

Handbook of Transdisciplinary Research

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Handbook of Transdisciplinary Research

Foreword by Jill Jäger

 Springer

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Foreword

In a world characterised by rapid change, uncertainty and increasing interconnectedness there is a growing need for science to contribute to the solution of persistent, complex problems. These problems include not only some of the now broadly known environmental issues such as climate change and biodiversity loss, but also related issues such as poverty, security and governance. For all of these problems, progress in finding and implementing solutions has been very slow. The increase in availability of scientific knowledge has not been reflected in decisive action.

It is this mismatch between knowledge and action that lies behind the need for a Handbook of Transdisciplinary Research. As the editors point out in their introduction, a transdisciplinary orientation in research, education and institutions aims to overcome the disconnection between knowledge production, on the one hand, and the demand for knowledge to contribute to the solution of societal problems, on the other hand. This is achieved through transdisciplinary approaches in which researchers from a wide range of disciplines work together with stakeholders. Internationally the term ‘transdisciplinary research’ is defined in different ways, ranging from a diffuse conceptual term located above individual disciplines, to any research that involves stakeholders. The Handbook contributes to a clarification of both the concept and the term, and shows that the uniqueness of the approach lies in the partnership between members of different disciplines and stakeholders.

Given the progress in transdisciplinary approaches during the past two decades, the Handbook provides an opportunity to learn from projects that have already been carried out. The examples described show how knowledge requirements for problem solving have been met. The conceptual and methodological advances in transdisciplinary approaches, in a variety of problem areas, illustrate the broad applicability of the approach. The structured presentation of the examples will encourage a broad community of researchers, educators and users to explore ways in which the approach can be used and further developed. In particular, the Handbook clearly demonstrates to the research community the special requirements and opportunities of this line of research. The authors come from several continents and their projects deal with a wide range of issues. This is a clear indication that the interest in transdisciplinary approaches is widespread.

While the need for transdisciplinary research in a world facing complex problems of a persistent nature is very evident, we should not underestimate the barriers that will have to be overcome in order to turn this emerging form of research into a mainstream endeavour. There are barriers within the scientific community where many scientists prefer to continue their basic research and not confront issues and questions raised by non-scientists. While such basic research will remain important, tackling complex issues of concern to the public and the policy-makers will need input from scientists and non-scientists, resulting in a different type of research. There are also barriers within the area of research funding, where traditional funding agencies often struggle with the notion of participatory research and whether it is 'scientific' or not.

The examples in this book show that participatory, interdisciplinary research can contribute to the solution of complex persistent problems. Such research succeeds by building joint visions of the issue of concern, by finding a common language, by jointly discussing the trade-offs that result from particular choices, and above all through collaborative *learning*. The projects succeed through effective project management, which can deal with, and profit from, the different backgrounds of the participants. With the Handbook as a guide, the emerging community of peers in transdisciplinary research can be strengthened and expanded, so that the bridges between knowledge and action become stronger and progress can be made in tackling major issues faced by society.

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At its first meeting in 2003, the advisory board of td-net decided to publish a 'Handbook of Transdisciplinary Research'. A key driver for this project was the strong belief that a handbook – assembling contributions on crucial topics in transdisciplinary research and written by scholars from all over the world – would be a big step forward in developing transdisciplinary practices. Although we realised that the task was challenging, we did not expect that it would take us more than three years to produce the result.

We started with a list of around ten core topics and sent out a call to about ninety colleagues, asking for comments and relevant published papers. We are very grateful to the more than thirty researchers who responded; they provided considerable assistance in shaping the ideas and structure of the Handbook. Their input was discussed at an advisory board workshop in March 2004, where we were joined by Wolfgang van den Daele from the Social Science Research Center Berlin (WZB). He was influential in steering us away from an abstract treatment of closely entangled topics towards the practical volume you have in your hands.

The editors – comprising members of the advisory board and collaborators from the td-net office – decided to base the Handbook on research projects in various problem-fields, structured according to the phases of a transdisciplinary research process. As a consequence, we searched for projects in a broad range of areas and developed a template for the contributions. About 20 colleagues reviewed proposals from project-teams and helped us select the ones that would best suit the Handbook. The structure of the Handbook developed further as draft contributions came in. It became clear to us that an additional section on cross-cutting issues in transdisciplinary research would help the analysis and sharing of research experiences. We therefore invited additional authors to join the project. In writing our introductory sections, we editors benefited considerably from Theo Koller's comments, and during the final editing from Gabriele Bammer's advice.

We are especially grateful to Paul Roos from Springer publishers for his enthusiastic support for the Handbook. He and the anonymous reviewers provided valuable advice on making the book more accessible to readers. Su Moore's English language editing was outstanding in improving the texts, most of which were written by non-native speakers. In the final stages of preparation of the chapters for publication, Betty van Herk from Springer was a reliable font of information and, in

our team Manuela Gähwiler, with the support of Michiel Fehr, Urs Allenspach and Benji Sunarjo, edited and finalised the texts, figures and tables with never-ending patience.

In the process of shaping the many contributions into a coherent book, accessible to readers inside and outside the field of transdisciplinarity, we asked a lot of the authors. We are very grateful for their willingness to share the process of writing this Handbook of Transdisciplinary Research with us.

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Part I
Introduction

Chapter 1

Idea of the Handbook

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Abstract Transdisciplinary orientations in research, education and institutions try to overcome the mismatch between knowledge production in academia, and knowledge requests for solving societal problems. Addressing societal knowledge demands by designing research processes in a transdisciplinary way has several major implications. It becomes necessary to transgress boundaries between different academic cultures, such as between the humanities and the natural sciences. Furthermore, researchers have to step into problem fields and engage in mutual learning with people in the life-world. In doing so, disciplinary standards of knowledge production are sacrificed. Therefore, it is necessary to develop a state of the art for transdisciplinary forms of research. This is best done by learning from experiences. The Handbook is intended to enable learning from exemplary experiences in research and to provide a more systematic account of some cross-cutting issues. This chapter describes the idea behind the Handbook and the contents of the Handbook.

Keywords: Networks · Research programmes · Case studies · Cross-cutting Issues · Paradigm

1.1 Transdisciplinary Research

Both in the North and in the South societies are developing towards knowledge societies. Research is becoming an integral component of innovation and problem solving strategies in the life-world, affecting not only the private sector, public agencies, and civil society, but also personal life. Scientific knowledge production in these societal contexts involves a wide range of different disciplines, ranging from natural sciences and engineering to social sciences, economics and humanities.

The large-scale application of scientific knowledge in the life-world has had both beneficial and harmful consequences. One of the reasons for this is the

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fragmentation of scientific knowledge. As Brewer (1999) stated: *'The world has problems, but universities have departments.'* The pursuit of research within university departments has given rise to the ongoing specialisation of disciplines and thematic fields with fuzzy, somewhat arbitrary, shifting boundaries. The high degree of compartmentalisation of scientific knowledge is due to two interacting factors. Institutional structures and incentives in academia result in an 'ethnocentrism of disciplines' (Campbell, 1969). At the same time the concepts, theories and methods used in basic research are becoming ever more sophisticated.

Knowledge is requested by actors in the life-world to address serious problems, such as poverty, sickness, crime and environmental degradation, from the local to the global scale. These requests have led to calls for a 'new social contract for science' (Lubchenco, 1998) or a 'new commitment of science' (Cetto, 2000) to tackle the problems of the 21st century. To solve or at least mitigate these problems, sufficient research capacities are required. In addition to that, research practices, institutions, education and the underlying conception of science need to be transformed.

The 'ideal' of scientific knowledge underlying basic research is concerned with universal concepts, theories, models and methods. Therefore, basic research is built on an idealisation of the multitude of phenomena and relationships. This is also the case for basic research in the humanities, for instance in ethics. It is unclear to what extent idealised theories and models are able to adequately describe, explain, understand, reflect and handle the reality of concrete problem situations. Nevertheless, the use of scientific knowledge in the private sector, in public agencies and the life-world has been seen as a one-way transfer of allegedly reliable instrumental knowledge from experts to 'ignorant' users. Serious harm has been caused by ignoring the uncertainty of scientific knowledge, by neglecting the users' knowledge, and by failing to consider contextual conditions of applications. In view of these risks, which were often unknown until damage occurred, the model of progress in modern civilisation has been questioned by social movements, intellectuals from the humanities and by concerned scientists.

It is in this context that ideas about transdisciplinarity emerged in the 1970s. Transdisciplinary orientations in research, education and institutions try to overcome the mismatch between knowledge production in academia, on the one hand, and knowledge requests for solving societal problems, on the other. Transdisciplinary research, therefore, aims at identifying, structuring, analysing and handling issues in problem fields with the aspiration *'(a) to grasp the relevant complexity of a problem (b) to take into account the diversity of life-world and scientific perceptions of problems, (c) to link abstract and case-specific knowledge, and (d) develop knowledge and practices that promote what is perceived to be the common good'* (Pohl and Hirsch Hadorn, 2007).

Knowledge requests from the life-world are only partly met by describing, analysing and interpreting empirical processes that influence problems and by giving projections into the future. This so-called systems knowledge (ProClim, 1997) has to be linked with answers to further, and equally important, questions of a different type: What are the subjects of concern? Where are changes needed in public institutions, in the private sector and in individual ways of acting? What policies

will be effective for improving, mitigating and solving these problems in the private sector and civil society? This so-called target knowledge is about the needs, interests and reasons of various practitioners and stakeholders who may be affected directly or indirectly. Their needs have to be taken into account to develop better societal practices. Furthermore, so-called transformation knowledge is needed to improve existing practices. It addresses questions about technical, social, legal, cultural and other possible means of acting that aim to transform existing practices and introduce desired ones. In the case of transformation knowledge, established technologies, regulations, practices and power relations must be taken into account.

Attention has to be paid to the mutual interrelations between these three forms of knowledge. The investigation of systemic processes has to be related to the societal purposes and practices on which they depend and which they influence. If the needs, interests and reasons of practitioners and stakeholders are ignored or if systemic processes are not taken into account in developing transformation knowledge, major unexpected obstacles and unintended effects may result.

Addressing the threefold societal knowledge demands by designing research processes in a transdisciplinary way has several major implications. It becomes necessary to transgress boundaries between disciplines and especially between different academic cultures, such as between the humanities and the natural sciences. Furthermore, the doors of laboratories and libraries must be opened and researchers have to step into problem fields and engage in mutual learning with people in the life-world. In doing so, academic standards of knowledge production and quality control criteria are sacrificed. Therefore, it is necessary to develop a state of the art and to define quality criteria that are appropriate for transdisciplinary forms of research. This is best done by learning from experiences.

1.2 The Background of the Handbook

In the case of transdisciplinary research, learning from experience requires special effort because of the heterogeneity of the fields and the participants. There is a lack of strong institutional structures for transdisciplinary research that are necessary for establishing scientific communities in which a state of the art can be developed. Transdisciplinary research groups enter into a variety of problem fields such as health and environmental issues, technology development, and social conflicts. In addition, cooperation and mutual learning between participants from various institutional contexts and heterogeneous backgrounds take place on a project related basis. Frequently, they do not outlast the temporary context of the research project or programme. As a consequence of professional mobility and lack of systematisation, the lessons learned on the job are seldom passed on to others for capacity building. Furthermore, the diversity of research problems makes it necessary to consider where and how systematisation can be recommended.

In view of this situation, transdisciplinarity-net (td-net) was initiated by the Swiss Academies of Arts and Sciences as a forum for transdisciplinary research in

order to facilitate capacity building and advancement in transdisciplinary research (www.transdisciplinarity.ch). Transdisciplinary efforts in Switzerland go back to the 1970s when a Man and Biosphere Programme was initiated in the Swiss Alps, based on an integrated systems approach and cooperation among scientists, inhabitants and decision-makers (Chapter 3). In 1979 a National Research Programme Man and Biosphere was initiated, funded by the Swiss National Science Foundation. During the 1990s, the Swiss Priority Programme Environment (SPPE) – also funded by the Swiss National Science Foundation – prepared the ground for a deepening of transdisciplinary research in Switzerland (www.sppe.ch). About 250 research projects covered subjects such as climate, biodiversity, soil, waste, social and economic issues and the North–South dimension. It was within the framework of SPPE that a discussion forum on transdisciplinarity was initiated. International workshops and cooperations among German, Austrian and Swiss researchers took place. Towards the end of the programme, the International Transdisciplinarity Conference in 2000 was initiated (Klein et al., 2001). It was at this conference that the Swiss Academic Society for Environmental Research and Ecology (SAGUF) started *sagufnet* as a network for transdisciplinary research. *Sagufnet* was transformed into *td-net* by the Swiss Academies of Arts and Sciences in 2003. *Td-net* is currently deepening international cooperations by contributing to the programmes, ‘Socio-Ecological Research’ (<http://www.bmbf.de/en/972.php>) in Germany, and ‘*proVision*’ (<http://www.bmbwk.gv.at/forschung/fps/provision.xml>) in Austria, and by maintaining close ties to the Integration and Implementation Sciences network (<http://www.anu.edu.au/iisn/>) in Australia, to mention a few.

The advisory board of *td-net* decided to propose ‘Principles for Designing Transdisciplinary Research’ (Pohl, 2007) and to edit this ‘Handbook of Transdisciplinary Research’ as a core means for enhancing transdisciplinary research. The Principles highlight the challenges in transdisciplinary projects, and suggest means of designing and shaping the research process to meet these challenges. Thus, the Principles provide the conceptual basis and structure for the Handbook. The Handbook is intended to enable learning from exemplary experiences in research and to provide a more systematic account of some cross-cutting issues. Due to the context in which *td-net* has emerged as a Swiss institution, a considerable number of authors are based in Switzerland. But the fact that authors come from several continents and are dealing with a broad range of issues indicates an emerging international college of peers in transdisciplinary research.

1.3 The Structure of the Handbook

The Handbook consists of six parts. The introductory part describes the idea behind the Handbook and the developments leading to transdisciplinarity as a form of research. The following three parts assemble the research projects, which are grouped according to the three phases of transdisciplinary research: (1) problem identification and structuring, (2) problem analysis, and (3) bringing results to fruition. The next part deals with cross-cutting issues. Contributions describe overarching

challenges in transdisciplinary research and draw upon both the general literature and upon the projects in the handbook. The final part provides a summary and outlook. It includes explanations of the core terms used in transdisciplinary research and a synthesis of the Handbook's contents in 15 propositions for enhancing transdisciplinary research.

While handbooks in well-established fields usually focus on methods, the core of this Handbook consists of a collection of research projects. Although scientific research is characterised by systematic procedures, transdisciplinary research cannot be learned using a collection of methods. Transdisciplinary research needs concrete paradigms to help researchers understand problems in context and to structure the research accordingly. This will eventually give rise to formalisation. As Don Rosenblum points out in his analysis of interdisciplinary conceptions in basic and applied research (Rosenblum, 1997) little has been written about research practices. An important reason for this, he argues, is the absence of paradigms as 'shared examples' that enable both problem recognition and problem solving efforts by grounding concepts, methods, tools and standards for research as well as the building a scientific community and its institutions.

The same applies to transdisciplinary research: there is a need for projects that have the potential to be approved by a college of peers. Shared experiences contribute to the systematisation and formalisation of concepts, methods and tools as well as standards. The Handbook is designed to overcome this obstacle: it collects transdisciplinary projects that have the potential to become paradigmatic research examples because they illustrate how the knowledge requirements for problem solving in the life-world are met. The chapters show how the challenges of problem identification, problem structuring, problem analysis and bringing results to fruition can be tackled. In this way, they contribute to a grounded systematisation and formalisation of research practices and to their in-depth analysis. The projects demonstrate the potential of transdisciplinary research in a broad range of problem fields such as environment and health, urban and landscape development, and new technologies. There is a variety of subjects, approaches, methods and tools used. Whether, and in what sense, there will one day emerge a general methodology of transdisciplinary research is not yet clear (Bammer, 2005).

The project based chapters are arranged on the basis of the project phase (problem identification and structuring, problem analysis, and bringing results to fruition) that we consider to be particularly interesting in the corresponding project. This does not imply that the other two phases were not part of the project. Each chapter is of interest in several different respects. Authors describe how they have addressed the genesis of a problem and possible further developments. They explain how the need for change was determined, how desired goals were selected, or how technical, social, legal, cultural and other possible means of acting were aimed at transforming existing approaches. At the end of each of these chapters, authors point out results and develop recommendations for further research relevant to other problem fields.

The chapters on cross-cutting issues deal with the overarching challenges that are relevant for most transdisciplinary projects: participation, values and uncertainties, learning from case studies, project management, education, and finally integration.

The authors describe important lines of thinking that have shaped research on these issues. They structure recent developments and directions and comment on how some of the projects described in the Handbook deal with the issues.

As a guide to the reader the following figure (Fig. 1.1) matches the chapters on cross-cutting issues and project chapters. The columns of the table represent the cross-cutting issues. The issue of integration has been split into two columns to provide more specific information. The rows of the table contain the individual project chapters. Grey cells indicate that an issue is discussed in detail in a particular chapter.

The summary and outlook section encompasses a list of core terms used in transdisciplinary research and a synthesis of the Handbook's contents in 15 propositions for enhancing transdisciplinary research. The description of the core terms provides a conceptual synthesis of transdisciplinary research, while the propositions summarise strategic elements.

1.4 The Contents of the Handbook

In this section, we briefly describe the chapters in the following three parts of the Handbook: research projects, cross-cutting issues, and finally a 'summary and outlook'.

We consider eight projects to be of special interest with regard to the way they address problem identification and problem structuring: two large-scale programmes on rural development and natural resources, two projects on urban development, two projects on ecological (biodiversity) issues, and two projects on emerging sciences and technologies. These projects address the challenge of defining the proper object for research and of establishing an adequate conceptual framework from different angles.

In Chapter 3, Bruno Messerli and Paul Messerli describe UNESCO's worldwide Man and Biosphere programme, which was launched in the 1970s. This project can be seen as a pioneer project within transdisciplinary research, since it was based on transdisciplinary thinking long before the term 'transdisciplinarity' became popular. The Swiss Man and Biosphere programme stimulated research that integrated natural and social sciences in order to understand and shape the socio-economic development in mountainous regions, while taking into account the ecological carrying capacity. The Swiss programme was based on a recursive approach to problem identification and problem structuring. It combined a careful analysis of the system dynamics with target knowledge about land use, desired aesthetic and recreational qualities and transformation knowledge about key factors that could be utilised to develop management options. In the 1980s, a participatory process was initiated to develop a long-term strategy. Since then, similar concepts such as the Syndrome Mitigation Approach have been applied in developing countries and in mountain research programmes, and since the 1990s, with a particular emphasis on global change.

Projects		Cross-cutting Issues						
		22 Participation	23 Values and Uncertainties	24 Learning from Case Studies	25 Management	26 Education	27 Integration: Concepts	27 Integration: System Analysis
Problem Identification and Problem Structuring								
3	From Local Projects to Global Change							
4	Sustainable River Basin Management							
5	Designing the Urban							
6	CITY:mobil:							
7	Shepherds, Sheep and Forest Fires							
8	Fischnetz							
9	Nanoscience and -Technologies							
10	Chimeras							
Problem Analysis								
11	Multilateral Environmental Agreements							
12	Climate Protection vs. Economic Growth							
13	Policy Analysis and Design							
14	Regional Development Strategies							
15	Evaluating Landscape Governance							
16	Children and Divorce							
Bringing Results to Fruition								
17	Health Services for Nomadic Pastoralists							
18	Water Associated Infection Risks							
19	Behavioural Sciences in the Health Field							
20	Coexistence of Ungulates and Trees							
21	Retrofitting Postwar Suburbs							

Fig. 1.1 Cross-cutting issues (chapters 22–27) in projects (chapters 3–21)

The programme ‘Sustainable River Basin Management in Kenya: Balancing Needs and Requirements’ (Chapter 4) by Boniface P. Kiteme and Urs Wiesmann, focuses on integrated water resources management in the upper Ewaso N’giri catchment of Mount Kenya in Kenya. In this region the socio-economic dynamics and ecological processes over the past decades have resulted in a water crisis that poses a major sustainability problem in the catchment. The authors describe the impact of the societal and political context on the restructuring of the research programme: starting with ‘Research for District and Project Planning’; then ‘Broader topical and geographical scope to respond to sustainability requirements’; and further implementation and consolidation of knowledge by the combination of scientific knowledge systems and local knowledge system. These steps in recursive problem identification and structuring broadened the understanding of the main challenge of sustainable river basin management and provided useful insights into designing a multistakeholder, multilevel strategy. The approach is validated by the project being extended from the test area to other regions.

The projects on urban development propose frameworks for integrating perspectives of design, engineering and planning with analytical perspectives from the natural and social sciences. ‘Designing the Urban: Linking Physiology and Morphology’ (Chapter 5) by Peter Baccini and Franz Oswald focuses on a conception of urban development in the Lowlands of Switzerland that meets the requirements of sustainable development. Two types of perceptions were combined when formulating the questions with regard to the fabric of new urban systems: the morphological approach, based on urban planning experience; and the physiological approach, based on natural science, engineering and economics. The authors describe the process of interdisciplinary learning to arrive at a common system approach ‘Netzstadt’. The urban system is defined by a limited set of elements, by four basic activities and by five essential system qualities. Methods and design tools for the reconstruction of urban systems aim at reducing the complexity of the mutual relationships between activities, territories and resources. The quality goals for a concrete urban project have to be determined by a participatory political process that ensures support and commitment. This procedure is systematised as the Synoikos method.

‘CITY:mobil: A Model for Integration in Sustainability Research’ (Chapter 6) by Matthias Bergmann and Thomas Jahn was realised in an interdisciplinary cooperation between engineers, planners, sociologists, and economists and was supported by the administration of the two German model cities of Freiburg and Schwerin (CITY:mobil). To disentangle the strong connection between ‘mobility’ and ‘automobility’ a three dimensional concept of mobility was developed. This was based on the idea of mobility/motion as a fundamental societal relation to nature mobility; of ‘spatial mobility’ in the sense that transportation is a technical realisation of transport; of ‘socio-spatial mobility’ in the sense of the movement of people between locations and the social purposes pursued therein; and of ‘socio-cultural mobility’ in the sense that the distinctive meanings of mobility and means of transportation have consequences for social positioning. Within this framework the research process was guided by the differentiation of interdisciplinary cooperations,

by the integration of knowledge from research and practice into concepts of agency; and by the intervention, using the integrated results, into the practical and scientific discourse of urban transportation policy and planning.

The ecological projects have developed procedures for problem framing and structuring and focus on agents and agencies. ‘Shepherds, Sheep and Forest Fires: A Reconceptation of Grazingland Management’ (Chapter 7) by Bernard Hubert, Michel Meuret and Joseph Bonnemaire deals with grazing in the Mediterranean rangelands of southern France, which are subject to scrub encroachment. The authors describe five steps for identifying and structuring the research objects in such a way that biological processes are coupled with the farmer’s management strategies. Firstly, it is necessary to identify an ecological problem. Secondly, the problem is reformulated with regard to the relevant agents and their practices. Thirdly, the research problem is focused. Fourthly, the problem-solving instrument is designed, and finally (innovative) research questions are addressed that investigate the processes related to the proposed problem-solving instruments. The chapter gives an example of how research on issues of practical relevance develops along the margins of disciplines through interdisciplinary cooperation and confrontation, causing disciplinary frameworks to evolve by inducing a reflexive process in the research activity.

‘Fischnetz: Involving Anglers, Authorities, Scientists and the Chemical Industry to Understand Declining Fish Yields’ (Chapter 8), described by Patricia Burkhardt-Holm, documents the health status of brown trout and the decline in fish numbers, the identification of causes and suggested measures for correction. The network of participants was central to the integration of already existing data and know-how and a prerequisite for jointly identifying knowledge gaps. The chapter describes the role of a network in formulating hypotheses and research questions and in initiating research projects. Collaboration throughout the project ensured an efficient exchange of results, ideas and conclusions leading to the setting of new priorities and to an agreement on further procedures and proposed measures.

Two projects focus on problem identification and structuring in the field of emerging sciences and technologies. In Chapter 9, Arie Rip describes the application of Constructive Technology Assessment to nanoscience and nanotechnologies. To enable reflexive co-evolution of science, technology and society, it is crucial to bridge the gap between actors in the life-world and nanoscientists and technologists. Interactive reflexive learning is required to develop better technologies in a better society. These activities encompass the mapping and analysis of the ongoing dynamics as well as an articulation of socio-technical scenarios about further developments, impacts and real-time experiments.

In Chapter 10, ‘Chimeras and other Human–animal Mixtures in Relation to the Swiss Constitution: A Case for Regulatory Action’, Hans-Peter Bernhard and Rainer J. Schweizer analyse a problem in the making: the artificial creation of human–animal mixtures for research and therapeutical purposes. Not surprisingly, normative elements are of crucial importance in this debate, but knowledge of biomedical research agendas is equally essential. To achieve a mutual understanding of the underlying biological facts and the arising normative issues, researchers followed an iterative process. They clarified definitions to achieve a commonly

accepted terminology and to reach an agreement on the pertinent problems. Such an understanding is a prerequisite for timely legislation.

We consider six projects of special interest with regard to problem investigation. Four of these describe the use of some kind of systems analysis to produce target knowledge, which reflects the systemic relations of problem development or the systemic relations that play a role in transformation. These chapters demonstrate how feedback about implementation and recurring adaptations of problem structuring can improve the results. The remaining two projects deal with issues of global change and regulation. 'The Development of Multilateral Environmental Agreements on Toxic Chemicals: Integrating the Work of Scientists and Policy Makers' (Chapter 11) by Nuria Castells and Ramon Guardans, is based on examples of recent Multilateral Environmental Agreements concerning environment and health. The authors argue that the procedures established in the framework of these agreements provide a solid international base for stable and effective scientific, industrial and political cooperation. Emphasis is put on involving relevant stakeholders and on institutional innovations from the national to the international and global scale. When developing and using Integrated Assessment Models in the design of policy scenarios, the cost of implementing commitments should be estimated *ex ante*. Transdisciplinary cooperation is a prerequisite for handling complex environmental problems and for designing effective abatement scenarios. *Ex post*, in the implementing phase, cooperation among all stakeholders (scientists, policy makers and civil society) is required.

In 'Climate Protection vs. Economic Growth as a False Trade off: Restructuring Global Warming Mitigation' (Chapter 12), Hermann Held and Ottmar Edenhofer describe methods for Integrated Assessment of climate change mitigation. The project addresses the intertemporally optimal mix of investments into energy efficiency, transformation to renewable energy sources and carbon capture and sequestration. A social optimum is determined, consistent with economic growth theory, in such a way that certain boundary conditions related to the evolution of the climate system are observed. The project integrates paradigms from natural science, economic growth theory and engineering, which shape the public debate by a delicate entanglement of target knowledge and systems knowledge arguments. Therefore, the clarification not only of the validity, but also of the category of those arguments, is addressed. The project identifies stylised climate policies that comply with both systems knowledge and presently competing target knowledge bases of various interest groups and thereby catalyses a societal consensus on climate policy.

Two projects use systems analysis in problem investigation to deal with regional issues of sustainable development. Chapter 13, 'Policy Analysis and Design in Local Public Management: A System Dynamics Approach' by Markus Schwaninger, Silvia Ulli-Beer and Ruth Kaufmann-Hayoz, portrays the strengths and limitations of the computer assisted theory building approach of System Dynamics and Group Model Building. A tested system dynamics simulation model helps to address solid waste management issues. The model structures dynamic interaction between public policies and environmentally relevant behaviour, as well as public management problems, which are important for the design of effective policies. The

study generated knowledge about system structure and transformation processes, and a computer based learning environment and a communication tool for political decisions. It is pointed out that transdisciplinary collaboration in action research has proven crucial for the societal relevance of problem oriented research and for societal learning processes.

The chapter, 'Constructing Regional Development Strategies: A Case Study Approach for Integrated Planning and Synthesis' (Chapter 14) by Alexander I. Walter, Arnim Wiek and Roland W. Scholz, presents a transdisciplinary integrated planning and synthesis (TIPS) approach. This is illustrated by a case study on sustainable regional development in a typical central European rural landscape, struggling with problems of structural change and migration. Numerous officials, representatives and inhabitants of the region, scientists and graduate students have been involved throughout the research process. TIPS puts emphasis on an integrated overall project architecture, which starts from a division (faceting) of the case, and then uses system analysis and variant construction for the problem investigation procedure. For implementation, which is closely linked with investigation, the preferences of the stakeholders are evaluated through multicriteria procedures. The results from the different facets are integrated to formulate possible development strategies for the region.

Other approaches for integrating the diversity of relevant perspectives and grasping the complexity of the problem focus on integrating different scientific cultures to investigate empirical effects of policies. Two projects, one on landscape management, the other on divorced parents and their children, address the empirical effects of implemented legal regulations. In Chapter 15, 'Evaluating Landscape Governance: A Tool for Legal-Ecological Assessments', Marianne Penker and Hans Karl Wytzens describe an interdisciplinary approach for the systematic identification and evaluation of the ecological effects of legal regulations. The concept draws on the fact that legislation has no direct effect on the landscape, but has the ability to influence human activity. The project is therefore based on (legal) socio-economic factors, e.g. awareness of the law among those subject to it, and on (landscape) ecological factors, e.g. the effects of behavioural change on flows of material and energy. The applicability and feasibility has been demonstrated by three case studies. The impact mechanisms that were identified could help to improve the instruments' effectiveness. An *ex ante* evaluation of policies and legal regulations may even help to involve diverse stakeholder views in the process of policy design. This could minimise the unintended destruction of both socio-economic and ecological development options.

In Chapter 16, 'Children and Divorce: Investigating Current Legal Practices and their Impact on Family Transitions', Heidi Simoni, Pasqualina Perrig-Chiello and Andrea Büchler investigate the implementation of the revised Swiss Divorce Law in current judiciary practice and its effects on the course of life of affected children and their parents after the divorce. Data were collected simultaneously at three levels: firstly through analysis of court files and interviews with judges; secondly from written interviews with divorced parents; and thirdly from in-depth interviews with children and parents. The problem investigation had to ensure that all objections and

perspectives of jurisprudence, psychology and sociology were incorporated into all parts of the project study and into the respective instruments for data collection. Through the discussion of the legal framework, its implementation and the everyday life of all parties involved, adequate knowledge will be gained about the best interests of the children, and children's rights. There is a close relationship between normative perceptions and persuasions on the one hand, and the acting and experiencing, on the other hand.

We consider five projects of special interest with regard to bringing results to fruition. Three projects deal with the iterative design and implementation of health services and education – two of them in Africa and one in Eastern Europe. The project, 'Towards Integrated and Adapted Health Services for Nomadic Pastoralists and their Animals: A North–South Partnership (Chapter 17) by Esther Schelling, Kaspar Wyss, Colette Diguimbaye, Mahamat Béchir, Moustapha Ould Taleb, Bassirou Bonfoh, Marcel Tanner and Jakob Zinsstag, was undertaken in Chad and starts from the concept of 'one medicine' – promoting a joint approach to human and veterinary medicine in order to develop adapted health and education systems for pastoralists. The strategy is one with strong action research components and comprises five stages: (1) the programme was launched and trust was built up by establishing institutional partnerships, interdisciplinary collaboration and stakeholder dialogue on the basis of accounted principles for North–South collaborations, (2) the inter- and transdisciplinary research into epidemiological pathways to disease and the identification of control strategies that are appropriate to the nomadic way of life, (3) the implementation began with four national workshops to formulate health service priorities and options, to readjust ongoing interventions and to discuss policy issues and strategies for ownership building, (4) joint vaccination campaigns for people and livestock were implemented with the help of local, trained staff with a strong commitment. Information campaigns were followed by an evaluation of the feasibility and costs, and (5) ensured subsequent regional activities and continued research.

Chapter 18, 'Sustainable Prevention of Water Associated Infection Risks: An Awareness Campaign Using Visual Media' by Anne Luginbühl, deals with infections that are associated with water–skin contact. These diseases are prevalent in tropical and subtropical environments. Within the project, environmental, socio-cultural and behavioural factors were examined to develop an effective awareness campaign based on local communication patterns. Qualitative and quantitative methodologies were used to identify the local populations' systems knowledge about infectious diseases. Based on these findings, a visual awareness campaign was developed to target illiterate population groups. To ensure that the information could be understood by the target group, the local population assisted in the design of the health education material.

In Chapter 19, 'Behavioural Sciences in the Health Field: Integrating Natural and Social Sciences', Bettina F. Piko and Maria S. Kopp describe the application of behavioural health sciences to increase understanding of health issues, and aid both prevention and therapy. The project is based on a framework called the 'biopsychosocial' model of human processes, which considers external and internal, genetic and environmental, somatic and psychosocial factors to be equally important

in determining health and in inducing disease. The chapter outlines three elements of an integrated strategy, each building on the other with multiple feedback systems: first, to create an integrated course under the name ‘Behavioural Science’ in which students in the field of medicine and health sciences can be provided with a set of social and behavioural sciences, as applied to medicine; second, to develop a health status monitoring system by means of two surveys (Hungarostudy, which collects data on the health status of the Hungarian adult population; and South Plain Youth Study, which gathers data on the health status of the adolescent population); and third, to apply theoretical knowledge and empirical research results in the field of practice, in this case, practical prevention programmes and skills development training.

Two projects focus on models for developing a common understanding of the problem and for consensus building among stakeholders about effective measures. Chapter 20, ‘Sustainable Coexistence of Ungulates and Trees: A Stakeholder Platform for Resource Use Negotiations’ by Karin E. Hindenlang, Johannes Heeb and Michel Roux, addresses browsing by ungulates as a major problem for tree regeneration in Alpine forests. This chapter describes a ‘platform for resource use negotiation’ for solving such a regional forest–wildlife conflict in a mountainous environment. Collaborative learning was used to develop a common understanding of the systemic structure of the problem and an agreement on the management aims. Preconditions for successful solution include the recognition of a conflict situation combined with strong interest from the concerned parties – foresters, hunters, farmers and conservationists – to solve conflicts. Their representatives must be willing to participate according to the agreed principles of communication. Process related success factors include the creation of mutual trust; sufficient time for building a broad common knowledge base about the problem; and the development of a common understanding of the systemic structure with the help of mental modelling. A transparent procedure that motivates participants to cooperate further was also essential.

In Chapter 21, ‘Retrofitting Postwar Suburbs: A Collaborative Design Process’, Carole Després, Andrée Fortin, Florent Joerin, Geneviève Vachon, Elise Gatti and GianPiero Moretti tell of the five year research and planning process that focused on the future of Quebec City’s aging postwar suburbs. The project was initiated by the Interdisciplinary Research Group on Suburbs (GIRBa). GIRBa’s ultimate aim was to generate knowledge that could be applied to urban design, planning, management and policy making. The transdisciplinary and collaborative research process was adopted to establish a consensual diagnosis, define planning objectives and to design a master plan for Quebec City’s first ring suburbs. The chapter outlines the procedure and evaluates the success of the transdisciplinary process on reaching, and sharing, a better understanding of postwar suburbs, on the planning and policy orientations of the involved institutions, as well as on generating ongoing collaborative work between participants.

The ‘cross-cutting issues’ section of the Handbook focuses on the overarching challenges of transdisciplinary projects: participation, values and uncertainties, learning from case studies, project management, education, and integration. Chapter 22, ‘Participation’, by Aant Elzinga, begins with a historical perspective