METHODOLOGY OF TRANSDISCIPLINARY RESEARCH

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Contents

Summary

Transdisciplinary research for sustainability investigates problems on a descriptive, normative and operational level. It not only produces knowledge about empirical syndromes in life-support systems (systems knowledge), it is also expected to produce both the knowledge required about the targets of agency and evaluative principles for analyzing the effects of such agency targets (target knowledge). Furthermore, transdisciplinary research also has to respond to the need for a third type of knowledge in this context, i.e. knowledge about the necessary conditions and strategies for changing undesired processes and enforcing desired processes (transformation knowledge). Given that sustainable development involves societal problem-solving based on research, the knowledge held by non-academic actors has an important role to play throughout the process of knowledge production. A number of focal areas exist within the practice of transdisciplinarity that are tied to specific methodological

challenges and hence result in different types of transdisciplinary research. The systematicity approaches develop general concepts and methods for the ordering of research questions and integration of heterogeneous knowledge originating from different disciplines operating on normative, operational and descriptive levels. The challenges here include doing justice to the interdependency of systems, target and transformation knowledge and dealing with the problems arising from uncertain knowledge and the accompanying incommensurability of concepts and methods. The trade-and-negotiate approaches describe research, knowledge production and the development of technologies from the perspective of an observing (social) scientist with the emphasis on extra-methodical aspects, such as the social factors behind successful transdisciplinary research. Research investigates and reconstructs the (social) process, in the course of which knowledge has become accepted. Ultimately, what is seen as a good technical solution to a problem in this context is viewed as a successful outcome achieved through "social" forces, such as power, trust, law etc. The learning approaches are target-group oriented and aim to develop actors' problem-solving competencies. It is a question here of working with the actors in transdisciplinary projects to identify issues of regional relevance and of developing the necessary knowledge and skills to resolve the problems. Thus, a core concern within these approaches is participatory consultancy and development, for which a strong need exists in the context of developmental cooperation and Local Agenda 21 projects.

1. Introduction

The sustainable development model and the need for research arising from it was developed out of concern for the threat to life-support systems and associated social conflicts arising from the new and ever-increasing uses of nature to sustain growing populations. At its core, the sustainable development model incorporates an obligation to use the natural, social and economic life-support systems for human welfare in such a way that the continued existence of these life-support systems is not threatened and priority is given to the needs of the poor. In this context, "development" includes human activities that are directly or indirectly related to the use of life-support systems, while "sustainable" or "sustainability" describes normative principles or criteria for the evaluation of this activity with respect to its effects and objectives.

What research is expected to do in this context is, firstly, to provide information as to whether and how the global and local changes in natural, social and economic systems are related to use practices, and whether and how changes in the different systems affect each other (systems knowledge). It then is a question of clarifying what exactly sustainable development means and how concrete use practices should be evaluated from the perspective of sustainable development (target knowledge). Finally, information is also required on how use practices can be changed or technically improved and how their implementation can be better regulated (transformation knowledge).

Causal knowledge, i.e. empirical and theoretical knowledge, is required to enable the description and explanation of processes in the life-support systems and how they relate to use practices. In many cases, it is not possible to meet this knowledge requirement through disciplinary research because numerous heterogeneous and coincidental factors

can be involved which the disciplinary theoretical models do not take into account. As Ludwik Fleck and Thomas Kuhn pointed out, scientific disciplines build cognitive units based on joint research concerns, theories, models and methods. These are shared by a scientific community as a social unit, which institutionally regulates the collaboration and communication between disciplines as well as the education of the next generation of academics. Disciplinary research is based on the cognitive progress made with respect to the research questions, theories, models and methods, in the area thus described, in accordance with recognized standards and is in the process of increasing specialization. In its observation, description and explanation of phenomena it reduces the range of aspects and possible correlations in the interest of more general knowledge, i.e. knowledge that is independent of temporal and spatial dimensions. What is involved here are idealizations based on simplifying assumptions that are only fulfilled under controlled conditions. Although in many respects the research required on sustainable development needs a disciplinary approach, transdisciplinary research is also necessary because the problems are resistant to the cognitive structures that prevail in the sciences and may be dependent on specific spatial and temporal factors. This is particularly true when it comes to understanding and designing real processes in concrete life-support systems, to which – for the aforementioned reasons – laboratory knowledge should not be applied untested.

As already stated, research for the conservation of life-support systems includes the evaluation and design of use practices from the perspective of sustainability. Thus, in order to fulfil the social need for orientation and action, the information requirement encompasses moral, technical and institutional knowledge. This means that knowledge from the entire spectrum of academic disciplines, i.e. ranging from the natural and social sciences to engineering and the humanities, may be required. This knowledge does not take the form of reliable off-the-peg solutions readily at the disposal of actors in public bodies, business and civil society, because it is knowledge of an uncertain nature. The uncertainties arise for a wide variety of reasons. For example, they can exist at the level of data – data can be lacking and problems can also arise with its quantifiability or interpretation. Uncertainties may also arise as a result of the application of different approaches to the modelling of data in mathematical models. Problems with the mathematical description of the non-linear dynamics of systems represent another source of uncertainty as does the application of unknown or dubious explanatory principles to the processes in question. Finally, it should be noted that the evaluation of processes, i.e. the determination of their benefits and risks in the broad sense, is not usually unambiguous and involves decisions based on estimations, consideration and appraisals. Thus, in view of competing requirements, action orientations and practices, it is impossible for research to provide clear answers to questions concerning optimum use practices (see Methods for Sustainability Assessment: Sustainability Indicators).

Problems concerning sustainable development cannot ultimately be solved by research, but only in collective life-practice, possibly with the support of knowledge from research – in other words in real experiments. To effectively meet the knowledge requirement for the conservation of our life-support systems in line with sustainable development, the situation of the users of knowledge must be taken into account. To do this, it may be necessary not only to transcend the boundaries between scientific

disciplines, but also to open the academic research process to actors in public bodies, business and civil society and go beyond the purely academic definition, analysis and interpretation of research problems. Whether anything at all – or what precisely – is achieved in the matter of sustainable development is ultimately dependent on the will, knowledge and ability of actors in public bodies, business and civil society from the local to the global level. Will, knowledge and ability influence each other. If understood as commitment, as opposed to mere wishful thinking, the will requires possibilities for action that must be supported by knowledge so that the desired effects can be achieved. Thus, research and social and economic processes develop mutual interdependencies. Research in the form of an expertocracy should not replace political decision-making in the context of economic and social matters, nor should research be entirely instrumentalized by political interests. Research is responsible for the knowledge bases necessary to find decisions that do justice to the poor and to future generations, political responsibility, however, is in the hands of the political actors. To be able to fulfil its research tasks, science must be related to political problems without, however, allowing itself to become an instrument of party politics.

This variety of problems, participants, interdependencies and expectations makes transdisciplinary research for sustainable development a highly diffuse matter when viewed from the outside. As a recent venture which emerged with the awareness of the risks faced by modern society, transdisciplinary research sometimes is more strongly based on promises than proven concrete achievements. In the remaining sections of this paper, the complex and contested field of transdisciplinary research will be explored and systematized from conceptual and methodical perspectives. While it is possible to make a distinction between different types of transdisciplinary research, it is not, however, possible to present a general paradigm.

2. A Typology of Transdisciplinary Research

Transdisciplinary research is a broad, colorful, and highly contested field. The label "transdisciplinary" can be found attached to the most wide-ranging projects. This is due to the variety of problems dealt with by transdisciplinary research, the different expectations with respect to the research and the heterogeneity of the participants from science and practice involved in this research. Thanks to the diversity arising from these factors, transdisciplinary research lacks the precise elements that underlie the strength and performance of disciplinary research: transdisciplinary research does not form a cognitive unity based on the common research issues, theories, models, and methods shared by a scientific community as a social unit. Co-operation and communication are regulated on a project-related basis and, as a general rule, they do not outlast the context created by the project. The next generation is trained "on the job" and thus the training remains closely linked with personal experience which, because of professional mobility, is seldom passed on and is also seldom systematized. In the context of research subsidies, applications which serve the systematization and development of concepts and methods have had little chance of success up to now, unless they were developed within the framework of special programmes.

The task of transdisciplinary research can be defined at different levels. Transdisciplinary research can, firstly, be related to the dialogue between science and

society and to the implementation of the results of scientific research. Thus it concerns communication with society. Secondly, transdisciplinary research can be related to reflection on processes in society and the economy and is therefore located at the level of studies. Between these lies the level of problem-related and integrative research which is concerned with both the description and analysis of processes and with action strategies. These tasks may differ, but they can often – and should – be complementary.

A single definition of transdisciplinarity cannot do justice to this variety. A normative definition, which prescribes the use of the concept, will be based on an arbitrary one-sidedness. The use of such a definition may be unavoidable in a concrete research context; however, it is not legitimate as a general definition. As opposed to this, a descriptive definition which takes into account the wide-ranging use of the term and identifies the common features from the diverse elements is not very informative. In fact, these common features are largely restricted to the integration of various disciplinary perspectives in transdisciplinary research, which provides the basis for the distinction between transdisciplinary research and multi-disciplinarity as a set of different and unconnected perspectives on a common theme. Different views already exist on the following issues which are frequently cited in definitions of transdisciplinary research (see Unity of Knowledge and Transdisciplinarity: Contexts of Definition, Theory and the New Discourse of Problem Solving, see Unity of Knowledge in Transdisciplinary Research for Sustainability):

* whether or not transdisciplinary research aims to achieve a holistic view of the problem being studied (holism);
* whether or not it relates to real-world problems (i.e. problems external to science) (problem orientation or issue orientation);
* whether or not it involves actors from non-scientific fields (participation);
* whether or not it primarily serves the implementation of research results and the development of concrete solutions for practice (practical knowledge);
* and, finally, whether repeated cyclical modification of basic observations in relation to research issues, study methods and interpretation concepts arise in the course of the research (process nature of research).

These issues are not, however, generally identified as the defining features of transdisciplinary research and are not exclusively applicable to transdisciplinary research.

Due to the lack of a common paradigm for transdisciplinary research which would provide a basis for an adequate definition and systematization of the research area with respect to conceptual and methodical perspectives, the range of approaches in transdisciplinarity is organized here in the form of a typology. This typology takes account of the different contexts in which research is carried out on a transdisciplinary basis. It also takes into account that transdisciplinary research involves a problem of unity on three different levels: the cognitive level of the knowledge system, the social level of the research community, and the level of the competencies of the individuals involved (see Unity of Knowledge in Transdisciplinary Research for Sustainability). Of necessity, the three types set one-sided perspectives among the above-listed features of transdisciplinary research. The typology does not provide a crystal-clear and

comprehensive classification; such claims do not make sense in an emerging field like transdisciplinary research for sustainability. The three types, which we have defined as the systematicity approaches, the trade and negotiate approaches and the learning approaches, have the status of ideal types which render the differences between complex transdisciplinary research problems comprehensible. Table 1 provides an overview of the features of the three types: they share some common features with the typologies devised by Funtowicz & Ravetz and by Becker et al. (see Transformations of Social and Ecological Issues into Transdisciplinary Research).

Type	**Main features**
Systematicity approaches	• Context: academic research • Focus: science-oriented • Aim: concepts and methods for transdisciplinary research • Level: concepts and methods for analysis and synthesis • Challenge: to design a knowledge system including systems knowledge, target knowledge, and transformation knowledge from various disciplines that is reliable for real world issues
Trade and negotiate approaches	• Context: Science and Technology Studies • Focus: Production and forming of knowledge and technologies • Aim: to analyze the social conditions and consequences of knowledge and technologies • Level: social intentions and implications • Challenge: to organize settings for “socially robust knowledge”
Learning approaches	• Context: development cooperation, local Agenda 21 projects etc. • Focus: actor-oriented • Aim: mutual learning of experts and practitioners/actors • Level: competencies of individuals • Challenge: to contextualize knowledge and commitments

Table 1: Typology of approaches in transdisciplinary research for sustainability

Of the three types, the systematicity approaches are most closely related to the classical cognitive objective of academic research in that they involve the systematization of knowledge, i.e. a method and conception based cognitive unity of knowledge. Approaches in the tradition of general systems theory and systems dynamics try to stucture and model the complex interactions of a multitude of parameters in certain regional problem areas as it is the case with the "syndromes of global change" (see Transdisciplinary Research in Development Cooperation: Origins and Paradigms) or in the earth system as a whole, "earth system analysis" for instance (see Systems Analysis

and Modeling in Transdisciplinary Research). Other approaches combine substantial theorems of selected disciplines in a more integrated explanatory approach, as it is the case with ecological economics, human ecology, or the institutional approaches that deal with the regimes for the use of natural resources. Some approaches explicitely address how to deal with specific contextual conditions, others develop a methodology how to take into account the values of stakeholders involved.

The general aim of research for the sustainability transition is to understand the interactions between socio-economic and technical systems, on the one hand, and environmental systems, on the other hand with respect to their evaluation and transformation according to the sustainability model. Therefore, it is possible to identify different focus areas among the systematicity approaches. The focus may lie, firstly, on the understanding of the origin and development of the problem, i.e. systems knowledge. The "syndromes of global change", for example, model the genesis and dynamics of developments, which are deemed as overtly unsustainable and derive the transformation knowledge required for the avoidance or transformation of such developments from the identified functional dependencies. Transdisciplinary projects may also have target knowledge as their central focus as is the case, for example, with "embedded case study methods", which focus on the evaluation of existing action options in regional issues and to do this refer to pertinent systems knowledge. An approach on the global scale addressing climate policy is the "Tolerable Windows Approach" (TWA), which is used in a project on "Integrated Assessment of Climate Protection Strategies" (ICLIPS). Besides, there exist various methods for sustainability assessment (see Methods for Sustainability Assessment: Sustainability Indicators). If the focus is on transformation knowledge, the problem definitions and research questions are about activities of the society to fulfil basic human needs and the corresponding technologies, such as nutrition, transport, housing and others. There are approaches in this line that develop the substance flow analysis in transdisciplinary directions by integration economic and social aspects in the analysis. Other approaches are based on theories of action in social sciences, as it is the case with the "integrative concept of sustainable development", elaborated at the Helmholtz Association of German Research Centers, and the "need-field approach" of the Swiss Priority Programme "Environment". They focus on collective and individual options for a more sustainable fulfilment of human needs, taking into account systems knowledge and target knowledge.

The "Science and Technology Studies" (STS) describe transdisciplinary research projects, knowledge production and the development of technologies from the perspective of an observing (social) scientist. They are described as "trade and negotiate approaches" hereafter, because the emphasis is on social factors for successful transdisciplinary research, encompassing the cooperation of experts from various disciplines as well as the communication with stakeholders. "Trade and negotiate" is the label for how interactions and processes, in the course of which "socially robust knowledge" emerges, are analyzed. The claim is that successful collaboration neither needs a shared paradigm among researchers nor a consensus among stakeholders about how things are and should be. Instead, participants are said to interact with their proper set of practices and meanings at a mainly metaphorical level in addressing the common boundary objects (a "boundary object" is a common material or abstract object to which the different disciplines in a project refer to). Socially robust knowledge, that is

technologies or practices, which are developed by "trade and negotiate" approaches, requires that the social forces (such as power and trust) are made explicit and are included equivalent to technical factors or natural forces into the process of problem solving.

The learning approaches primarily target sustainable development actors in practice and their aim is to develop the skills and willingness of the actors to resolve societal problems. This usually necessitates a process of mutual learning between experts and practitioners as context-related factors known only to the practitioners may have an important role to play. This type of approach is common in development cooperation where it is being adopted as an alternative to the often ineffectual technology-transfer and traditional expert-consultancy approaches (see Transdisciplinary Research in Development Cooperation: Origins and Paradigms); it is also common in local Agenda 21 processes in industrial countries, in which the main focus is the identification of regionally relevant issues and the joint development with actors of the necessary knowledge, competencies and will to resolve problems. New policy forms also arise in this context.

The conceptual and methodological problems of the different approaches in transdisciplinary research are described in greater detail in the next section. The differences, similarities, transitions between these approaches and their combinations emerge more clearly in the course of these descriptions.

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Biographical Sketches

Gertrude Hirsch Hadorn, born in 1953, is Professor at the Department of Environmental Sciences of the Swiss Federal Institute of Technology Zurich, Switzerland and Private-docent in philosophy at the University of Konstanz, Germany. She got a Ph.D. in educational sciences at the University of Zurich in 1989 and replaced the chair in ethics at the University of Göttingen, Germany in 2000. Her research interests actually include the philosophy of environmental sciences, concepts and methodology of transdisciplinary research and environmental ethics. Her publications include articles and a book on environmental ethics (Umwelt, Natur und Moral. Freiburg: Alber 2000) and various articles on philosophy of science and on transdisciplinary research.

Christian Pohl, born 1966, is lecturer at the Department of Environmental Sciences of the Swiss Federal Institute of Technology (ETH) Zurich, Switzerland. He is also Co-Executive-Director of the Transdisciplinarity-Net of the Swiss Academies of Sciences in Bern, Switzerland (www.transdisciplinarity.ch). After studying environmental sciences at ETH and a PhD in the field of ecological assessment, he explored the collaboration between natural and social sciences in environmental research. His present research interest and his main field of publication is the design and methodology of transdisciplinary research (Gestaltungsprinzipien der transdisziplinären Forschung - Ein Beitrag des td-net. München: oekom 2006, co-authored with Gertrude Hirsch Hadorn)

Martin Scheringer, born in 1965, received a diploma in chemistry from the University of Mainz, Germany, a doctoral degree in natural sciences and a habilitation in environmental chemistry and chemical engineering from the Swiss Federal Institute of Technology (ETH) Zürich, Switzerland. Currently, he is a senior scientist with the Safety and Environmental Technology Group at the Institute for Chemical and Bioengineering of ETH Zürich. His research topics include the environmental risk assessment of chemical products, the investigation of the global distribution dynamics of Persistent Organic Pollutants, the inclusion of normative aspects into the assessment of chemicals, and the methodology of transdisciplinary research. His publications include a book on novel approaches to chemicals assessment (Persistence and Spatial Range of Environmental Chemicals. Wiley-VCH: Weinheim, 2002).