects or programmes on key problem fields and the ensuring of academic capacity development and career opportunities should be among TR's science policy goals.*

Annex

A1 Definitions of transdisciplinarity

A2 "Modes of operation" of transdisciplinarity known under other designations

A3 Participants in the peer review process

Annex A1 offers an overview of definitions of transdisciplinarity from the literature. The heterogeneity and lack of clarity among these definitions is often deplored. While our inventory does not correct this impression, it at least imparts a certain order to this diversity. The *Principles for Designing Transdisciplinary Research* are based on four characteristics of transdisciplinarity that can also be found in the definitions presented in this Annex. Not all elements in the definitions cited here have the same importance: Our comments in italics indicate which elements specifically influenced aspects evoked in the previous chapters of the present publication.

Moreover, descriptions that touch upon forms of research similar to transdisciplinarity are listed in Annex A2. Here too, italics indicate what was particularly relevant to the orientation of the *Principles*.

A1 Definitions of transdisciplinarity

Despite their diversity, definitions of transdisciplinarity from the literature are characterised by recurring elements. One of them is that in nearly all definitions, transdisciplinarity comes at the end of a list that starts with multi- or pluridisciplinarity and continues with cross- and interdisciplinarity. This sequence is based on increasing involvement in confronting disciplinary boundaries: Cross- and interdisciplinarity are defined as going further than multi- and pluridisciplinarity, while transdisciplinarity is said to go further than cross- and interdisciplinarity. But the definitions and their authors do not agree on what characteristics or concerns make transdisciplinarity go beyond the other "disciplinarities". A basic distinction can be made between four such characteristics or concerns:
- the transcending and integrating of disciplinary paradigms;
- participatory research;
- the focus on life-world problems;
- the search for unity of knowledge beyond disciplines.

The definitions presented here emphasise one or several combined individual characteristics from this list. We have therefore grouped them according to similarities in how they characterise transdisciplinarity. The resulting classification into four groups is a first attempt at systematisation; it can be modified and extended.

Group 1	**Transcending and integrating disciplinary paradigms**	**Participatory research**	Relating to life-world problems	Searching for unity of knowledge

In the first group, "trans" means the opening and crossing of the border between the scientific community and other parts of society. The term "interdisciplinarity" refers to a form of coordinated and integration-oriented collaboration between researchers from different disciplines. Transdisciplinarity in the definitions below thus adds an aspect to the understanding of interdisciplinarity: that of participatory research with actors from other parts of society.

ProClim/CASS 1997

"**Interdisciplinarity:** The joint planning and execution of projects across various disciplines. Key factors are the joint definition and elaboration of the concept, the adoption of findings from other disciplines, and the joint presentation of findings to the public.

Transdisciplinarity: The expansion of the interdisciplinary approach towards participation, e.g. researchers working with affected parties and users (...). This method is expected to lead to new approaches in environmental research as a prerequisite to a holistic assessment of the environment." (ProClim 1997, footnote 14)

Defila and Di Giulio 1999

"Interdisciplinary research here denotes the integration-oriented cooperation of scientists from at least two disciplines with the aim to reach common objectives, thereby merging the sundry disciplinary viewpoints into a greater, more complete view. The disciplines involved are those likely to make a useful contribution to the treatment of a theme." (Defila and Di Giulio 1999, p. 6)

"Transdisciplinary research, in turn, here denotes interdisciplinary cooperation, involving not only scientists but also practitioners from beyond the realm of science (e.g., the users) in the research work." (Defila and Di Giulio 1999, p.13)

Lawrence 2004

"In this article, disciplinarity refers to the specialisation of academic disciplines that became strong during the 19th century. Multidisciplinary refers to research in which each specialist remains within her/his discipline and contributes using disciplinary concepts and methods. Interdisciplinary contributions can be interpreted as the bringing together of disciplines which retain their own concepts and methods that are applied to a mutually agreed subject. In these studies one contributor will usually co-ordinate the research process and seek integration. Interdisciplinarity can be considered as the mixing together of disciplines, whereas transdisciplinarity implies a fusion of disciplinary knowledge with the know-how of lay-people that creates a new hybrid which is different from any specific constituent part. This interpretation means that transdisciplinarity is not an automated process that stems from the bringing together of people from different disciplines or professions. In addition, it requires an ingredient that some have called 'transcendence'. This implies the giving up of sovereignty over knowledge, the generation of new insight and knowledge by collaboration, and the capacity to consider the know-how of professionals and lay-people. Collectively, trans-disciplinary contributions enable the cross-fertilisation of ideas and knowledge from different contributors that leads to an enlarged vision of a subject, as well as new explanatory theories. Transdisciplinarity is a way of achieving innovative goals, enriched understanding and a synergy of new methods." (Lawrence 2004, pp. 488–489)

▷ *According to the* Principles*, it is important to integrate actors in research concerned with all three forms of knowledge (transformation, target and systems knowledge) and at all stages of the research process. Integration of actors and the crossing and integrating of disciplinary boundaries is the consequence of aiming to analyse a socially relevant problem in a specific manner (see Tool 1, p. 30).*

Group 2	Transcending and integrating disciplinary paradigms	Participatory research	Relating to life-world problems	Searching for unity of knowledge

As in Group 1, the prefix "trans" in Group 2 also refers to the opening up of science to society and its crossing of the boundary with the non-scientific world. Apart from insisting on the need to involve non-scientific actors in the research process, these definitions also underline the fact that the problem to be dealt with comes from the life-world, i.e. from outside science. By contrast, interdisciplinarity is understood as collaboration between researchers from different disciplines, with the aim of achieving scientific integration.

Häberli and Grossenbacher-Mansuy 1998
"Experience garnered by the SPP Environment [Swiss Priority Program Environment] shows that 'transdisciplinarity' should fulfil at least the following four conditions ... (1) The problems that are studied originate in the life-world. The questions are formulated and structured jointly or in close contact with practitioners and those concerned. (2) Teams are formed with experts from disciplines that make it possible to answer the questions posed (alliances of disciplines), as well as with practitioners and those concerned. (3) The actual research activities are carried out as a collaborative effort between the researchers, and in close contact with practitioners. (4) Results are disseminated among a broad public." (Häberli and Grossenbacher-Mansuy 1998, p. 200; translation by A. Zimmermann)

Kötter and Balsiger 1999
"Any form of unspecified collaboration will be called *multidisciplinary* and the term *interdisciplinary* will only be used for those forms of supradisciplinary collaboration where various disciplines, keeping their own autonomy (i.e. without becoming a serving discipline), solve a given problem which cannot be solved by one discipline alone, in a joint way. As soon, as a given problem raises from outside the scientific context and it has to be solved in the form of a joint collaboration between scientists and practitioners, the terminological suggestion is to use the term *transdisciplinarity*. But there is a special danger which has to be taken in consideration. Transdisciplinary projects should not be loaded down with tasks which do not belong to the scientific context. In no way can the implementation

of suggested solutions into practice be carried out by science as a *substitute* for practice. If this occurs there is a definite danger of science drifting into ideology." (Kötter and Balsiger 1999, p. 102, italics in the original)

Klein et al. 2001
"The core idea of transdisciplinarity is different academic disciplines working jointly with practitioners to solve a real-world problem. It can be applied in a great variety of fields." (Klein et al. 2001, p. 4)

Jahn 2005
"What is unquestioned is that societal (life-world, social) problems rather than purely scientific issues are the starting point for the transdisciplinary research process. This leads to a more complex research process compared to disciplinary research. Indeed, on the one hand it is necessary to go beyond disciplinary boundaries and establish relations between the methods and theoretical frameworks in the natural, social and technical sciences. On the other, everyday and scientific knowledge need to be related in such a way that practice-oriented knowledge can adequately be taken into account. As a consequence, the aim of research changes: Apart from tackling purely scientific issues, it also deals with problems defined by society." (Jahn 2005, p. 34; translation by A. Zimmermann)

Burger and Kamber 2003
"We characterise 'transdisciplinary science' as (1) cognitive and social cooperation across disciplinary boundaries, (2) an intention towards the direct application of scientific knowledge in both political *decision-making* and *societal problem-solving*, and (3) the participation of non-scientific stakeholders within research processes." (Burger and Kamber 2003, p. 44, italics in the original)

Bruce et al. 2004
"In the course of a series of projects studying interdisciplinary research processes, we have found that the following basic set of definitions covers the most important categories and makes useful distinctions:

Transdisciplinary research focuses on the organisation of knowledge around complex heterogeneous domains, rather than the disciplines and subjects into which knowledge seems inevitably to become organised in academic settings, 'transcending' the academic disciplinary structure. In the context of problem solving, soft systems analysis has many parallels with transdisciplinary research and attempts to devise approaches which are tailored specifically to the problem context and do not rely on any pre-determined disciplinary bias. References to academic disciplines rarely feature in the literature from soft systems analysis and these trans-disciplinary approaches specifically set themselves apart from discipline-based academic structures. Such approaches may also seek to break down the distinction within research programmes between researchers and stakeholders from industry or civil society.

Multidisciplinary research approaches an issue from the perspectives of a range of disciplines, but each discipline works in a self-contained manner with little cross-fertilisation among disciplines, or synergy in the outcomes.

Interdisciplinary research similarly approaches an issue from a range of disciplinary perspectives but in this case the contributions of the various disciplines are integrated to provide a holistic or systemic outcome." (Bruce et al. 2004, p. 459, italics in the original)

▷ *In the* Principles, *a life-world problem is a problem relevant to society; it has to be identified within a problem field and structured accordingly. However, according to the* Principles, *this starting point, the participatory nature of the research process and the fact that researchers collaborate in an integrative manner do not suffice to make research transdisciplinary. Research is truly transdisciplinary only if it develops knowledge and practices that promote what is perceived to be the common good, if it takes into account the complexity of a problem and the diversity of perceptions of the problem, and if it links abstract and concrete, case-specific knowledge (see Chapter 3.1).*

Group 3	**Transcending and integrating disciplinary paradigms**	Participatory research	**Relating to life-world problems**	Searching for unity of knowledge

In Group 3, the starting point for transdisciplinary research is the increasing specialisation of scientific knowledge, which detaches itself increasingly from social problems and concerns, "or, as cynics have stated it: 'The world has problems, but universities have departments'" (Brewer 1999, p. 328). Authors such as Brewer demand that science should deal more often with life-world problems, apart from conducting research in disciplinary paradigms. For this purpose, knowledge needs to be re-organised and weighted in a different manner: from a disciplinary pattern to a pattern which is as appropriate as possible for perceiving and analysing life-world problems. The transition from inter- to transdisciplinarity implies a change in the aim of organising and assessing knowledge: Even if interdisciplinary collaboration focuses on life-world problems, the organisation and assessment of knowledge is primarily determined by scientific concerns. In transdisciplinary research, this role is played by the life-world problem and its solution-oriented analysis. Disciplinary organisation and values can be transgressed or abrogated if analysis of the problem requires such a move.

Mittelstrass 1992

"A different orientation within research is necessary when specialised knowledge and expertise alone are unsuccessful, when interdisciplinarity cannot capture problems because it remains biased within the scientific system and is unable to transform it, and when reductionism of whatever kind leads only to illusory solutions. This different orientation is called *transdisciplinarity*. Transdisciplinarity refers to knowledge or research that frees itself of its specialised or disciplinary boundaries, that defines and solves its problems independently of disciplines, relating these problems to extra-scientific developments. The intention is not to dissolve the order of specialised and disciplinary knowledge – since transdisciplinarity presupposes disciplinary competence – but to ensure that problems are not perceived one-dimensionally, namely only from a specialised or disciplinary perspective. The reason why it is necessary to extend the scientific perception was mentioned above: Nowadays, problems seldom do us the favour of letting themselves be defined according to the order of our scientific habits. Scientific knowledge must re-connect with life-world problems and life-world purposes, with the objective of developing solutions." (Mittelstrass 1992, p. 250; translation by A. Zimmermann)

Mittelstrass 1996

"Term used in philosophy of science to characterise forms of research that focus on problems and go beyond the specialised and disciplinary constitution of science. This constitution is determined mainly historically and has led to an asymmetry in the way problems (e.g. in the fields of environment, health and energy) and disciplinary or specialised research have developed. This asymmetry is constantly increasing due to the fact that disciplinary and specialised research is determined by increasing differentiation. There is a danger that the boundaries between special fields and disciplines will severely limit scientific insight. Compared with the older term *interdisciplinarity* – which also expresses an attempt to counter this trend by re-organising research (and education), but continues to adhere to traditional disciplinary boundaries – the concept of transdisciplinarity suggests a different agenda with regard to the philosophy of science and to research practices: within the historical context of the constitution of disciplines and special fields, and with a view to expanding the capacity of scientific perception, to abrogate narrow disciplinary and expert conceptions wherever such conceptions have lost touch with their historical memory and forfeited their power to solve problems because they have reached too great a degree of specialisation. In this sense, transdisciplinary research does not leave disciplinary, specialised things as they are (and have become as a result of a historical process). Indeed, in specific contexts of problem-solving it even gives a very concrete substance to the original idea of the *unity of science* – in the sense of a unity of scientific rationality – though not at the theoretical level but at the concrete operational level of research practices. Before being a *theoretical principle*, transdisciplinarity is thus first and foremost a *research principle*, even if theories emerge from transdisciplinary research programmes." (Mittelstrass 1996, p. 329, italics in the original; translation by A. Zimmermann)

Jaeger and Scheringer 1998

"Thus, the starting point in the transdisciplinary research process is a non-scientific problem." Furthermore: "We suggest that scientific analysis of problems which have a non-scientific origin requires transdisciplinary work: What we mean is that it requires a process of problem formulation and problem-solving that detaches itself – even more radically than interdisciplinary work – from cognitive interests and methodologies motivated by the quest for disciplinary knowledge." (Jaeger and Scheringer 1998, p.14; translation by A. Zimmermann)

Jantsch 1972

The definition offered by Erich Jantsch – to whom (besides Piaget) the concept of transdisciplinarity is usually attributed – goes in a similar, though more general direction. Instead of referring to a specific life-world problem, Jantsch refers to a general social *purpose*; and instead of mentioning a specific research project, he mentions science, education and innovation as the controllable parts of the larger social system which leads to self-renewal of society.

Multi-, pluri-, cross-, inter- and transdisciplinarity refer to various levels of coordination within science, education and innovation. Interdisciplinarity stands for coordinated collaboration between disciplines, none of which has a perspective that dominates the others. In the case of transdisciplinarity, science, education and innovation constitute a whole oriented towards a specific societal purpose, which results in a new orientation and assessment of knowledge.

"A system approach – as it is proposed in this paper – would consider science, education and innovation, above all, as general instances of purposeful human activity, whose dynamic interactions have come to exert a dominant influence of the development of society and its environment. *Knowledge* would be viewed here as *a way of doing*, '*a certain way of management of affairs*' (Churchmann)." (Jantsch 1972, p. 99, italics in the original)

"If education is accepted as being essentially education for the self-renewal of society, it becomes an important, or even the most important agent of innovation. Going even further, we may speak of an integral education/innovation system in which both education and innovation become aspects of one and the same structure of thought and action. Such an education/innovation system constitutes a most suggestive example for the systems notion according to a recent definition: A system is a relationship among objects described (or specified, defined) in terms of information processing and decision-making concepts (Mesarovic).

Scientific, or more generally, educational disciplines become organised in such a system in a particular way which depends on the *normative* orientation of education and innovation. The boundaries of disciplines, their interfaces and interrelationships no longer correspond to an *a priori* system of science. In order to emphasise this viewpoint of *human action model* – as distinct from a mechanistic model

– we may simply speak of an education/innovation system, instead of a science/education/innovation system." (Jantsch 1972, p. 103, italics in the original)

"In a purposive system, or human action model, however, interdisciplinarity constitutes an organisational principle for a two-level coordination of terms, concepts and disciplinary configurations which is characteristic of a two-level multi-goal system. The important notion here is that with the introduction of interdisciplinary links between organisational levels, the scientific disciplines defined at these levels change their concepts, structures, and aims. They become co-ordinated through common axiomatics – a common viewpoint or purpose. [...] The ultimate degree of co-ordination in the education/innovation system, finally, which may be called transdisciplinarity, would not only depend on a common axiomatics – derived from a co-ordination towards an 'overall system purpose' – but also on the mutual enhancement of epistemologies in certain areas, what Ozbekhan calls 'synepistemic' co-operation. With transdisciplinarity, the whole education/innovation system would be co-ordinated as a multi-level, multi-goal system, embracing a multitude of co-ordinated interdisciplinary two-level systems, which, of course, will be modified in the transdisciplinary framework. Transdisciplinary concepts and principles for the whole system change significantly with changes in the 'overall system purpose' [...]. For example, adopting a notion of 'progress' (as inherent in Christian thought) at this top level would imply a totally different education/innovation system from one for which 'ecological balance,' or a notion of cyclical development (as inherent in Hinduism and Buddhism), were adopted." (Jantsch 1972, pp. 105–106)

"Multidisciplinarity: A variety of disciplines, offered simultaneously, but without making explicit possible relationships between them.

Pluridisciplinarity: The juxtaposition of various disciplines, usually at the same hierarchical level, grouped in such a way as to enhance the relationship between them.

Crossdisciplinarity: The axiomatics of one discipline is imposed upon other disciplines at the same hierarchical level, thereby creating a rigid polarisation across disciplines toward a specific disciplinary axiomatics.

Interdisciplinarity: A common axiomatics for a group of related disciplines is defined at the next higher hierarchical level or sub-level, thereby introducing a sense of purpose; *teleological* interdisciplinarity acts between the empirical and the pragmatic levels, *normative* interdisciplinarity between the pragmatic and the normative levels, *purposive* interdisciplinarity between the normative and the purposive levels.

Transdisciplinarity: The co-ordination of all disciplines and interdisciplines in the education/innovation system on the basis of a generalised axiomatics (introduced from the purposive level down) and an emerging epistemological ('synepistemic') pattern." (Jantsch 1972, p. 106, italics in the original)

The two definitions below explicitly establish a connection with Jantsch's definition:

Gibbons et al. 1994

"There have been many attempts to discern pluri- from inter- and transdisciplinarity. Following the definition given by Erich Jantsch (1972), pluri-/multidisciplinarity is characterised by the autonomy of the various disciplines and does not lead to changes in existing disciplinary and theoretical structures. Cooperation consists in working on the common theme but under different disciplinary perspectives.

Interdisciplinarity is characterised by the explicit formulation of a uniform, discipline-transcending terminology or a common methodology. The form scientific cooperation takes consists in working on different themes, but within a common framework that is shared by the disciplines involved. Transdisciplinarity arises only if research is based upon a common theoretical understanding and must be accompanied by a mutual interpenetration of disciplinary epistemologies. Co-operation in this case leads to a clustering of disciplinary rooted problem-solving and creates a transdisciplinary homogenised theory or model pool." (Gibbons et al. 1994, pp. 28–29)

"Transdisciplinarity: Knowledge which emerges from a particular *context of application* with its own distinct theoretical structures, research methods and modes of practice but which may not be locatable on the prevailing disciplinary map." (Gibbons et al. 1994, pp. 167–168, italics in the original)

Horlick-Jones and Sime 2004

"The idea of investigating, and seeking to understand, the world in ways that cut across the domains of orthodox disciplinary-based inquiry has a long and, it seems, somewhat obscure history. However, for the purposes of this paper, it is convenient to trace this perspective back to the 1970s, especially to the work of scholars like Jantsch and Piaget. Both were concerned with the future: Jantsch with technological forecasting and 'futurology;' Piaget's analysis arising from a UNESCO study into identifying 'the paths on which ... the sciences of tomorrow may embark.' This preoccupation with finding ways of managing future contingency (or risk) has played an important role in motivating, shaping, and thinking about cross-disciplinarity. Indeed, the recent International Transdisciplinary Conference, held in Switzerland in 2000, was centrally concerned with addressing anticipated problem areas in a complex, globalised and plural world, including environmental sustainability, health, energy, and transport." (Horlick-Jones and Sime 2004, p. 442, italics in the original)

"Let us consider first the question of nomenclature. So far we have used the terms 'cross-disciplinarity' and 'transdisciplinarity.' Multidisciplinarity is also sometimes used in the literature. All these terms tend to be used in a generic and rather ambiguous manner. We suggest that, in essence, two meanings are possible. In the first, which may be termed 'multidisciplinarity,' the implication is a division of labour in which different disciplinary frames survey separate aspects of the same whole. There is co-operation between disciplines, but the methodological processes of disciplinary-based investigation remain distinct. In the second, which may be termed 'transdisciplinarity,' elements of methodologies drawn from different disciplines are combined within a single approach. That is, inputs and outputs are exchanged across disciplinary boundaries, in an evolved methodology, which transcends 'pure' disciplines. In epistemological terms, transdisciplinary involves an integration of knowledges." (Horlick-Jones and Sime 2004, p. 444)

▷ *Reference to a life-world problem in research questions is one of the key characteristics of the* Principles*, especially with regard to how transdisciplinary research differentiates itself from other forms of research (see Figure 4, p. 34).*

Group 4	Transcending and integrating disciplinary paradigms	Participatory research	Relating to life-world problems	Searching for unity of knowledge

In Group 4, the transcending of disciplinary paradigms is also motivated by the reference to life-world problems, but it leads to the search for a general standpoint or perspective beyond all disciplines. In interdisciplinary research, disciplinary concepts and methods are exchanged or combined. In the following definitions of transdisciplinary research, there is a search for fundamental structures of knowledge that go beyond problems and disciplines, and a corresponding search for broadly acceptable methods.

Kockelmans 1979

"*Interdisciplinary Work*: Scientific work done by one or more scientists who try to solve a set of problems whose solution can be achieved only by integrating parts of existing disciplines into a new discipline, e.g., psycholinguistics, biophysics. This work does not imply that the original disciplines themselves become totally integrated, although this is not excluded either. The term predominantly refers to research and only secondarily to education." (Kockelmans 1979, pp. 127–128)

"*Crossdisciplinary Work*: Scientific work done by one or more scientists who try to solve a problem or a set of problems that no discipline in isolation can adequately deal with, by employing insights and methods or techniques of some related disciplines, without, however, any attempts being made to integrate the disciplines themselves or even parts thereof into a new discipline. It is obviously mandatory to integrate the scientific knowledge that immediately pertains to the problems at hand; however, it is not assumed that the integration achieved in this way and the experience so gained can be used as a paradigm for the solution of other analogous problems, without major modification. The scientists involved in such a project must have some common ground; the work proceeds from such a common ground but does not aim at developing this ground; e.g. economists, social scientists, physicians, and architects trying to find a better solution for a housing problem in a large city. This term is used predominantly to refer to large research projects." (Kockelmans 1979, p. 128)

"*Transdisciplinary Work*: Scientific work done by a group of scientists, each trained in one or more different disciplines, with the intention of systematically pursuing the problem of how the negative side effects of specialisation can be overcome so as to make education (and research) more socially relevant. In transdisciplinary work the discussion between the members of a carefully selected group may also focus on concrete problems with which society confronts the members of a society or an academic community. The difference between crossdisciplinarity and transdisciplinarity consists in the fact that crossdisciplinary work is primarily concerned with finding a reasonable solution for the problems that are so investigated, whereas transdisciplinary work is concerned primarily with the development of an overarching framework from which the selected problems and other similar problems should be approached. For some authors transdisciplinary investigations should focus primarily on the unification of all sciences concerned with man; in their opinion the aim of transdisciplinary work consists in the development of an all-encompassing theoretical framework that is to be taken as the basis for all empirical research in the behavioral and social sciences. For other authors transdisciplinary efforts are concerned primarily with the unity of our world view; in their view transdisciplinary work presupposes that those who participate in it first try to establish a common ground that implies a conception of our culture, the function of science and education in it, and the basic elements of the entire process of acculturation." (Kockelmans 1979, p. 128–129)

Nicolescu 1996

"Pluridisciplinarity concerns studying a research topic not in only one discipline but in several at the same time. For example, a painting by Giotto can be studied not only within art history but within history of religions, European history, and geometry. Or else Marxist philosophy can be studied with a view toward blending philosophy with physics, economics, psychoanalysis or literature. The topic in question will ultimately be enriched by blending the perspectives of several disciplines. Moreover, our understanding of the topic in terms of its own discipline is deepened by a fertile multidisciplinary approach. Multidisciplinarity brings a plus to the discipline in question (the history of art or philosophy in our examples), but we must remember that this 'plus' is always in the exclusive service of the home discipline. In other words, the multidisciplinary approach overflows disciplinary boundaries while its goal remains limited to the framework of disciplinary research.

Interdisciplinarity has a different goal from multidisciplinarity. It concerns the transfer of methods from one discipline to another. One can distinguish three degrees of interdisciplinarity: a) a degree of application. For example, when the methods of nuclear physics are transferred to medicine it leads to the appearance of new treatments for cancer; b) an epistemological degree. For example, transferring methods of formal logic to the area of general law generates some interesting analyses of the epistemology of law; c) a degree of the generation of new disciplines. For example, when methods from mathematics were transferred to physics mathematical physics was generated, and when they were transferred to meteorological phenomena or stock market processes they generated chaos theory; transferring methods from particle physics to astrophysics produced quantum cosmology; and from the transfer of computer methods to art computer art was derived. Like pluridisciplinarity, interdisciplinarity overflows the disciplines but its goal still remains within the framework of disciplinary research. It is through the third degree that interdisciplinarity contributes to the disciplinary big bang.

As the prefix 'trans' indicates, transdisciplinarity concerns that which is at once between the disciplines, across the different disciplines, and beyond all disciplines. Its goal is the understanding of the present world, of which one of the imperatives is the unity of knowledge.

Is there something between and across the disciplines and beyond all disciplines? From the point of view of classical thought there is nothing, strictly nothing: the space in question is empty, completely empty, like the vacuum of classical physics. Even if it renounces the pyramidal vision of knowledge, classical thought considers each fragment of the pyramid which is generated by the disciplinary big bang as an entire pyramid; each discipline claims that it is sufficient unto itself. For classical thought, transdisciplinarity appears absurd because it does not appear to have an object. In contrast, within the framework of transdisciplinarity, classical thought does not appear absurd; rather, it simply appears to have a restricted sphere of applicability.

In the presence of several levels of Reality the space between disciplines and beyond disciplines is full just as the quantum vacuum is full of all potentialities: from the quantum particle to the galaxies, from the quark to the heavy elements which condition the appearance of life in the universe. The discontinuous structure of the levels of Reality determines the discontinuous structure of transdisciplinary space, which in turn explains why transdisciplinary research is radically distinct from disciplinary research, even while being entirely complementary. Disciplinary research concerns, at most, one and the same level of Reality; moreover, in most cases, it only concerns fragments of one level of Reality. On the contrary, transdisciplinarity concerns the dynamics engendered by the action of several levels of Reality at once. The discovery of these dynamics necessarily passes through disciplinary knowledge. While not a new discipline or a new superdiscipline, transdisciplinarity is nourished by disciplinary research; in turn, disciplinary research is clarified by transdisciplinary knowledge in a new, fertile way. In this sense, disciplinary and transdisciplinary research are not antagonistic but complementary.

The three pillars of transdisciplinarity – levels of Reality, the logic of the included middle, and complexity – determine the methodology of transdisciplinary research." (Nicolescu 1996)

Perrig-Chiello and Darbellay 2002

"*Pluridisciplinarity* (or *multidisciplinarity*) is the juxtaposition of different disciplines within a single institution. The field of science is divided into autonomous and (hyper)specialised disciplines. Schematically, this can be shown as a simple alignment of disciplines A, B, C etc., without real interaction.

By contrast, *interdisciplinarity* is characterised by collaboration between specialists with a very different scientific socialization who come together to tackle a complex problem. The disciplines interact and share the same knowledge objective. [...]

Transdisciplinarity is a global and integrated vision that re-organises disciplinary knowledge in order to solve a complex problem. As Piaget hypothesised it, it 'would not be confined to the attainment of interactions or reciprocities between specialised research; instead, it would situate these relationships at the centre of an overall system without stable frontiers between the disciplines' (1973[93]). The concept of 'retroaction', for example, is typically transdisciplinary, as it pervades the fields of information theory, cybernetics, communication sciences, biology, psychology etc." (Perrig-Chiello and Darbellay 2002, pp. 23–24; translation by A. Zimmermann)

Ramadier 2004

"Multidisciplinarity and interdisciplinarity do not break with disciplinary thinking [...]. In the case of *multidisciplinarity*, the aim is mainly the juxtaposition of theoretical models belonging to different disciplines. Disciplines are considered as being complementary in the process of understanding phenomena. The point is not to take into account the entire model, but only part of each model, that which can be the object of bilateral consensus, in order to maintain coherence. The advantage of this approach is that it highlights the different dimensions of the studied object and respects the plurality of points of view. These aspects of multidisciplinarity are most visible in colloquia.

Interdisciplinarity differs from multidisciplinarity in that it constructs a common model for the disciplines involved, based on a process of dialogue between disciplines. For this reason, interdisciplinarity is often implemented within the same disciplinary field and its purpose is to create synthesis. However, the second important aspect of interdisciplinarity lies in the practice of transfers, either of models or of tools (such as mathematics, statistics), from one discipline to others. In one version, the participating disciplines must submit to the rules and principles of a specific discipline. In a second version, the concepts of one discipline are appropriated by the other disciplines. For example, environmental psychology uses the concept of identity, with several variations (for example, spatial identity, housing identity, etc.). The advantage of this second version of interdisciplinarity is that it can be practiced on an individual basis, rather than collectively. In any case, however, regardless of the form it takes, interdisciplinarity, like multidisciplinarity, avoids paradoxes and having to solve them. As a result, both interdisciplinarity and multidisciplinarity approaches are fragmented. Once again, we are dealing with disciplinary thinking, and thus it is no surprise that multidisciplinarity encourages the creation of new sub-disciplines and the emergence of new levels of reality.

Transdisciplinarity breaks away with this type of thinking in a significant way, since the objective is to preserve the different realities and to confront them. Thus, transdisciplinarity is based on a controlled conflict generated by paradoxes. The goal is no longer the search for consensus but, as we have already said, the search for articulations. The aim is thus to avoid reproducing fragmentary models typical of disciplinary thinking. In the end, transdisciplinarity simultaneously combines multidisciplinarity and interdisciplinarity in order to rise above these forms of thought. From multidisciplinarity, transdisciplinarity has inherited its awareness of different realities. From interdisciplinarity, it has adopted the effort to reinterpret knowledge in order to readjust the different levels of reality. Thus, these three scientific approaches of disciplinarity, multidisciplinarity and interdisciplinarity have contributed to the emergence of transdisciplinarity." (Ramadier 2004, pp. 433–434, italics in the original)

Després et al. 2004

"It has become increasingly evident to many scholars that the historical making and functioning of disciplinary segmentation should not be confused with the common social, spatial, politico-economical [sic] and historical reality to be observed. Indeed, disciplinary segmentation appears as the outcome of the process of knowing about reality which, to operate, needs to reduce it to formal objects, that is, to define analytical dimensions. In other words, it is the outcome of a methodological reduction of reality. The sociology of knowledge and Foucault's archaeology of knowledge remind us that disciplines are the outcome of social and epistemological determinations and that they are socially produced across institutionalisation and 'professionalisation' processes. In this respect, scientific and academic worlds are dealing with the tension between specialisation, on the one hand, and complexity of the reality to be understood, on the other hand.

Interdisciplinarity came forth as the answer to the fragmentation of knowledge into disciplines. The research object being always more complex than its disciplinary representation, researchers then co-construct their research object across several disciplines. Most interdisciplinary research fits the following characteristics: 1) the object construction goes beyond a single disciplinary framework; 2) concepts from various disciplines are combined and partially translated in the research scheme; 3) methods are borrowed from various disciplines; 4) researchers with complementary disciplinary profiles are involved. This being said, on a pragmatic level, the research program might very well be confined within one discipline, or be split between two or more disciplines in almost autonomously sub-research.

What is new then with transdisciplinary? The Latin prefix trans- somehow answers the question. While interdisciplinary research *concerns several disciplines*, transdisciplinary research implies *crossing the boundaries between disciplines*. It defines a mediation space between them. Our own experience of the inter- and transdisciplinarity suggests that the latter activates a mutation process within the disciplines involved, as comprehension of the research problem intensifies. If the research methods are borrowed from multiple disciplines and the disciplinary competencies of team members used to their best advantages, the definition of the research strategy and the on-going interpretation process are truly transdisciplinary. Researchers are looking for convergent interpretative schemes, for shared explanatory models based on concepts and theories that will hold together across multiple disciplinary filters. The mediation space in transdisciplinary research includes the following: 1) definition of complex research objects and problems; 2) definition of epistemological positions; 3) selection of operational concepts; 4) elaboration of the research strategy; 5) combination of research methods; and 6) construction of interpretative theoretical frameworks. On a day-to-day basis, transdisciplinary research requires a different way of conducting research. It namely calls for close and constant collaboration among co-researchers, at all steps of the research program, which translates inevitably into generous mediation time and space. This is undoubtedly easier to realise when geographical distance among co-researchers is not at stake." (Després et al. 2004, pp. 475–476, italics in the original)

▷ *In the* Principles *transdisciplinary research is defined through its reference to and specific analysis of a socially relevant problem. The search for a general perspective beyond all disciplines is not a priority here.*

A2 "Modes of operation" of transdisciplinarity known under other designations

The characteristics that are important in the definitions of transdisciplinarity can also be found in the definitions of types of research that are not called "transdisciplinarity". Listed below are several definitions of research types that are all characterised by their reference to life-world problems, as well as – for some of them – their preference for participatory research and their decision to transcend and integrate disciplinary paradigms.

Integration and implementation sciences

"There are three aspects to Integration and Implementation Sciences. First is that the specialization will aim to find better ways to deal with the defining elements of many current societal issues and problems–namely complexity, uncertainty, change, and imperfection. Second is that there will be three theoretical and methodological pillars for doing this: 1) systems thinking and complexity science, 2) participatory methods, and 3) knowledge management, exchange, and implementation. Third, operationally, Integration and Implementation Sciences will be grounded in practical application and will generally involve large-scale collaboration." (Bammer 2005)

▷ *This definition of Implementation and Integration Sciences emphasises two core challenges also addressed by TR: the need to integrate scientific disciplines and perspectives (see Tool 3, p. 59) and to bring results to fruition (see Chapter 4.4).*

Interdisciplinary problem-solving

"All nations face the challenge of developing and applying effective problem-solving strategies to manage their natural resources for the common interest of their citizens. Strategies that integrate knowledge to improve policy and on-the-ground action are being demanded by many sectors of society. In universities calls for interdisciplinary problem-solving are growing, in natural resources arenas the new emphasis is on comprehensive ecosystem management, and in business the focus is on integrating environmental concerns to modernise operations. Interdisciplinary problem-solving is the means by which knowledge integration can take place." (Clark 1999, p. 393)

▷ *The concept of "interdisciplinary problem-solving" comes from the policy sciences (see below) and describes what policy sciences does. What has been taken over into the* Principles *is the aim of analysing problems in the "common interest", i.e. of focusing on what is perceived to be the common good when working on problems.*

Mode 2 interdisciplinarity (vs. Mode 1 interdisciplinarity)

"*Mode 1 Interdisciplinary Research* brings together researchers from different disciplines in order to overcome a blockage to further development within a discipline, or to enable the discipline to move into new and productive areas of research. In the long run, it furthers the expertise and competence of academic disciplines, for example through developments in methodology and instrumentation, and may even lead to the formation of new disciplines or sub-disciplines. Mode 1 interdisciplinary research is thus one of the primary engines of the evolution of disciplines. Although in this sense, it supports rather than challenges the discipline-based structure of academic and research institutions, in the short-term (e.g. the timescale of an individual project) it can meet resistance from existing academic structures just as much as Mode 2 interdisciplinary research. Overall, the academic barriers to Mode 1 interdisciplinary research are not so strong as for Mode 2 and there are fewer difficulties in evaluating and administering projects.

Mode 2 Interdisciplinary Research addresses issues of social, technical and/or policy relevance where the primary aim is problem-oriented and discipline-related outputs are less central to the project design. The relevant mix of disciplines tends to be project specific. Researchers who develop a career working on such projects build up expertise on the integration of disciplines in a range of contexts and the management of other researchers from different disciplines working together, skills not highly valued in an academic context. Mode 2 interdisciplinary research is thus often regarded as undermining academic research, taking its evolution in a direction with which many academics are uncomfortable and is often seen by discipline based researchers as at best irrelevant and at worst threatening. The barriers to this type of interdisciplinary research are correspondingly greater, as are the difficulties of evaluating and managing it." (Bruce et al. 2004, p. 460, italics in the original)

▷ *Wherever the term "interdisciplinarity" is used in this publication, it refers to Mode 1 Interdisciplinarity.*

La recherche interdisciplinaire finalisée (interdisciplinary research with a purpose)

Hubert and Bonnemaire (2000), whose perspective is discussed in depth in Chapter 4.2.3, describe their approach as "recherche interdisciplinaire finalisée" (interdisciplinary research with a purpose).

"The relevance of research that is carried out will depend on the relevance of the objects of study. Indeed, these objects will have to be approached in their new complexity, since they combine ecological and biophysicochemical processes, the perceptions and practices of those who influence these processes and those who are affected by their impacts, and the knowledge produced by the researchers who set up procedures to study them. The researchers' partners are thus both objects and subjects in these procedures, as they take part in them, formulate and conduct projects on them, and are the main persons concerned by the results achieved. Moreover, in this situation the researchers themselves are stakeholders, given the fact that they intervene." (Hubert and Bonnemaire 2000, p. 7; translation by A. Zimmermann)

Trans-scientific

"Many of the issues which arise in the course of the interaction between science or technology and society – e.g., the deleterious side effects of technology, or the attempts to deal with social problems through the procedures of science – hang on the answers to questions which can be asked of science and yet *which cannot be answered by science*." (Weinberg 1972, p. 209, italics in the original)

For these kinds of questions, Weinberg proposes the term "trans-scientific", because answering them leads beyond science's field of competence and knowledge.

Post-normal science

"Whereas science was previously understood as steadily advancing in the certainty of our knowledge and control of the natural world, now science is seen as coping with many uncertainties in policy issues of risk and the environment. In response, new styles of scientific activity are being developed. The reductionist, analytical worldview which divides systems into ever smaller elements, studied by ever more esoteric specialism, is being replaced by a systemic, synthetic and humanistic approach. The old dichotomies of facts and values, and of knowledge and ignorance, are being transcended. Natural systems are recognised as dynamic and complex; those involving interactions with humanity are 'emergent', including properties of reflection and contradiction. The science appropriate to this new condition will be based on the assumptions of unpredictability, incomplete control, and a plurality of legitimate perspectives." (Funtowicz and Ravetz 1993, p. 739)

"For him [Thomas Kuhn], 'normal science' referred to the unexciting, indeed anti-intellectual routine puzzle solving by which science advances steadily between its conceptual revolutions. In this 'normal' state of science, uncertainties are managed automatically, values are unspoken, and foundational problems unheard of. The post-modern phenomenon can be seen in one sense as a response to the collapse of such 'normality' as the norm for science and culture. As an alternative to post-modernity, we show that a new, enriched awareness of the functions and methods of science is being developed. In this sense, the appropriate science for this epoch is 'post-normal'.

This emerging science fosters a new methodology that helps to guide its development. In this, uncertainty is not banished but is managed, and values are not presupposed but are made explicit. The model for scientific argument is not a formalised deduction but an interactive dialogue. The paradigmatic science is no longer one in which location (in place and time) and process are irrelevant to explanations. The historical dimension, including reflection on humanity's past and future, is becoming an integral part of scientific characterisation of Nature." (Funtowicz and Ravetz 1993, p. 740)

▷ *In the* Principles, *the aspects of post-normal science described above are reflected in the uncertainty and strong commitment that characterise the starting point for transdisciplinary research (see Chapter 3.1).*

Sustainability science

"A new field of sustainability science is emerging 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. The regional character of much of what sustainability science is trying to explain means that relevant research will have to integrate the effects of key processes across the full range of scales from local to global. It will also require fundamental advances in our ability to address such issues as the behaviour of complex self-organising systems as well as the responses, some irreversible, of the nature–society system to multiple and interacting stresses. Combining different ways of knowing and learning will permit different social actors to work in concert, even with much uncertainty and limited information. [...]

The sustainability science that is necessary to address these questions differs to a considerable degree in structure, methods, and content from science as we know it. In particular, sustainability science will need to do the following: (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) recognise the wide range of outlooks regarding what makes knowledge usable within both science and society. Pertinent actions are not ordered linearly in the familiar sequence of scientific inquiry, where action lies outside the research domain. In areas like climate change, scientific exploration and practical application must occur simultaneously. They tend to influence and become entangled with each other.

In each phase of sustainability science research, novel schemes and techniques have to be used, extended, or invented. These include observational methods that blend remote sensing with fieldwork in conceptually rigorous ways, integrated place-based models that are based on semiqualitative representations of entire classes of dynamic behaviour, and inverse approaches that start from outcomes to be avoided and work backwards to identify relatively safe corridors for a sustainability transition. New methodological approaches for decisions under a wide range of uncertainties in natural and socioeconomic systems are becoming available and need to be more widely exploited, as does the systematic use of networks for the utilisation of expertise and the promotion of social learning. Finally, in a world put at risk by the unintended consequences of scientific progress, participatory procedures involving scientists, stakeholders, advocates, active citizens, and users of knowledge are critically needed." (Kates et al. 2001, p. 641)

"Kates et al. list four methodological challenges: (i) spanning the range of spatial scales; (ii) accounting for temporal inertia and urgency; (iii) dealing with functional complexity and multiple stresses on human and environmental systems; and (iv) recognising the wide range of outlooks. We would expand this list of challenges to include (v) linking themes and issues (e.g., poverty, ecosystem functions, and climate); (vi) understanding and reflecting deep uncertainty; (vii) accounting for human choice and behaviour; (viii) incorporating surprise, critical thresholds, and abrupt change; (ix) effectively combining qualitative and quantitative analysis; and (x) linking with policy development and action through stakeholder participation." (Swart et al. 2002, p. 1994)

Mode 2 knowledge production

"Mode 1: The complex of ideas, methods, values and norms that has grown up to control the diffusion of the Newtonian model of science to more and more fields of enquiry and ensure its compliance with what is considered sound scientific practice.

Mode 2: Knowledge production carried out in the *context of application* and marked by its: *transdisciplinarity*; *heterogeneity*; organisational heterarchy and transience; social accountability and *reflexivity*; and quality control which emphasises context- and use-dependence. Results from the parallel expansion of knowledge producers and users in society." (Gibbons et al. 1994, p. 167; italics in the original)

Policy sciences

"The *policy sciences* consist of a set of integrated concepts or conceptual tools for framing thought and action and for guiding analysis, interpretation, and resolution of any problem (Lasswell 1968). The *sciences* part of the term refers to systematic, empirical inquiry. The concepts focus our attention on three key questions that can be asked about any policy, proposal, or initiative (Brunner, personal communication): Is it rational? Is it politically practical? Is it morally justified? This framework suggests additional important questions: From whose standpoint is the policy problem best understood? What methods are required to understand the problem? How should answers to these questions be integrated with ongoing practices? These interrelated questions should be asked and addressed in every management and policy case." (Clark 2002, p. 4, italics in the original)

"There are many misconceptions about the term *policy* in natural resource fields. It is sometimes thought to be synonymous with politics; terms such as biopolitics embody this view. It is also common to hear resource professionals talk about science versus politics, with the implication that politics is bad and science is good and that if we had more science and less politics life would somehow be better. Another misconception is to equate policy with a plan, mission, goal or law. Hogwoos and Gunn (1986, 13–19) distinguish ten ways in which the term policy is commonly used, all of which can be observed in any newspaper over the course of a few weeks: (1) a field of study, such as wildlife policy, (2) an expression of general purpose or desired state of affairs, as in 'we shall endeavour to restore endangered species,' (3) a specific proposal such as 'we shall establish ten populations,' (4) a decision of government, including specific, on-the-ground management decisions, (5) formal authorisation, such as the Endangered Species Act, (6) a program, as in 'our policy is to set up public-private partnerships,' (7) output, or what government delivers, (8), outcome, or what is actually achieved, (9) a theory or model, such as 'assumptions about cause and effect relationships' about a problem and how it should be solved, and (10) a process, as of complexities unfolding over time.

Care should be taken in using the term. *Policy*, as used in this book and following Lasswell and McDougal (1992), is a social process of authoritative decision making by which the members of a community clarify and secure their common interests. In other words, the people who interact in a community share expectations about who has the authority to make decisions about what, when and how. According to Brunner (1996a, p. 46), ultimate authority in society to make policy rests 'in perspectives of living members of the community – their identifications, demands and expectations – which, like other factors in social process, are amenable to empirical inquiry.' The policy sciences can help professionals conduct this vital 'empirical inquiry' into people's perspectives, interactions, and outcomes of decision-making processes." (Clark 2002, p. 6, italics in original)

Policy analytic activities

"Policy analysis has been defined in different ways. Common core elements shared by most authors in the field are [...]:

- policy analysis is a purposeful and systematic activity that can be delimited with respect to the subject matter and time;
- the objective of policy analysis is to assist those responsible for making changes;

- the emphasis in policy analysis is on the collection, interpretation and communication of information that is of relevance to a policy issue;
- policy analysis is a decision, action, or policy oriented activity, which seeks to enlighten policy discussions;
- the policy issues considered typically involve multiple interests, a variety of often conflicting objectives, and uncertainty." (Thissen and Twaalfhoven 2001, p. 628)

A3 Participants in the peer review process

The following experts reviewed the preliminary version of the *Principles for Designing Transdisciplinary Research* (see Pohl 2004); their feedback was essential for the present version.

Bestvater, Hanne, Bern
Brand, Karl-Werner, Munich
Grossenbacher-Mansuy, Walter, Bern
Guggenheim, Michael, Zurich
Hoffmann-Riem, Holger, Zurich
Hofmänner, Alexandra, Cape Town
Kaufmann-Hayoz, Ruth, Bern
Kissling-Näf, Ingrid, Bern
Küffer, Christoph, Zurich
Loibl, Marie Céline, Vienna
Nölting, Benjamin, Berlin
Perrig-Chiello, Pasqualina, Bern
Scheringer, Martin, Zurich
Schlachter Willy, Brugg
Späth, Philipp, Graz
Valsangiacomo, Antonio, Bern
Voss, Jan-Peter, Berlin

Various drafts of the *Principles* were also presented to the following bodies, groups and events; the ensuing discussions made it possible to further develop this publication.

- Working group on ”Environmental Research” (Arbeitsgruppe ”Umweltforschung”) of the Federal Office for the Environment, Bern
- td-net Scientific Advisory Board, Bern
- Advisory Commission for Environmental Research (Beratende Kommission für Umweltforschung, BKUF) of the Federal Office for the Environment, Bern
- Institute for Human-Environment Systems (Prof. R.W. Scholz, ETH Zurich)
- Annual Symposium of the German Society for Human Ecology (DGH) and the Swiss Academic Society for Environmental Research and Ecology (SAGUF) in 2005, Sommerhausen
- Swiss National Centre of Competence in Research (NCCR) North-South, Bern

Notes

1 See for example (Epton et al. 1983, Klein 1990, Klein 1996, Defila and Di Giulio 1999, Loibl 2001, Mogalle 2001, Röbbecke and Simon 2001, Hollaender et al. 2002, Bergmann 2003, Boix Mansilla and Gardner 2003, Bruce et al. 2004, Schophaus et al. 2004, Loibl 2005, Stokols et al. 2005, National Academy of Sciences 2005, Bergmann et al. 2005, Moll and Zander 2006, and Defila, Di Giulio and Scheuermann 2006)

2 (Pohl 2004)

3 According to Rolf (1999), "Lebenswelt" or "life-world" refers to the human world prior to scientific knowledge. While philosophy (led by Edmund Husserl who coined the term) uses this concept within the framework of both phenomenology and constructivism as a possibility of critiquing and explaining science, Schütz's interpretive sociology links "life-world" with the concept of the everyday world as a system of meaning: "Life-world", for him, describes the structural properties of social reality as grasped by the agent. We use the term "life-world" to mark the difference, within society, between the scientific and other communities (the private sector, public agencies, civil society). It was Mittelstrass (1992) who introduced the term "life-world" into the definition of transdisciplinarity (see Annex A1).

4 In the present publication, the term "paradigm" is broadly defined according to Kuhn (1996) and is understood as comprising a disciplinary language, a worldview, values, exemplary problem-solving, forms of communication, and institutional structures. A scientific community – a discipline or special field – is characterised by its paradigm.

5 Participatory research goes beyond doing research on actors, and implies that actors can help shape the research process (cf. "la recherche interdisciplinaire finalisée", Annex A2)

6 We use the term "actor" for persons and institutions in public agencies, the private sector and civil society who are involved in one way or another in a problem field. Their relation to the problem field is the reason why transdisciplinary researchers work with them.

7 We use the term "public agencies" to refer to public institutions from the local to the global level, i.e. the inter- and transnational level.

8 The term "science" is used with a very broad meaning in this publication: it refers to scientific communities, activities and institutions of all kinds, and includes the social sciences, natural sciences, humanities, engineering sciences, health sciences etc.

9 When we refer to empirical questions, we also use the term "systems knowledge", as it underlines that there is a need for knowledge regarding complex relations between empirical aspects. Knowledge generation of this kind can involve description of empirical evidence, quantitative modelling of complexity, theoretical elucidation of relations, and hermeneutic interpretation of empirical facts. Practice-oriented questions cover the goals and means of action. They thus also comprise "target knowledge" and "transformation knowledge" (see Chapter 3.3).

10 We use the term "problem field" for an area in which the need for knowledge related to empirical and practice-oriented questions arises within society due to an uncertain knowledge base and diffuse as well as controversial perceptions of problems. Funtowicz and Ravetz (1993, p. 744), who introduced the concept of "post-normal science" (see Annex A2), use the term "issues" when dealing with problem fields relevant to values in society. By contrast, we use the term "problem" for concrete, identified and structured questions within problem fields. These cannot be considered as given. Rather, in view of the initial random array of difficulties, it is important in the first phase of TR to determine what concrete problems there are and what they consist of. Research questions then specify these problems in such a way that they can be investigated and hopefully answered. Depending on the context we speak either of "problems" or of "research questions".

11 Within this context, Funtowicz and Ravetz (1993, pp. 741 ff.) speak also of the "reinvasion of the laboratory by nature". Gibbons et al. (1994) refer to this as the production of knowledge in the context of application, which they describe as "Mode 2" knowledge production and contrast with disciplinary or "Mode 1" knowledge production (see also Annex A2).

12 The notion of the common good or common interest has not yet really entered the debate on transdisciplinarity. Kötter and Balsiger characterised TR in relation to "public goods" in 1999: "... the concept of transdisciplinary research should be reserved for a special kind of interdisciplinary research, which is oriented to the solving of problems growing from our treatment of public goods" (Kötter and Balsiger 1999, p. 117). A public good such as fresh air is conceived

of in economics as a good that is non-rival and non-excludable. This means that consumption of the good by one individual does not reduce the amount of the good available for consumption by others and that it is not possible to exclude individuals from consumption of the good. The common good as an ethical principle, however, refers to having the social systems, institutions, and environments on which we all depend work for the well-being of all people. In the policy sciences (see Annex A2) Clark refers to what he calls the "concept of common interest". "*Common Interests* are those that are widely shared within a community and demanded on behalf of the whole community". (Clark 2002, p. 13, italics in the original.) It is often tacitly assumed that applied research serves the common good.

13 Regarding requirement a), see also Wynne (1992), Koontz and Moore Johnson (2004, p. 188), and Nölting et al. (2004, pp. 255 & 258). For requirements c) and d), see Arias et al. (2000, p. 90), and Nölting et al. (2004, pp. 255 & 259). Quinlan and Scogings (2004, pp. 540 ff.) also mention that participation in "social anthropology" first served the purpose of increasing reflexivity (see also note 79).

14 It is Costanza (2003, p. 654) who refers to the importance of collaboration between the analytical and the creative disciplines. Baccini and Oswald (1998) offer an example of such collaboration (see also Example 5).

15 (Bagamoyo College of Arts et al. 2002)

16 See for example German Advisory Council on Global Change (1997, pp. 106 ff.), Schellnhuber et al. (1997), Petschel-Held et al. (1999a), Petschel-Held et al. (1999b), Schellnhuber (1999), Petschel-Held (2003), and Lüdeke et al. (2004).

17 What we refer to as a "regulative idea", following Van den Daele (1993), is a guiding principle. Sustainable development is such a regulative idea (Minsch et al. 1998, pp. 18ff.) referring to a way of living together in society that can give an orientation to society's debates about institutions and practices. Van den Daele explains the use of ecological concepts as regulative ideas in the following way:

"Concepts such as 'ecological stability', 'balance of nature' and 'functionality of the natural system' may not be criteria that make direct measurement of the environmental impact of interventions possible. But they define the framework of problems within which all environmental impact assessments must situate themselves. The danger that human interventions may put too great a strain on the capacity of ecological relations, leading to drastic reorganisation – and perhaps even the collapse – of entire systems, is the core of our environmental problems. We do not decide whether a threat 'truly' exists as long as we have to 'prudently' define it as real. Since the conditions for ecological stability cannot be conclusively defined, it remains open whether current environmental norms allow us to keep a sufficiently secure distance from those unknown borders that we must cross under no circumstances. Ecological stability, though hard to define, is a good that is fundamentally worth protecting. It is not an operational standard but a regulative idea, a normative prong that keeps discussions about appropriate environmental norms going and gives them a course to follow." (Van den Daele 1993, p. 227; translation by A. Zimmermann)

[18] See also Brand (2000, p. 21).

[19] In the draft version of the present publication (Pohl 2004), the focus on the common good was not elucidated. This may be the reason why the only fundamental controversy that arose during the review process was triggered by this point. For some, the focus on the common good is the link that was missing until now in the definition of TR, as it underlines the need to refer to a normative principle when addressing practice-oriented problem-solving with actors. But for social scientists in particular, the normative requirement to focus on the common good should definitely be taken out of the definition of TR: They argue that common good issues are not a particularity of TR alone, that it is not clear what the common good means, that this in turn only opens a new, difficult field in the debate, and that normative decisions are not part of science's responsibilities. By explaining the focus on the common good in greater detail in this publication, we have tried to do justice to this valid criticism.

We would like to thank Jan-Peter Voss for providing a series of definitions of the common good. The Rowohlt handbook of political studies (Shell 1985) offers a pluralist understanding of the concept:

1. "The concept of the common good can mean that all members of an organised society actually share the same values and goals. However, this empirically identifiable state has never been attained yet, as there are always deviant or opponent groups in a society (e.g. pacifists or war opponents in times of war). However, if the 'common good' is defined as the 'interest of the majority', it is necessary to ask whether the principle can be binding for those who do not share the majority's understanding of what constitutes this 'good'.
2. The 'reasonable' common good. This definition is not tied to the empirically identifiable consent of a society's members. Instead, it postulates that an objectively verifiable good exists. But in the case of a conflict between groups or individuals who believe that they have the only correct understanding of what is reasonable – and this case is the norm in political debates – an objective, impartial judge will always be lacking.

3. The 'moral' common good is closely related to the 'reasonable' common good. It presupposes an overall binding value system. The interests of individuals and groups who do not follow it are denigrated as 'immoral' and not compatible with the common good.
4. The 'common good' as a balance of interests. The concept in this case is not defined in terms of content. Instead, it is equated with the process of reaching a balance (which presupposes and promotes stability) and with the results that emerge in each case. Stability of the system becomes the highest value; and equating the results of a compromise that is often obviously dysfunctional runs counter to the definition of the common good as a 'reasonable' (appropriate) solution." (Shell 1985; translation by A. Zimmermann)

The *Principles for Designing Transdisciplinary Research* do not claim that TR is the only form of research that focuses on the common good. Rather, they underline that one of the tasks of TR is to deal explicitly with the common good as part of the research process.

[20] "However, it would be wrong to assume that users will automatically have a better understanding than academics of the 'real world' nature of problems. On the contrary, user communities might have only a partial understanding of what their problem is and, in certain cases, might compromise the quality of the research and even lead it in unproductive directions. Though user involvement was seen by some as an alternative to social science inputs in technical research and development projects, the latter offered tools and concepts not necessarily possessed by users. Interactions with stakeholders can be problematic and a clear plan for stakeholder and user engagement is needed given the different exigencies and concerns of stakeholders and researchers." (Bruce et al. 2004, p. 466)

[21] The importance of clarifying roles is underlined by Bruce et al. (2004, p. 466), de Wit (2004, pp. 37 ff.), Nölting et al. (2004, p. 257), Quinlan and Scogings (2004), and Schophaus et al. (2004, pp. 72 and 165). A role comprises not only responsibility for content but also a specific (hierarchic) position. Nölting et al. (2004, p. 257) therefore differentiate between the roles of the "observer", "moderator" and "idea giver", while Schophaus et al. (2004, p. 175) list "the scientist, the author, the co-practitioners' counsellor, the complaint box for colleagues, the busy bee, the coordinator, the proof-reader, the networker, the telephone expert, the reader, the endless complainer, the indefatigable motivator, etc." as possible roles. Moreover, Loibl (2005, p. 109) mentions that the same person may play different roles with different hierarchic positions in the same project. Quinlan and Scogings (2004, p. 541) insist on how important –

and at the same time difficult – it is to always clearly distinguish between the roles of "researcher, facilitator, advocate and activist".

[22] Concrete research projects can be a mixture of the different forms of research, as ideal types are constructs that insist on specific analytical differences and structures. Max Weber (1949 [1904], in particular pp. 89–95) introduced the concept of ideal types in order to show what was particular to social science theories in contrast to laws in the natural sciences. "An ideal type is formed by the *one-sided accentuation* of one or *more* points of view and by the synthesis of a great many diffuse, discrete, more or less present and occasionally absent concrete *individual* phenomena, which are arranged according to those one-sidedly emphasised viewpoints into a unified analytical construct (*Gedanken*-bild). In its conceptual purity, this mental construct (Gedankenbild) cannot be found empirically anywhere in reality. It is a *utopia*." (Weber 1949 [1904], p. 90, italics in the original.) The concept of the ideal type is expounded in Hirsch Hadorn (1997).

[23] In this publication, we use the terms "discipline" and "special field" as synonyms (see note 4).

[24] The differentiation between various "policy cultures" is taken from the literature on science studies. Nowotny and her colleagues implicitly refer to it when they write about changes in the scientific community's relation to politics, the market and culture (Nowotny et al. 2001, pp. 21 ff.). Elzinga (1996) analyses the "orchestration of the global climate change research" as a power play between four "policy cultures": the "scientific", "bureaucratic", "economic" and "civic" policy cultures. Jasanoff and Wynne (1998, p. 17) further develop this idea by presenting the four "policy cultures" as a complex system of interdependencies. Our understanding of governmental policy culture includes inter- and transnational organisations.

[25] We use the term interdisciplinarity in the sense of the definition of Mode 1 interdisciplinarity (see Bruce et al. 2004, p. 460; see also Annex A2). What inspires collaboration of this kind between disciplines is the potential for scientific innovation that emerges when existing disciplinary viewpoints are combined. Sometimes, "interdisciplinarity" is also used in transdisciplinary contexts, but with a different meaning (see Annex A2).

[26] See also "post-normal science" (Annex A2). What we term "interests" are referred to there as "decision stakes". "By 'decision stakes' we understand all the various costs, benefits, and value commitments that are involved in the issue through the various stakeholders." (Funtowicz and Ravetz 1993, p. 744)

[27] Bruce et al. note: "Disciplines have survived for so long in the academic world because they serve the very useful function of constraining what the researcher has to think about. They set a boundary on the parameters of interest (what to include and what to leave out) and dictate the range of methodological approaches that are relevant. They thus provide a clearly defined starting point for a research project but they also pre-determine to a large extent what the outcomes of the research will be. If this framework is removed (...) in-experienced researchers can be overwhelmed by complexity." (Bruce et al. 2004, p. 467)

[28] In the *Visions of Swiss Researchers*, "systems knowledge" is introduced as knowledge of the current status, "target knowledge" is knowledge about a target status, and "transformation knowledge" is knowledge about how to make the transition from the current to the target status (ProClim 1997). As this formulation can be misinterpreted and given a technocratic bias, we describe the contents differently (see Table 1). There are different ways of distinguishing between the three forms of knowledge, especially in relation to TR on sustainable development (Deppert 1998, p. 36, Becker et al. 1999, pp. 1–20, Becker and Jahn 2000, p. 79, Brand 2000, pp. 19–21, Burger and Kamber 2003, p. 52, Nölting et al. 2004, p. 254). Jantsch makes a similar distinction when he describes the "empirical level", the "normative level" and the "pragmatic level". He also mentions the "purposive level", which is at the overall level of the "science/innovation/education" system (Jantsch 1972, see Annex A1). Similar groups of questions can be found in Costanza (1997, p. 79) and Grunwald (2004).

[29] See also Sarewitz (2004).

[30] See Brand (2000, pp. 20–21), and Brand (2005, in particular pp. 152–158).

[31] Routines of practice, regulations, technologies and power relations exist and develop in a very close relationship to one another, rather than independently (see e.g. Hughes 1986, Callon et al. 1992, Callon 1995, Hughes 1998, and Oudshoorn and Pinch 2003).

[32] See for example studies on the eco-labelling of hydropower (e.g. Truffer et al. 2003).

[33] The term used in the German original of the present publication is "eierlegende Wollmichsau" (literally an "egg-laying, wool-bearing dairy sow") – i.e. an impossible but highly desirable animal in agricultural production. The "eierlegende Wollmichsau" was a central metaphor both at the inaugural conference on socio-ecological research in Berlin, 2002, and at the conference on the future of collaborative research ("Zukunft der Verbundforschung") of the

German Society for Human Ecology in Sommerhausen in 2003. In an analysis of experience garnered by the Swiss Priority Programme Environment, Defila und Di Giulio (1996) describe this multiplicity of requirements and explore its significance in research projects.

34 According to Mogalle, "the way in which transdisciplinary production of knowledge is organised can typically be divided into three modules (...): 1) problem identification, 2) problem analysis, 3) application" (2001, p. 305; translation by A. Zimmermann). Bergmann (2003) also divides a questionnaire for the evaluation of transdisciplinary projects into three parts revealing a similar logic. In a more recent publication on evaluation criteria for transdisciplinary research (Bergmann et al. 2005), he and his colleagues present the "organization of the criteria" in the following manner: "The Basic Criteria and the Detailed Criteria are organized in three sections that follow a project chronology (A: Project Formulation and Construction – B: Project Execution – C: Project Results). In the course of project analyses, it was noted that the logic of project chronology eases access to the complex matter and interdependencies of a transdisciplinary research project, and makes the evaluation transparent for all participants because the process of developing the research project can be understood, and causes and effects recognized. This chronological approach is therefore recommended, especially for a more precise project evaluation." (Bergmann et al. 2005, p. 22) Röbbecke and Simon also suggest such a tripartite division of evaluation criteria in a comment on how to evaluate the institutes of the German umbrella organization Wissensgemeinschaft Gottfried Wilhelm Leibniz (WGL), which cover "a wide spectrum of tasks from basic research to application-oriented research and services" (Röbbecke and Simon 2001, p. 45): "In each case, we need to differentiate between three categories of descriptors that relate to the input, output and throughput of a research organization. The term 'input' refers to all of the external influences and prerequisites that are needed for the process of producing results, while the results of this process are called 'output'. The third category, referred to as 'throughput', is less common: it consists of the processes and structures that support the transformation of the input into the desired output" (Röbbecke and Simon 2001, p. 65; translation by A. Zimmermann). Finally, Thissen and Twaalhofen quote a similar subdivision for policy analysis: "*The input mode* considers the people involved and the wide variety of material that enter the study, e.g., data, assumptions, models, mathematical procedures, and professional specialists on the analysis teams. *The output mode* focuses on the results of the activity and how they relate to reality and to the process of

analysis. Furthermore, the focus of this mode is on the prescriptions emerging from the results and, if implemented, possibly on the eventual outcomes. In the third mode, *the process mode*, various process related aspects are considered including the appropriateness of all steps taken in carrying out the activity, the basis on which they were chosen, and the effectiveness of communicating the process and the material entering to the actors involved." (Miser and Quade 1988, quoted by Thissen and Twaalfhoven 2001, p. 631, italics in the original)

35 Scheringer et al. (2005) have reflected on this issue in the case of environmental research.

36 "The expertise [of non-scientific actors] is particularly important in the initial phase of formulating the research questions. Listen to their contributions with greatest attention and take up expert opinions from practitioners in an adequate way when you conceive your project." (Loibl 2001, p. 10; translation by A. Zimmermann.) Similar advice can be found in Häberli and Grossenbacher-Mansuy (1998, p. 200), Defila and Di Giulio (1999, pp. 18–21), Mogalle (2001, p. 307), Kruse (2003, p. 97), and Luhmann and Langrock (2003, pp. 46–47).

37 See for example Funtowicz (1998, p. 104): "The objective of scientific endeavour in this new context may well be to enhance the process of the social resolution of the problem, including participation and mutual learning among stakeholders, rather than a definitive 'solution' or technological implementation. This is an important change in the relation between the problem identification and the prospects of science-based solutions." In their analysis of political reactions to the greenhouse effect, Pohl and Gisler (2003, pp. 178–179) show how specific views of a problem make particular solutions seem the most adequate.

38 (Després et al. 2004)

39 We have borrowed the term from Clark (2002, p. 32). To date, we have found no standardised procedure for this, only checklists with questions such as the ones quoted below, which – although they structure the procedure in the sense of heuristic tools – leave the procedure open with regard to methodological aspects:

- "*Trend description:* To what extent have past events approximated the preferred goals? What discrepancies exist between goals and trends? What problems hinder achievement of the goals?
- *Analysis of conditions:* What factors or conditions have affected or caused the direction and magnitude of the trends described? How do these contribute to the problem?

- *Projection of developments:* If current policies are continued, what are the probable future trends with regard to goal realisations and discrepancies? How will these affect the problem?
- *Invention, evaluation, and selection of alternatives:* What other policies or practices might achieve the goals and solve the problems? How should these be evaluated with regard to past trends, conditioning factors, and projected trends?" (Clark 1999, p. 400, italics in the original.) Eck (2003) offers an example from criminalistics.

[40] Regarding this aspect, see the heuristics of options and restrictions (Hirsch Hadorn et al. 2002). For the difference between structuring the problem from the perspective of actors and structuring it from the perspective of the dynamics of a natural system, see also Hirsch Hadorn (1995). In this context, Pinson (2004, p. 511) distinguishes between "knowledge as an object" and "knowledge as a project".

[41] (Hubert and Bonnemaire 2000)

[42] Hubert and Bonnemaire (2000) call this the "objet de recherche Niveau 1" (i.e., Level 1 research object).

[43] Hubert and Bonnemaire (2000) present a counter-example of disciplinary problem-solving that does not take practice into account: In this example, tables listing nutrient contents are distributed to livestock producers, who are asked to determine the nutrient content of various bushes on their own and manage pasturing activities accordingly.

[44] (Baccini and Oswald 1998, Oswald and Baccini 2003)

[45] The German-language literature on TR characterises the phase of problem analysis in this manner; see for example Häberli and Grossenbacher-Mansuy (1998, pp. 200–201), Jaeger and Scheringer (1998), Defila and Di Giulio (1999), Mogalle (2001, pp. 309–313), and Bergmann (2003, p. 70).

[46] See also Rossini and Porter (1979). In the debate within TR, they were taken up by Krott (1996), and Defila and Di Gulio (2001, pp. 344–346).

[47] In TR, persons from the life-world are also considered as "specialists of everyday life" ("spécialistes du quotidien") (Després et al. 2004, p. 474).

[48] According to Chubin et al. (1979), integration based on "common group learning" was preferred by most groups.

[49] There is an example of such a negotiation in the literature from the USA (see Policansky 1999); negotiation in this case involved only scientific experts.

[50] See also Arias et al. (2000).

[51] See also Gough et al. (1998), Toth and Hizsnyki (1998), and Toth and Mwandosya (2001).

[52] We thank Michael Stauffacher, long-standing co-director of ETH-NSSI Case Studies, for having provided this text.

[53] See for example Scholz et al. (1995 and 2004).

[54] (Scholz, Mieg and Oswald 2000)

[55] See also Scholz (2000).

[56] (Scholz and Stauffacher 2001)

[57] (Scholz and Marks 2001)

[58] (Scholz and Tietje 2002)

[59] See also Stauffacher and Scholz (2004).

[60] This characterisation follows Pohl (2001), who characterises the different hierarchical relationships between the disciplines in transdisciplinary projects as "master–slave", "deadlock", "give-and-take" and "new commonality".

[61] Regarding this aspect, see also the reflections on the categories in Mathieu et al. (1997, pp. 26–28).

[62] Regarding this aspect, see in particular Giri (2002), Costanza (2003), and Loibl (2005). To point out what depth of insight participants need to acquire into the relativity of their own position, Giri refers to the philosopher R. Sunder Rajan: "For Sunder Rajan, 'each perspective or point of view is such only as a member of a community of points of view; this is a community and not a collection, for each perspective, from within its own resources, refers to the possibility of others' (...). The problem with modern disciplinary thinking is that it fails to realise that its claim to universality needs to be relativised by recognising the significance of other disciplines in gaining multiple perspectives about the world to which both one's as well as another's discipline contribute. In this context, for Sunder Rajan, 'each discipline must shed an illusory universality to gain a perspectival universality' (...) The task here is to realise that 'the possibility of other perspectives is not merely a contingent or incidental feature but is essential to the very form of a perspective; a perspective is because it is one among others' (...). Sunder Rajan calls this 'interperspectivity.' The calling for transdisciplinarity requires a practice of interperspectivity." (Giri 2002, pp. 105–106) In this sense, insight into interperspectivity is the first step that needs to be taken on the path of transdisciplinarity.

[63] For Giri, transdisciplinarity is therefore located within the network of relations that is created between the perspectives in the course of TR: "In transdisciplinary striving, relationship rather than our separate disciplinary Being is the ground of our identity." (Giri 2002, p. 106) For Loibl, "a central task for the members of a transdisciplinary research team is therefore to understand the team as an alliance of persons belonging to different systems with different

histories, whose task is to confront one another with the aim of analysing the different logics of decision-making and different rules of the game, rather than to encounter one another in a superficial manner." (Loibl 2005, p. 34; translation by A. Zimmermann; see also pp. 138–146)

64 Within the sciences, such overlapping positions can be found for example in quantitative descriptive research and qualitative interpretative research. A few years ago, the so-called "science wars" illustrated mutual incomprehension between both sides in an impressive manner. Rayner and Malone (1998) in particular point out the lack of such understanding and collaboration in climate research. In economics, Harriss (2002) requires that the predominantly quantitative perspective be more open to qualitative contributions, while Elkana (1978) suggests that both positions be taken up at the same time ("two-tier thinking").

65 The concept of the "paradigm" (see Note 4) was first developed to explain the evolution of disciplines in the natural sciences (Kuhn 1996), but it is used much more broadly today in all areas of knowledge. The concept of "thought styles" originally came from Fleck and is used primarily, but not exclusively, for scientific groups (Fleck 1979, Cohen and Schnelle 1986). See Egloff (2005, especially pp. 57–90) for examples of the use of the concept of "thought styles" in science and consulting. The use of the ethnological concepts of (academic) "tribes" and "cultures" when referring to science and the production of knowledge can be found in Knorr Cetina (1981), Becher (1989), Galison (1997), and Knorr Cetina (1999). The definition of collaboration between actors in science and society as an exercise in understanding between social worlds comes from Star and Griesemer (1989). The division of society into self-organising social sub-systems comes from Luhmann (see for example Luhmann 1997). In his anthropology of knowledge, Elkana (1986, pp. 46–52) uses a matrix of analysis with which a differentiation and classification of different "images of knowledge" can be made. When applying this matrix approach, the following questions are asked: what sources of knowledge are used in each case? What hierarchies exist between sources of knowledge? Who are the holders and recipients of knowledge? How stable does knowledge remain over time? Where can it be located on the scale ranging from "sacred" to "secular"? How conscious is it? How strongly does it depend on norms, values and ideologies? And how effectively can it be translated in statements about nature?

66 See in particular Luhmann (1990). Brand (2005) offers a compilation of various sociological theories and their significance for communication in the field of sustainable development.

[67] (Nagel 1986)

[68] See Gieryn (1995) regarding the concepts of "boundary work" and "cognitive authority". See Klein (1996, pp. 57–84) for the significance of these concepts for collaboration between disciplines.

[69] Regarding this aspect, Loibl remarks: "The practice-oriented projects tended to deal in a rather pluralistic way with the theoretical backgrounds and value systems of the disciplines involved, and were in agreement on integrating results on the basis of priority criteria that primarily take into account the capacity to connect with contexts of application and partners' scope for manoeuvre." (2005, p. 29; translation by A. Zimmermann) In this context, Ezrahi also speaks of "eclectic pluralism", which he believes is a phenomenon typical of our times: "Toward the latter decades of the twentieth century, it is incoherence and inconsistency instead which indicate the absence of large-scale arbitrary action. In a society deeply affected by ethical relativism and cognitive scepticism, coherence tends to stand for pretence, untenable claims of knowledge and authority, and the unacceptable exercise of power. Incoherence, by contrast, seems to indicate humility, a refusal to suppress subjectivity and diversity, the toleration of numerous notions of purpose, causation, and reality. In a society in which the incoherence or the inconsistency of public actions indicates the desirable absence of a directing mind or a guiding hand, where the shape of the public realm is more like an eclectic pile of discrete structures than a unified comprehensive structure, coherence in public actions would tend to suggest numerous invasions of freedom. As a feature of public actions and policies, eclectic pluralism is therefore more compatible with contemporary liberal-democratic sensibilities than coherent pluralism; it indicates the existence of freedom from the domination of any particular idea, logic, or agency in the sphere of political action. It is one of the main features of the post-modern condition that grand narratives, the collective superstories which provide a sense of direction and meaning to history and society, lose their credibility and legitimating power." (Ezrahi 1990, p. 284, quoted by Wachelder 2003, p. 265)

[70] See for example Mathieu et al. (1997, pp. 22 & 28–29), and Loibl (2005, pp. 28–30).

[71] "Boundary objects are objects which are both plastic enough to adapt to local needs and the constraints of the several parties employing them, yet robust enough to maintain a common identity across sites. They are weakly structured in common use, and become strongly structured in individual-site use. These objects may be abstract or concrete. They have different meanings in different

social worlds but their structure is common enough to more than one world to make them recognisable, a means of translation." (Star and Griesemer 1989, p. 393) Star and Griesemer developed this concept while explaining the founding of a museum. The concept of the "boundary object" was meant to counter the "myth of consensus", which is based on the assumption that community efforts always rely on consensus among those involved.

72 (Nicolini 2001)

73 For an example of such harmonisation between psychological research and the method of life cycle assessment, see for example Hirsch Hadorn et al. (2002, in particular pp. 53–102 and 103–157).

74 (Hughes 1987, pp. 76–80)

75 Després et al. describe such a process – in this case between researchers from different disciplines – in the following way: "If the research methods are borrowed from multiple disciplines and the disciplinary competencies of team members used to their best advantages, the definition of the research strategy and the on-going interpretation process are truly transdisciplinary. Researchers are looking for convergent interpretative schemes, for shared explanatory models based on concepts and theories that will hold together across multiple disciplinary filters." (Després et al. 2004, p. 475)

76 Mathieu et al. (1997, in particular pp. 26–29) offer an example of this: Only after years of collaboration did urban geographers and insect ecologists succeed in formulating what the mutual potential was of collaborating on how to deal with cockroaches. Pohl (2005) also concludes that partners need several years of collaboration to reach a profound understanding of one another's conceptual frameworks.

77 See note 34. Loibl (2005) uses the German term "In-Wert-Setzung", translated in this publication as "bringing results to fruition".

78 In this figure, it would be a hasty conclusion to see science only on the left-hand side of the diagram and social actors only on the right. Both positions can also be found within collaborative research projects. Within the scientific field, it is possible to find C.P. Snow's "two cultures", which became famous in the 1960s: the problem- and solution-oriented nuclear physicist and the contemplative intellectual always ready for a discussion. Pohl (2005) makes a similar distinction between the "engaged problem solver" and the "detached specialist" in his analysis of collaboration between the natural and the social sciences in environmental research.

For Snow (1959), the lack of communication between the two cultures was one of the main reasons why such pressing global problems as poverty were not being addressed. A few years after the publication of his famous "Rede Lecture" (Snow 1959), Snow cast a critical eye on the debate that was triggered by his lecture: He complained that he was mainly being quoted because of "the two cultures": "Before I wrote the lecture I thought of calling it 'The Rich and The Poor,' and I rather wish that I hadn't changed my mind." (Snow 1964, p. 79)

79 The terms "reflexive modernity" and "modernisation" are often used in this context. The concept of reflexive modernisation goes back to Ulrich Beck, who describes it in the following way: "Corresponding to the distinction between modernization of tradition and reflexive modernization of industrial society, two constellations can be differentiated in the relationship of scientific practice and the public sphere: *primary* and *reflexive* scientisation. At first, science is applied to a 'given' world of nature, people and society. In the reflexive phase, the sciences are confronted with their own products, defects, and secondary problems, that is to say, they encounter *a second creation in civilization.* The developmental logic of the first phase relies on a *truncated* scientisation, in which the claims of scientific rationality to knowledge and enlightenment are still spared from the application of scientific scepticism to themselves. The second phase is based on a *complete* scientisation, which also extends scientific scepticism to the inherent foundations and external consequences of science itself. In that way both its claim to truth and *its claim to enlightenment are demystified*. The transition from one constellation to another takes place within the *continuity* of scientisation, but precisely because of that, changed internal and external relationships of scientific work come into being." (Beck 1992, p. 155, italics in the original.) Beck's statement contains two aspects of reflexivity: first, reflexivity in the sense of applying a specific way of observing and acting to itself – in this case the scientific way to science. In the social sciences, reflexivity is often understood in this manner (Wynne 1993, p. 323, Nowotny et al. 2001, pp. 43–47). Second, Beck's definition also contains a critical analysis of the impact of the use of a specific way of observing and acting. Wynne extends the explanation of this type of reflexivity within the context of the "public understanding of science": "By reflexivity in this context I mean the process of identifying, and critically examining (and thus rendering open to change), the basic, preanalytic assumptions that frame knowledge-commitments. (...) My interest is (...) to ask how public institutions like science act (or do not act) as systems for reflexive learning in the sense of understanding their own precommitments, so that these can be negotiated, rather than blindly imposed on society at large or different publics within it." (Wynne 1993, p. 324.) In the present publication, reflexivity is used in this second way:

It implies a critical assessment of the assumptions and models with which TR approaches a problem, as well as an observation of the expected and unexpected impacts of solutions proposed by TR, and the resulting adjustments that are made. Hubert and Bonnemaire underline that this should not be understood as the task of science alone: "This approach to 'reflexive modernity' invites us to deal with these issues by learning to be reflexive together, that is the people who pose the problems, those who are implicated in the problems and those who help deal with them." (2000, p. 6; translation by A. Zimmermann)

80 The concepts were borrowed from the following authors: "single and double-loop learning" from Argyris (1976, pp. 368–369); "muddling through", "adaptive management" and "sophisticated trial-and-error" from Guston and Sarewitz (2002, p. 100); "experimental implementation" from Van den Daele and Krohn 1998); "real-world experiments (Realexperimente)" from Hoffmann-Riem (2003, pp. 205–210), Gross et al. (2003, p. 287) and Gross et al. (2005, pp. 270–271); "research-intervention (recherche-intervention)" from Hubert and Bonnemaire (2000, p. 8). For a detailed discussion of the "Reflective Practitioner" see also Schön (1983).

81 Regarding this aspect, see for example: Knorr Cetina (1981), Hughes (1986), Callon et al. (1992), Callon (1995), Hughes (1998), Nowotny et al. (2001, in particular pp. 33–49), and Oudshoorn and Pinch (2003).

82 "The theoretical starting point is that research programs develop in mutual interaction with the broad environment in which they are embedded. A research program's success depends on the way in which its researchers connect with the themes that predominate in the surrounding environment and the way in which that environment accepts and consolidates the group's knowledge products." (Spaapen and Wamelink 1999, pp. 11–12)

83 See Chen and Rossi (1980, especially pp. 115–116).

84 See Defila and Di Giulio (1999, p. 14), Thissen and Twaalfhoven (2001), and Maselli et al. (2004, pp. 17–19).

85 Accordingly, Thissen and Twaalfhoven describe the possibilities of assessing impacts in a broad manner: "These are criteria that relate to the possible effects of the policy analytic activity, e.g., feeding the policy discussion, affecting the policy process, affecting the decisions taken, increasing the insights into the problem and possible solutions, improving of the problem situation, and/or changing communication patterns and shifting the balance of power and responsibilities among the actors involved in the problem situation." (Thissen and Twaalfhoven 2001, p. 629)

86 Thus, with regard to research conducted by universities, Spaapen and Wamelink (1999) suggest supplying a "Research Embedment and Performance Profile" (REPP). The purpose of a REPP is to record and make visible specific forms of exchange with various sectors in society. A REPP documents what texts and funds have flown from one direction into another and vice versa, and what interactions have taken place between actors. However, when it is elaborated, a REPP does not go beyond the fields that are also taken into account by other forms of evaluation (Spaapen and Wamelink 1999, especially pp. 14–19). As a REPP does not say anything about the durability and intensity of exchange, Spaapen and Wamelink suggest making an additional "user analysis", through which results and the impacts of results in the different sectors are assessed. Similar to their comprehensive understanding of project impacts, they also have a very broad definition of "users": "When referring to use and user one tends to think, perhaps, only of end use(r). (...) Moreover, by limiting use to end use, one tends to ignore that much innovation is the result of many different actors who mutually influence each other. (...) The concept user is therefore broadened in this user analysis to include the entire field of interested parties, also known as stakeholders. Research colleagues as well as non-funding organisations with a general societal mission (such as the furthering of scientific research in a particular field, for example) are here taken into account. Research is seen here as a part of an innovation process that progresses through the interaction of a multiplicity of actors, scientists, technicians, professionals, policy makers and the public. A user analysis is thus a broad inquiry that encompasses, in principle, all actors associated with innovation. This broad approach implies that the differences between actors with respect to the nature and goal of their involvement have to be accounted for." (Spaapen and Wamelink 1999, p. 21) Both methods – the REPP and the user analysis – do not yet seem to have reached a high degree of elaboration, nor are they designed specifically for TR.

87 What *does* exist are questions in the sense of checklists from the field of policy sciences, as for example:

- "What are the linkages between the research and emerging public policy issues? Are they numerous and solid and becoming more so? If not, why? Who is responsible, for better or worse?
- What means and lines of communication exist between decision makers, researchers, and other stakeholders? Are efforts in place to ensure and/or improve such means and lines? If not, why not? Who is responsible, for better or worse?" (Berry et al. 1998, p. 67)

[88] Regarding this aspect, see Freiburghaus (1989).

[89] See Luhmann and Langrock (2003, pp. 45–47). They add: "In each case, ... knowledge is checked on and formulated in a manner that adequately addresses specific actors in a political process on the occasion of a specific event on an agenda – i.e. delivered at a specific moment in time. The timeliness of delivery, content and addressees (and therefore the form) of products of scientific political advice is therefore determined by political processes or the requirements of these processes. That is the lesson of the scientific discourse on politics. Political science is of no use if its ('scientific') products are delivered in a neutral form, i.e. in a form independent of event (as part of an agenda), time and addressee; from its perspective, such products simply do not have a function." (Luhmann and Langrock 2003, p. 47; translation by A. Zimmermann)

[90] For example, the implementation of soil conservation policy can usefully be supported by so-called knowledge trading zones, in which new farming methods are communicated from farmer to farmer (see Fry 2001).

[91] (Rosenblum 1997)

[92] (Kueffer et al. 2007)

[93] The translation into English of Jean Piaget's 1970 definition of transdisciplinarity was graciously provided by Professor Les Smith, leading Piagetian scholar.

List of References

Argyris C. 1976. Single-loop and double-loop models in research on decision making. *Administrative Science Quarterly* 21: 363–375.

Arias E, Eden H, Fischer G, Gorman A, Scharff E. 2000. Transcending the individual human mind: Creating shared understanding through collaborative design. *ACM Transactions on Computer-Human Interactions* 7(1): 84–113.

Austin S, Steele J, Macmillan S, Kirby P, Spence R. 2001. Mapping the conceptual design activity of interdisciplinary teams. *Design Studies* 22: 211–232.

Baccini P, Oswald F. 1998. *Netzstadt – Transdisziplinäre Methoden zum Umbau urbaner Systeme*. Zurich: Hochschulverlag AG.

Bagamoyo College of Arts, Tanzania Theatre Centre, Mabala R, Allen KB. 2002. Participatory action research on HIV/AIDS through a popular theatre approach in Tanzania. *Evaluation and Program Planning* 25: 333–339.

Bammer, G. 2005. Integration and Implementation Sciences: Building a New Specialization. *Ecology and Society*, 10(2) [online], http://www.ecologyandsociety.org/vol10/iss2/art6/

Becher T. 1989. *Academic Tribes and Territories – Intellectual Enquiry and the Cultures of Disciplines*. Stony Stratford, Milton Keynes: The Society for Research into Higher Education [etc.].

Beck U. 1992 [original German version 1986]. *Risk Society, Towards a New Modernity*. Transl. from German by Mark Ritter, and with an Introduction by Scott Lash and Brian Wynne. London: Sage.

Becker E, Jahn T. 2000. Sozial-ökologische Transformationen – Theoretische und methodische Probleme transdisziplinärer Nachhaltigkeitsforschung. *In:* Brand KW, ed. *Nachhaltige Entwicklung und Transdisziplinarität*: *Besonderheiten, Probleme und Erfordernisse der Nachhaltigkeitsforschung*. Berlin: Analytica, pp 67–84.

Becker E, Jahn T, Stiess E. 1999. Exploring uncommon ground: Sustainability and the social sciences. *In:* Becker E, Jahn T, eds. *Sustainability and the Social Sciences*. London: Zed Books Ltd, pp 1–22.

Bergmann M. 2003. Indikatoren für eine diskursive Evaluation transdisziplinärer Forschung. *TA-Datenbank-Nachrichten* 1(12): 65–75.

Bergmann M, Brohmann B, Hoffmann E, Loibl MC, Rehaag R, Schramm E, Voss JP. 2005. *Quality Criteria for Transdisciplinary Research. A Guide for the Formative Evaluation of Research Projects.* ISOE Studientexte 13. English Version. Frankfurt am Main: Institute for Social-Ecological Research (ISOE).

Berry J, Brewer GD, Gordon JC, Patton DR. 1998. Closing the gap between ecosystem management and ecosystem research. *Policy Sciences* 31: 55–80.

Boix Mansilla V, Gardner H. 2003. Assessing interdisciplinary work at the frontier. An empirical exploration of 'symptoms of quality'*. Interdisciplines,* www.interdisciplines.org, accessed on 1 November 2006.

Brand K-W. 2000. Nachhaltigkeitsforschung: Besonderheiten, Probleme und Erfordernisse eines neuen Forschungstypus. *In:* Brand KW, ed. *Nachhaltige Entwicklung und Transdisziplinarität*: *Besonderheiten, Probleme und Erfordernisse der Nachhaltigkeitsforschung*. Berlin: Analytica, pp 9–28.

Brand K-W. 2005. Nachhaltigkeitskommunikation: Eine soziologische Perspektive. *In:* Michelsen G, Godemann J, eds. *Handbuch Nachhaltigkeitskommunikation. Grundlagen und Praxis*. Munich: oekom Verlag, pp 149–159.

Brewer GD. 1999. The challenges of interdisciplinarity. *Policy Sciences* 32: 327–337.

Bruce A, Lyall C, Tait J, Williams R. 2004. Interdisciplinary integration in Europe: The case of the Fifth Framework Programme. *Futures* 36: 457–470.

Burger P, Kamber R. 2003. Cognitive integration in transdisciplinary science: Knowledge as a key notion. *Issues in Integrative Studies* 21: 43–73.

Callon M. 1995. Technological conception and adoption network: Lessons for the CTA practitioner. *In:* Rip A, Misa TJ, Schot J, eds. *Managing Technology in Society. The Approach of Constructive Technology Assessment*. London: Pinter Publisher, pp 307–330.

Callon M, Laredo P, Rabeharisoa V. 1992. The management and evaluation of technological programs and the dynamics of techno-economic networks: The case of the AFME. *Research Policy* 21: 215–236.

Chen H-T, Rossi PH. 1980. The multi-goal, theory-driven approach to evaluation: A model linking basic and applied social sciences. *Social Forces* 59(1): 106–122.

Chubin DE, Rossini FA, Porter AL, Mitroff II. 1979. Experimental technology assessment: Explorations in process of interdisciplinary team research. *Technological Forecasting and Social Change* 15: 87–94.

Clark TW. 1999. Interdisciplinary problem solving: Next steps in the Greater Yellowstone ecosystem. *Policy Sciences* 32: 393–414.

Clark TW. 2002. *The Policy Process: A Practical Guide for Natural Resource Professionals*. New Haven and London: Yale University Press.

Cohen RS, Schnelle T. 1986. *Cognition and Fact: Materials on Ludwik Fleck*. Dordrecht, Boston [etc.]: Reidel.

Costanza R. 2003. A vision of the future of science: Reintegrating the study of humans and the rest of nature. *Futures* 35: 651–671.

Costanza R, Cumberland J, Daly H, Goodland R, Norgaard R. 1997*. An Introduction to Ecological Economics*. Boca Raton, FL: St. Lucie Press.

de Wit B. 2004. *Methodology of Boundary Work at the Interface of Science, Policy and Society: Basis for a Manual*. Den Haag: Ed. RMNO.

Defila R, Di Giulio A. 1996. Interdisziplinäre Forschungsprozesse: Erwartungen und Realisierungsmöglichkeiten in einem Forschungsprogramm – Das Schwerpunktzentrum "Umweltverantwortliches Handeln" in seinem Umfeld. *In:* Kaufmann-Hayoz R, Di Giulio A, eds. *Umweltproblem Mensch – Humanwissenschaftliche Zugänge zu umweltverantwortlichem Handeln*. Bern: Haupt, pp 79–129.

Defila R, Di Giulio A. 1999. *Evaluating Transdisciplinary Research – Evaluation Criteria for Inter- and Transdisciplinary Research: Project Report, Instrument.* Swiss Priority Programme (SPP) "Environment" Newsletter. (Panorama). Special Issue 1.

Defila R, Di Giulio A. 2001. Inter- and transdisciplinary processes — Experiences and lessons learnt. *In:* Kaufmann-Hayoz R, Gutscher H, eds. *Changing Things – Moving People. Strategies for Promoting Sustainable Development at the Local Level*. Basel: Birkhäuser, pp 337–356.

Defila R, Di Giulio A, Scheuermann M. 2006. *Forschungsverbundmanagement – Handbuch für die Gestaltung inter- und transdisziplinärer Projekte*. Zurich: vdf Hochschulverlag AG.

Deppert W. 1998. Problemlösen durch Interdisziplinarität. *In:* Theobald W, ed. *Integrative Umweltbewertung. Theorie und Beispiele aus der Praxis*. Berlin: Springer, pp 35–64.

Després C, Brais N, Avellan S. 2004. Collaborative planning for retrofitting suburbs: Transdisciplinarity and intersubjectivity in action. *Futures* 36: 471–486.

Eck J. 2003. Policy problems: The complexity of problem theory, research and evaluation. *Crime Prevention Studies* 15: 79–113.

Egloff R. 2005. *Tatsachen – Denkstile – Kontroverse: Auseinandersetzungen mit Ludwik Fleck*. Heft 1. Zurich: Collegium Helveticum.

Elkana Y. 1978. Two-tier-thinking: Philosophical realism and historical relativism. *Social Studies of Science* 8: 309–326.

Elkana Y. 1986. *Anthropologie der Erkenntnis – Die Entwicklung des Wissens als episches Theater einer listigen Vernunft*. Frankfurt am Main: Suhrkamp Verlag.

Elzinga A. 1996. Shaping worldwide consensus: The orchestration of global climate change research. *In:* Elzinga A, Landström C, eds. *Internationalism and Science*. Cambridge, UK: Taylor Graham Publishing.

Epton SR, Payne RL, Pearson AW, eds. 1983. *Managing Interdisciplinary Research.* Proceedings of the Second International Conference on the Management of Interdisciplinary Research, Manchester, July 1981. Chichester: John Wiley & Sons.

Ezrahi Y. 1990. *Descent of Icarus. Science and the Transformation of Contemporary Democracy*. Cambridge, MA: Harvard University Press.

Fleck, L. 1979. *Genesis and Development of a Scientific Fact*. Chicago and London: The University of Chicago Press.

Freiburghaus D. 1989. Interface zwischen Wissenschaft und Politik. *In:* V.d.S.V.f.p. Wissenschaft, ed. *Schweizer Jahrbuch für politische Wissenschaft*. Bern: Haupt, pp 267–277.

Fry P. 2001. *Bodenfruchtbarkeit: Bauernsicht und Forscherblick*. Weikersheim, GER: Margraf Verlag.

Funtowicz SO, Ravetz JR. 1990. *Uncertainty and Quality in Science for Policy*. Theory and Decision Library Series A: Philosophy and Methodology of the Social Sciences. Ed. Leinfellner W, Eberlein G. Vol 15. Dordrecht, NL: Kluwer Academic Publishers.

Funtowicz SO, Ravetz JR. 1993. Science for the Post-Normal Age. *Futures* September: 739–755.

Funtowicz SO, Ravetz JR, O'Connor M. 1998. Challenges in the use of science for sustainable development. *Int. J. Sustainable Development* 1(1): 99–107.

Galison P. 1997. *Image and Logic – A Material Culture of Microphysics*. Chicago: The University of Chicago Press.

German Advisory Council on Global Change (WBGU). 1997. *World in Transition: The Research Challenge*. Berlin: Springer Verlag.

Gibbons M, Limoges C, Nowotny H, Schwartzman S, Scott T, Trow M. 1994. *The New Production of Knowledge:The Dynamics of Science and Research in Contemporary Societies*. London, Thousand Oaks, New Delhi: Sage.

Gieryn TF. 1995. Boundaries of science. *In:* Jasanoff S, ed. *Handbook of Science and Technology Studies*. London, Thousand Oaks, New Delhi: Sage, pp 393–443.

Giri AK. 2002. The calling of a creative transdisciplinarity. *Futures* 34: 103–115.

Gough C, Castells N, Funtowicz SO. 1998. Integrated assessment: An emerging methodology for complex issues. *Environmental Modelling and Assessment* 3: 19–29.

Gross M, Hoffmann-Riem H, Krohn W. 2003. Realexperimente: Robustheit und Dynamik ökologischer Gestaltungen in der Wissensgesellschaft. *Soziale Welt* 54: 241–258.

Gross M, Hoffmann-Riem H. 2005. Ecological restoration as a real-world experiment: Designing robust implementation strategies in an urban environment. *Public Understanding of Science* 14: 269–284.

Grunwald A. 2004. Strategic knowledge for sustainable development. The need for reflexivity and learning at the interface between science and society. *International Journal of Foresight and Innovation Policy* 1: 150–167.

Guston DH, Sarewitz D. 2002. Real-time technology assessment. *Technology in Society* 24: 93–109.

Harriss J. 2002. The case for ccross-disciplinary approaches in international development. *World Development* 30(3): 487–496.

Hirsch Hadorn G. 1995. Beziehungen zwischen Umweltforschung und disziplinärer Forschung. *GAIA* 4(5–6): 302–314.

Hirsch Hadorn G. 1997. Webers Idealtypus als Methode zur Bestimmung des Begriffsinhaltes theoretischer Begriffe in den Kulturwissenschaften. *Journal for General Philosophy of Science* 28(2): 275–296.

Hirsch Hadorn G, Maier S, Wölfling Kast S. 2002. *Transdisziplinäre Nachhaltigkeitsforschung in Aktion*. Themenband Schwerpunktprogramm Umwelt Schweiz. Zurich: Verlag der Fachvereine vdf.

Hirsch Hadorn G, Wölfling Kast S, Maier S. 2002. Restrictions and options: A heuristic tool to integrate knowledge for strategies towards a sustainable development. *International Journal for Sustainable Development and World Ecology* 9: 193–207.

Hirsch Hadorn G, Bradley D, Pohl C, Rist S, Wiesmann U. 2006. Implications of Transdisciplinarity for Sustainability Research. *Ecological Economics* 60:1119–128.

Hoffmann-Riem H. 2003. *Die Sanierung des Sempachersees: Eine Fallstudie über ökologische Lernprozesse*. Munich: oekom Verlag.

Hollaender K, Loibl MC, Wilts A. 2002. Management of Transdisciplinary Research. *In:* Hirsch G, ed. *Unity of Knowledge in Transdisciplinary Research for Sustainability in Encyclopaedia of Life Support Systems*. Oxford, UK: Eolss Publisher.

Horlick-Jones T, Sime J. 2004. Living on the border: Knowledge, risk and transdisciplinarity. *Futures* 36: 441–456.

Hubert B, Bonnemaire J. 2000. La construction des objets dans la recherche interdisciplinaire finalisée: de nouvelles exigences pour l'évaluation. *Natures Sciences Sociétés* 8(3): 5–19.

Hughes TP. 1986. The seamless web: Technology, science, etcetera, etcetera. *Social Studies of Science* 16: 281–292.

Hughes TP. 1987. The evolution of large technological systems. *In:* WE, Bijker, TR, Hughes, Pinch TJ, eds. *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*. Cambridge, MA and London: The MIT Press, pp 51–82.

Hughes TP. 1998. *Rescuing Prometheus*. New York and Toronto: Random House.

Hurni H, Wiesmann U. 2004. Towards transdisciplinarity in sustainability-oriented research for development. *In:* Hurni H, Wiesmann U, Schertenleib R, eds. *Research for Mitigating Syndromes of Global Change. A Transdisciplinary Appraisal of Selected Regions of the World to Prepare Development-Oriented Research Partnerships*. Bern: University of Berne, pp 31–41.

Häberli R, Grossenbacher-Mansuy W. 1998. Transdisziplinarität zwischen Förderung und Überforderung. Erkenntnisse aus dem SPP Umwelt. *GAIA* 7(3): 196–213.

Jaeger J, Scheringer M. 1998. Transdisziplinarität. Problemorientierung ohne Methodenzwang. *GAIA* 7(1): 10–25.

Jahn T. 2005. Soziale Ökologie, kognitive Integration und Interdisziplinarität. *Technikfolgenabschätzung – Theorie und Praxis* 14(2): 32–38.

Jantsch E. 1972. Towards interdisciplinarity and transdisciplinarity in education and innovation. *In:* Leo Apostel L, Berger G, et al., eds. *Problems of Teaching and Research in Universities*. Paris: Organisation for Economic Cooperation and Development (OECD) and Center for Educational Research and Innovation (CERI), pp 97–121.

Jasanoff S, Wynne B. 1998. Science and decision making. *In:* Rayner S, Malone EL, eds. *Human Choice and Climate Change*. Columbus, OH: Battelle Press, pp 1–87.

Kates RW, Clark WC, Corell R, Hall JM, Jaeger CC, Lowe I, McCarthy JJ, Schellnhuber HJ, Bolin B, Dickson NM, Faucheux S, Gallopin GC, Grübler A, Huntley B, Jäger J, Jodha NS, Kasperson RE, Mabogunje A, Matson P, Mooney H, Moore BI, O'Riordan T, Svedin U. 2001. Sustainability science. *Science* 292: 641–642.

Klein JT. 1990. *Interdisciplinarity. History, Theory, and Practice*. Detroit: Wayne State University Press.

Klein JT. 1996. *Crossing Boundaries. Knowledge, Disciplinarities, and Interdisciplinarities*. Charlottesville: University Press of Virginia.

Klein JT, Grossenbacher-Mansuy W, Häberli R, Bill A, Scholz RW, Welti M. 2001. *Transdisciplinarity: Joint Problem Solving among Science, Technology, and Society*. Synthesebücher, SPP Environment. Basel: Birkhäuser.

Knorr Cetina K. 1981. *The Manufacture of Knowledge – An Essay on the Constructivist and Contextual Nature of Science*. Oxford, UK: Pergamon Press.

Knorr Cetina K. 1999. *Epistemic Cultures – How the Sciences make Knowledge*. Cambridge, MA: Harvard University Press.

Kockelmans JJ. 1979. Why interdisciplinarity? *In:* Kockelmans JJ, ed. *Interdisciplinarity and Higher Education*. University Park and London: The Pennsylvania State University Press, pp 125–160.

Koontz TM, Moore Johnson E. 2004. One size does not fit all: Matching breadth of stakeholder participation to watershed group accomplishments. *Policy Sciences* 37: 185–204.

Krott M. 1996. Interdisziplinarität im Netz der Disziplinen*. In:* Balsiger PW, Defila R, Di Giulio A, eds. *Ökologie und Interdisziplinarität – eine Beziehung mit Zukunft?* Basel: Birkhäuser, pp 87–97.

Kruse L. 2003. Neue Ansprüche an Umwelt- und Nachhaltigkeitsforschung bedürfen neuer Evaluationsansätze. *GAIA* 2(12): 95–98.

Kueffer C, Hirsch Hadorn G, Bammer G, van Kerkhoff L, Pohl C. 2007. Towards a publication culture in transdisciplinary research. *GAIA* 16(1): 22–36.

Kuhn TS. 1996. *The Structure of Scientific Revolutions*. 3rd ed. Chicago: The University of Chicago Press.

Kötter R, Balsiger PW. 1999. Interdisciplinarity and transdisciplinarity. A constant challenge to the sciences. *Issues in Integrative Studies* 17: 87–120.

Lawrence RJ. 2004. Housing and health: From interdisciplinary principles to transdisciplinary research and practice. *Futures* 36: 487–502.

Loibl MC. 2001. *Empfehlungen zu Praxiseinbezug, Produktentwicklung und Ressourcenplanung*. Vienna: Begleitforschungsprojekt SU11 zur Österreichischen Kulturlandschaftsforschung und Internationale D-A-CH Kooperation.

Loibl MC. 2005. *Spannung in Forschungsteams: Hintergründe und Methoden zum konstruktiven Abbau von Konflikten in inter- und transdisziplinären Projekten*. Heidelberg: Verlag für Systemische Forschung im Carl-Auer Verlag.

Loibl MC. 2006. Integrating perspectives in the practice of transdisciplinary research. *In:* Voss J-P, Bauknecht D, Kemp R, eds. *Reflexive Governance for Sustainable Development.* Cheltenham: Edward Elgar, pp 294–309.

Luhmann H-J, Langrock T. 2003. Der entscheidende Punkt in der Evaluation des Wuppertaler Instituts: Was ist wissenschaftliche Politikberatung? *TA-Datenbank-Nachrichten* 1(12): 42–50.

Luhmann N. 1990. *Ökologische Kommunikation. Kann die moderne Gesellschaft sich auf ökologische Gefährdungen einstellen?* Opladen: Westdeutscher Verlag.

Luhmann N. 1997. *Die Gesellschaft der Gesellschaft*. Frankfurt a. M.: Suhrkamp.

Lüdeke MKB, Petschel-Held G, Schellnhuber H-J. 2004. Syndromes of global change. The first panoramic view. *GAIA* 13(1): 42–49.

Maselli D, Lys J-A, Schmid J. 2004. *Improving Impacts of Research Partnerships*. Bern: Geographica Bernensia and Swiss Commission for Research Partnerships with Developing Countries (KFPE).

Mathieu N, Rivault C, Blanc N, Cloarec A. 1997. Le dialogue interdisciplinaire mis à l'épreuve: réflexions à partir d'une recherche sur les blattes urbaines. *Natures Sciences Sociétés* 5(1): 18–30.

Minsch J, Feindt P-H, Meister H-P, Schneidewind U, Schulz T. 1998. *Institutionelle Reformen für eine Politik der Nachhaltigkeit*. Berlin: Springer.

Mittelstrass J. 1992. Auf dem Weg zur Transdisziplinarität. *GAIA* 1(5): 250.

Mittelstrass J. 1996. *Enzyklopädie Philosophie und Wissenschaftstheorie*. 4 vols. Stuttgart: Metzler.

Mogalle M. 2001. *Management transdisziplinärer Forschungsprozesse*. Basel: Birkhäuser.

Moll P, Zander U. 2006. *Managing the Interface – From Knowledge to Action in Global Change and Sustainability Science*. Munich: oekom verlag.

National Academy of Sciences. 2005. *Facilitating Interdisciplinary Research*. Washington, D.C.: The National Academies Press.

Nagel T. 1986. *The view from nowhere.* Oxford [a.o.]: Oxford University Press.

Nicolescu B. 1996. *La Transdisciplinarité – Manifeste*. Monaco: Éditions du Rocher. The translation into English comes from: nicol.club.fr/ciret/english/visionen.htm; accessed on 1 November 2006.

Nicolini M. 2001. *Sprache – Wissenschaft – Wirklichkeit. Zum Sprachgebrauch in inter- und transdisziplinärer Forschung*. Vienna: Bundesministerium für Bildung, Wissenschaft und Kultur.

Nölting B, Voss J-P, Hayn D. 2004. Nachhaltigkeitsforschung – jenseits von Disziplinierung und anything goes. *GAIA* 13(4): 254–261.

Nowotny H, Scott P, Gibbons M. 2001. *Re-Thinking Science – Knowledge and the Public in an Age of Uncertainty*. Cambridge, UK: Polity Press.

Oswald F, Baccini P. 2003. *Netzstadt – Einführung in das Stadtentwerfen*. Basel: Birkhäuser.

Oudshoorn N, Pinch T. 2003. *How Users Matter: The Co-Construction of Users and Technology*. Cambridge, MA and London, UK: The MIT Press.

Perrig-Chiello P, Darbellay F. 2002. Inter- et transdisciplinarité: concepts et méthodes. *In:* Perrig-Chiello P, Darbellay F, eds. *Qu'est-ce que l'interdisciplinarité? Les nouveaux défis de l'enseignement*. Lausanne: Éditions Réalités Sociales, pp 13–34.

Petschel-Held G. 2003. System analysis and modelling in transdisciplinary research. *In:* Hirsch Hadorn G, ed. *Unity of Knowledge in Transdisciplinary Research for Sustainability in Encyclopaedia of Life Support Systems*. Oxford. UK: Eolss Publisher, [online], www.eolss.net.

Petschel-Held G, Block A, Cassel-Gintz M, Kropp J, Lüdeke MKB, Moldenhauer O, Reusswig F, Schellnhuber H. 1999a. Syndromes of Global Change – A Qualitative Modelling Approach to Assist Global Environmental Management. *Environmental Modelling and Assessment* 4: 295–314.

Petschel-Held G, Lüdeke MKB, Reusswig F. 1999b. Actors, structures and environment – A comparative and transdisciplinary view on regional case studies of global environmental change. *In:* Lohnert B, Geist H, eds. *Coping with Changing Environments*. London: Ashgate, pp 255–293.

Piaget J. 1973. L'épistémologie des relations interdisciplinaires. *Bulletin Uni-information Genève* 31: 4–8.

Pinson D. 2004. Urban planning: An 'undisciplined' discipline? *Futures* 36: 503–513.

Pohl C. 2001. How to bridge between natural and social sciences – An analysis of three approaches to transdisciplinarity from the Swiss and German field of environmental research. *Natures Sciences Sociétés* 9(3): 37–46.

Pohl C. 2004. *Guidelines für die transdisziplinäre Forschung – 1. Vorschlag September 2004 zur Peer Review und zur Vernehmlassung*. Bern: td-net.

Pohl C. 2005. Transdisciplinary collaboration in environmental research. *Futures* 37: 1159–1178.

Pohl C, Gisler P. 2003. Barriers and opportunities in realising sustainable energy concepts: An analysis of two Swiss case studies. *Energy Policy* 31: 175–183.

Policansky D. 1999. Interdisciplinary problem solving: The National Research Council. *Policy Sciences* 32: 385–391.

ProClim/CASS. 1997. *Research on Sustainability and Global Change – Visions in Science Policy by Swiss Researchers*. Bern: CASS/SANW.

Quinlan T, Scogings P. 2004. Why bio-physical and social scientists can speak the same language when addressing sustainable development: Discussion. *Environmental Science and Policy* 7: 537–546.

Ramadier T. 2004. Transdisciplinarity and its challenges: The case of urban studies. *Futures* 36: 423–439.

Rayner S, Malone EL. 1998. The challenge of climate change to the social sciences. *In:* Rayner S, Malone EL, eds. *Human Choice and Climate Change*. Vol 4. Columbus, OH: Battelle Press, pp 33–69.

Rolf T. 1999. Lebenswelt. *In:* Sandkühler H-J, ed. *Enzyklopädie Philosophie*. Hamburg: Meiner, pp 758–761.

Rosenblum D. 1997. In the absence of a paradigm. The construction of interdisciplinary research. *Issues in Integrative Studies* 15: 113–123.

Rossini FA, Porter AL. 1979. Frameworks for integrating disciplinary research. *Research Policy* 8: 70–79.

Röbbecke M, Simon D. 2001. *Reflexive Evaluation*. Ed. W.B.f. Sozialforschung. Berlin: Edition Sigma.

Sarewitz D. 2004. How science makes environmental controversies worse. *Environmental Science and Policy* 7: 385–403.

Schellnhuber HJ. 1999. 'Earth System' analysis and the second Copernican Revolution. *Nature* 402(Supp 2): C19–C23.

Schellnhuber HJ, Block A, Cassel-Gintz M, Kropp J, Lammel G, Wiebke L, Lienenkamp R, Loose C, Lüdeke MKB, Moldenhauer O, Petschel-Held G, Plöchl M, Reusswig F. 1997. Syndromes of global change. *GAIA* 6(1): 19–34.

Scheringer M, Valsangiacomo A, Hirsch Hadorn G, Pohl C, Ulbrich Zürni S. 2005. Transdisziplinäre Umweltforschung: Eine Typologie. *GAIA* 14(2): 192–195.

Scholz RW. 2000. Mutual learning as a basic principle of transdisciplinarity. *In:* Scholz RW, Häberli R, Bill A, Welti M, eds. *Transdisciplinarity: Joint Problem-Solving among Science, Technology and Society*. Workbook II. Zurich: Haffmans Sachbuch Verlag AG, pp 13–17.

Scholz RW, Koller T, Mieg HA, Schmidlin C. 1995. *Perspektive "Grosses Moos": Wege zu einer nachhaltigen Landwirtschaft. UNS Fallstudie 1994*. Zurich: vdf.

Scholz RW, Marks D. 2001. Learning about transdisciplinarity: Where are we? Where have we been? Where should we go? *In:* Klein JT, Grossenbacher-Mansuy W, Häberli R, Bill A, Scholz RW, Welti M, eds. *Transdisciplinarity: Joint Problem Solving among Science, Technology, and Society*. Basel: Birkhäuser, pp 236–252.

Scholz RW, Mieg HA, Oswald JE. 2000. Transdisciplinarity in groundwater management: Towards mutual learning of science and society. *Water, Air, and Soil Pollution* 123: 477–487.

Scholz RW, Stauffacher M. 2001. Transdisziplinaritäts-Laboratorium ETH-UNS Fallstudie – Werkstatt für ein neuartiges Zusammenwirken von Wissenschaft und Praxis. *In:* Mieg HA, Hübner P, Stauffacher M, Bösch S, Balmer M, eds. *Zukunft Schiene Schweiz 2: Ökologisches Potenzial des Schienengüterverkehrs am Beispiel der Region Zugersee.* ETH-UNS Fallstudie 2000. Zurich: Rüegger, pp 243–254.

Scholz RW, Stauffacher M, Bösch S, Krütli P. 2004. *Mobilität und zukunftsfähige Stadtentwicklung: Freizeit in der Stadt Basel.* ETH-UNS Fallstudie 2003. Zurich: Rüegger und Pabst.

Scholz RW, Tietje O. 2002. *Embedded Case Study Methods: Integrating Quantitative and Qualitative Knowledge*. London, Thousand Oaks: Sage.

Schön DA. 1983. *The Reflective Practitioner. How Professionals Think in Action*. London and Temple Smith.

Schophaus M, Schön S, Dienel H-L. 2004. *Transdisziplinäres Kooperationsmanagement*. Munich: oekom Verlag.

Shell KL. 1985. Gemeinwohl, Zusammenfassung. *In:* Görlitz A, ed. *Handlexikon zur Politikwissenschaft*. Reinbek b. Hamburg: Rowohlt Taschenbuchverlag, pp 118–119.

Snow CP. 1959. *The Two Cultures and the Scientific Revolution*. Cambridge, UK: Cambridge University Press.

Snow CP. 1964. *The Two Cultures: And a Second Look. An Expanded Version of the Two Cultures and the Scientific Revolution*. 2nd ed. Cambridge, UK: University Press.

Spaapen J, Wamelink F. 1999. *The Evaluation of University Research: A Method for the Incorporation of the Societal Value of Research*. The Hague: National Council for Agricultural Research.

Star SL, Griesemer JR. 1989. Institutional ecology, 'Translations' and boundary objects: Amateurs and professionals in Berkeley's Museum of Vertebrate Zoology, 1907–39. *Social Studies of Science* 19: 387–420.

Stauffacher M, Scholz RW. 2004. ETH-UNS case studies: A university course to develop transdisciplinarity and sustainability learning. *ipublic-Psychologie im Umweltschutz* 7(1): 55–63.

Stokols D, Harvey R, Gress J, Fuqua J, Phillips K. 2005. In vivo studies of transdisciplinary scientific collaboration: Lessons learned and implications for active living research. *American Journal of Preventive Medicine* 28(2S2): 202–213.

Swart R, Raskin P, Robinson J, Kates RW, Clark WC. 2002. Critical challenges for sustainability science. *Science* 297: 1994–1995.

Thissen WAH, Twaalfhoven PGJ. 2001. Towards a conceptual structure for evaluating policy analytic activities. *European Journal of Operational Research* 129: 627–649.

Toth FL, Hizsnyki E. 1998. Integrated environmental assessment methods: Evolution and applications. *Environmental Modelling and Assessment* 3: 193–207.

Toth FL, Mwandosya M. 2001. Decision-making frameworks*. In:* Metz B, Davidson O, Swart R, Pan J, eds. *Climate Change 2001: Mitigation. Contribution of Working Group III to the Third Assessment Report of the Intergovernmental Panel on Climate Change IPCC*. Cambridge, UK: Cambridge University Press, pp 602–687.

Truffer B, Bratrich C, Markard J, Peter A, Wüest A, Wehrli B. 2003. Green hydropower: The contribution of aquatic science research to the promotion of sustainable electricity. *Aquatic Science* 65: 99–110.

Van Den Daele W. 1993. Sozialverträglichkeit und Umweltverträglichkeit. Inhaltliche Mindeststandards und Verfahren bei der Beurteilung neuer Techniken. *Zeitschrift der Deutschen Vereinigung für Politische Wissenschaft* 4: 219–248.

Van Den Daele W, Krohn W. 1998. Experimental implementation as linking mechanism in the process of innovation. *Research Policy* 27: 853–868.

Wachelder J. 2003. Democratizing science: Various routes and visions of Dutch science shops. *Science, Technology & Human Values* 28(2): 244–273.

Weber Max. 1949 [1903–1917]. *The Methodology of the Social Sciences.* Edited by Edward Shils and Henry Finch. New York: Free Press.

Weinberg AM. 1972. Science and trans-science. *Minerva* 10(2): 209–222.

Wynne B. 1992. Misunderstood misunderstandings: Social identities and public uptake of science. *Public Understanding of Science* 1: 281–304.

Wynne B. 1993. Public uptake of science: A case for institutional reflexivity. *Public Understanding of Science* 2: 321–337.

In the information or knowledge society, there is a need for transdisciplinary research, i.e. research that deals with complex life-world problems. Transdisciplinary projects aim to come up with practice-oriented solutions that serve what is perceived to be the common good. In order to achieve this, they transcend disciplinary boundaries and include the perspectives of public agencies, the business community and civil society in the research process. This process is therefore particularly challenging for those involved.

This book is proposed by the transdisciplinarity-net, which is a project supported by the Swiss Academies of Arts and Sciences. It offers a means of designing transdisciplinary research. The tools presented here help structure the research process, in particular with a view to:

- adequately reducing the complexity of a problem field,
- taking into account the multiplicity of perspectives,
- embedding research into the social context, and
- adapting concepts and methods in the course of the research process.

This publication shows how these tools can be used in the three phases of a transdisciplinary research process: identifying and structuring the problem, analyzing the problem and bringing results to fruition.

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