“General Ecology” or “Ecotopia Science” – Chances and Challenges of Innovative Inter- and Transdisciplinary Approaches to Sustainable Development Issues

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Abstract: Science responded to the public awareness of environmental problems and the ecology movement that began 40 years ago and ultimately developed into the vision of Sustainable Development (as expressed in various United Nations’ documents since 1987) in two ways: By establishing “environmental sciences” as special branches within existing disciplines (e.g., environmental chemistry, psychology, ethics, or history), and by defining new inter- and transdisciplinary, problem-oriented research fields. While the first type of response requires only minor changes within the disciplines and is compatible with the developmental logic of the science system, the second type necessitates more fundamental methodological reflection and institutional adaptation and therefore encounters the numerous obstacles typical for transversal missions in vertically structured systems. The EcoTopia Science Institute (ESI) at Nagoya University, Japan, and the Interdisciplinary Centre for General Ecology (IKAOe) of the University of Bern, Switzerland, are examples of the second type of innovations. IKAOe has been existing for 20 years now, and much could be learned about what it means to establish an inter- and transdisciplinary field of science, which is not intended to be a new discipline but lives of the disciplinary competences of those who collaborate on ever new real-world problems. The mission, history, organization, and future perspectives of IKAOe are briefly described and discussed. Then some key insights concerning teaching and research are presented. The current interdisciplinary study programs in General Ecology aim at enabling students of all fields to treat questions and problems of human-nature interrelations in an interdisciplinary way and to draw on their respective disciplinary competences. These programs are described and their conceptual underpinnings are discussed. With respect to research, requirements of inter- and transdisciplinary research are overviewed, and illustrative examples of research projects carried out at IKAOe are given.

Keywords: Interdisciplinarity, transdisciplinarity, problem-oriented research, study programs, environmental problems, sustainable development

1. HOW SCIENCES DEVELOP AND RESPOND TO EMERGING SOCIAL ISSUES

The progress of science takes place in two basic ways:

(1) “Curiosity driven”: Whenever scientists find out something new about their object of research, new questions will arise as a natural side effect of the insights that were produced. This leads to new research, theoretical revisions, and methodological refinements, in an ongoing recursive process. The driving forces of progress lie within science, the questions and problems to be investigated arise, e.g., from an insufficient fit between theories and empirical findings. This process, familiar to all scientists, has produced a differentiation of the science system into a growing number of specialized disciplines and sub-disciplines that all deal with well-defined and ever smaller parts of the phenomenal world. The knowledge produced by such a system risks to become more and more fragmented.

(2) “Problem driven”: Although scientists are sometimes accused to live in an ivory tower, the science system is still part of society, it is largely financed by public funding, and society expects scientific knowledge to be useful for improving human wellbeing and for solving society’s problems. This means that issues which arise in the society may call for a response of scientists; society expects them to deal with the issues, to explain them and to develop solutions. Often scientists themselves feel a certain social responsibility, and they want to respond to such expectations.

The emergence of environmental issues, the political ecology movement in the second part of the 20th century and the responses in the science system are a prime example of such “problem driven” development of science.

1.1. Environmental sciences

A first type of response of sciences to environmental issues is consistent with the structure and logic of the science system: Within existing disciplines new fields or subdisciplines and new fields of application develop. The environmental issues that are discussed in society (e.g., air and water pollution) are translated in research questions in accordance with what a discipline has defined as its objects. That is, the various disciplines focus on different specific aspects of an environmental issue and treat them within the scope of their disciplinary theories, concepts, and methodologies. The names of these approaches often contain the word “environmental” before the name of the discipline, e.g. environmental chemistry, sociology, or history.

At first – starting in the 1960s – environmental
sciences were very much confined to the natural and technical sciences. Impacts of human activities (such as industrial production or agriculture) on ecosystem functions were described, and undesired or dangerous effects were identified or anticipated. Also, general solutions were suggested and politicians and industries were called to action. Classic examples for these early responses are Rachel Carson’s “Silent Spring” [1] or Paul Ehrlich’s “Population Bomb” [2]. However, their political recommendations were difficult to implement; environmentalists became frustrated about the obvious gap between knowledge and action. It was realized more and more that environmental problems are not problems of nature or the environment but of human beings and societies. From the late 1980s responses in the social sciences and the humanities grew stronger; they typically focus on the mental, social and cultural factors and processes that cause or might solve environmental problems, but ask also more fundamental questions about the relation between human societies and nature. Examples are Herman Daly’s publications on steady-state economics [3], Riley Dunlap’s call for a paradigmatic change in sociology [4], or Howard Gardner and Paul Stern’s comprehensive analysis of human behavior and environmental problems from a psychological perspective [5].

Since that time environmental sciences have generated—and still generate—an ever increasing body of valuable scientific knowledge about environmental issues and human-nature relations. However, this knowledge tends to be fragmented and dispersed in the different scientific disciplines. In order to be “useful” for society, the fragmented pieces of knowledge have to be brought together, which calls for more integrated, inter- and transdisciplinary approaches. “Interdisciplinarity” is defined as the integration-oriented co-operation of individuals from at least two disciplines, towards common objectives, i.e., the synthesis of various disciplinary points of view. “Transdisciplinarity” refers to a special form of interdisciplinarity involving extra-scientific experts and stakeholders in research [6].

1.2. Inter- and transdisciplinary approaches

The question, what type of science would be adequate for dealing with environmental issues and questions of sustainable development gave rise to quite extended debates in theory and sociology of science, and to innovative research programs. The book by Michael Gibbons and his colleagues on “the new production of knowledge” [7], or “Mode-2”, has been receiving much attention since it was published in 1994. These authors described an ongoing transformation in the relationship of science and society, at the heart of which was a new way of producing knowledge. Mode-2 according to them is characterized by five criteria: (1) Research is carried out in contexts of application, and problems are formulated in dialogue with a large number of interests from the very beginning; (2) multiple stakeholders bring an essential heterogeneity of skills and expertise to the problem solving process taking place within loose organizational structures; (3) transdisciplinarity, a new kind of intellectual endeavor that transgresses disciplinary and institutional boundaries; (4) accountability of the “knowledge producers” to different stakeholders or users; (5) new quality criteria: in addition to be reliable, knowledge must also be “socially robust”.

In Europe, several environmental research programs were set up explicitly to realize this new type of problem-oriented inter- and transdisciplinary research. An example is the Swiss Priority Programme Environment that ran from 1992 through 2002. It was one of the first initiatives to integrate social as well as natural environmental science approaches, and to promote interdisciplinary research and the involvement of stakeholders and extra-scientific experts in the research process. In the year 2000, a large international conference on transdisciplinarity was organized in connection with this program [8].

The experiences and accomplishments of this and other programs, especially in Austria and Germany, were partly successful, but they showed also that there are several lines of potential conflict between the ideas of integrative, holistic scientific approaches and the established and successful science system built on an analytic, reductionist paradigm. The main lines of conflict can be characterized by the following polarities [9]:

- specialization vs. integration
- disciplinarity vs. interdisciplinarity
- knowledge orientation vs. problem orientation
- hard science vs. soft science
- hierarchical and sectorial organization vs. flexible network organization

These polarities don’t necessarily result in conflicts—they may be regarded as complementary and equally legitimate forms of practicing science. However, in today’s science system, one pole of the polarities is usually much more valued than the other. This is expressed, for example, in the criteria that are applied in established peer review and other formalized evaluation processes, in allocating research means, and in evaluating candidates for academic positions. Young scientists aiming at an academic career should better specialize in fundamental research in a mainstream disciplinary field, preferably in one of the “hard sciences” using experimental and formal methods, and publish a large number of short articles in highly ranked disciplinary journals. Someone working in inter- and transdisciplinary, problem-oriented projects and coming up with integrated results that are published in books and media addressed to various stakeholder groups rather than in specialized journals will hardly be considered a valuable candidate for a higher academic position. I am aware that this is a very black-and-white description. Fortunately there exist some pioneering developments and experiences, which show that change is possible. I am happy to have been able to work for 15 years now in an interdisciplinary institute that can be regarded as a pioneer in my country, just as ESI seems to be a pioneer in Japan. During the 20 years of its existence some important experiences were made.

2. THE INTERDISCIPLINARY CENTRE FOR GENERAL ECOLOGY AT THE UNIVERSITY OF BERN

2.1. The beginnings

General Ecology at the University of Bern was the result of a political initiative: In 1984 a motion was submitted to the cantonal parliament, which demanded that the University established “General Ecology” as a com-
General Ecology was described as “a comprehensive perspective on natural, human, and societal spheres”, by which science was to contribute to solving the manifold problems of industrial societies in connection with economy and politics. In Europe, the public attention to environmental issues had reached a first peak in the 1980s, which presumably made the parliament approve the motion, and the University was requested by the state authorities to implement it. This is a quite remarkable story, because, although the University of Bern is a public institution, it is very unusual that political actors intervene directly into its internal affairs; for the freedom academic research and teaching is a highly valued and uncontested principle. The story indicates how strong the public environmental concern at that time was, and it also reflects a certain mistrust of the willingness and ability of the academic system to deal adequately with the complexity of environmental issues. Subsequently, a broad discussion was launched within the University in order to find out how to realize “General Ecology” in teaching, research, and organizational respects. The result was that an interdisciplinary institute “between the faculties” was founded in 1987, headed by a full professor, and supported by an advisory board of representatives of all faculties, students, and a number of extra-academic experts.

2.2. Understanding of “General Ecology”

Since the German zoologist Ernst Haeckel had first introduced the term “Ecology” in 1866 to designate the interrelations between a living organism and its physical and biological environment, the concept has been interpreted in a number of different ways. Today the term has various meanings: “Ecology”, besides still being an important branch of biology, is also used for an integrative systems approach, for the scientific study of environmental issues or human-nature relations in general (also called Human Ecology or Social Ecology), and it is even used to name certain worldviews and value orientations, or a political (environmentalist) movement.

In the face of this variety of meanings, it was necessary to clarify what the understanding of “General Ecology” at the University of Bern should be. The following are the main defining characteristics of General Ecology as it exists today at our University:

- General Ecology belongs to science; it is neither a worldview nor a political or spiritual movement.
- The object of General Ecology is the relationship between humans (as individuals and as societies) and their natural environment.
- General Ecology is a comprehensive and integrative approach to the phenomena of human-nature interrelations, including material-energetic as well as socio-cultural aspects.

The consequence of this definition of General Ecology by referring to a broad and open range of phenomena is that it necessitates interdisciplinarity in education and research. It is an interdisciplinary domain of science that lives of the contributions of varying disciplines, in particular of environmental sciences in the above sense. It does not aspire to become itself a new discipline by establishing boundaries against existing disciplines, but it seeks to integrate the disciplinary approaches to specific phenomena of the human-nature relationship. The contributing disciplines vary according to the concrete problems and questions under investigation.

2.3. Integration of General Ecology in the organizational structure of the University

The institutional embedding of General Ecology has to take into account its inter- and transdisciplinary character, its open and broad scientific object, and its particular relationship to the existing disciplines. Since the organizational structure of the universities usually reflects the vertical differentiation of science, this represents a particular challenge. The University of Bern found a solution, which might not be the only possible or even the best one – but one that after all has been surviving for 20 years now.

The Interdisciplinary Centre for General Ecology (IKAOe) is one of the University institutes that – due to their interdisciplinary character and their coordination functions – do not belong to a faculty. Each of these institutes or centers is accompanied by an Advisory Board consisting of representatives of all faculties, mid-career scientists, and students, as well as a number of extra-University experts. For administrative purposes the Interdisciplinary Centers are taken together to form a “conference” that is analogous to a faculty.

The fact that the IKAOe is an academic structure equivalent to a “normal” faculty institute, with a full professor as its head and a suitable staff, gives it a certain academic weight and stability. Other universities have chosen mere coordination structures without genuine scientific mandate, or have assigned certain interdisciplinary functions to environmental science institutes within a faculty. These solutions seem to be much weaker and less capable to negotiate with all relevant disciplines from an equal distance and thus to sustain a flexible interdisciplinary orientation over years.

But although this particular organizational structure of General Ecology at the University of Bern has stood the test of time, certain system forces tend to work against it and make life cumbersome at times: (1) institutional memories are limited: when positions in the rectorate, the faculties, or institutes are occupied by new persons who have not personally experienced the formation of a interdisciplinary center, the knowledge of its specific mission and characteristics risks to get lost, and the center is misperceived as a “normal” discipline that should be integrated in the “normal” structures; (2) the strong accent on interdisciplinarity is often not completely understood from a disciplinary perspective; it may mistakenly be interpreted as an exclusive claim and therefore rejected, or people may downplay the challenges and value of interdisciplinarity and hence deny the need and legitimation of a special institute; (3) the interdisciplinary centers have no power base, they are weak players in the power game of the university; it is difficult to find lobbies, because the faculties are either indifferent or envious of the centers when it comes to questions of resource allocations; (4) the university administration may perceive the centers as a continuous nuisance, because they don’t fit in the grids of ordinary statistics and often need special treatment. Thus, interdisciplinary centers or similar transversal structures rely upon the political will and endorsement of
the university leaders, since suitable institutional arrangements have to be set up that enable the centers to resist such opposing system forces.

2.4. Study programs: Minors open to all students

In order to understand the complexity of human-nature interrelations and in order to mitigate and avoid environmental problems, many disciplines have to cooperate. Since no one can study all subjects and be competent in all disciplines, the study programs in General Ecology aim at providing interdisciplinary knowledge and skills that are complementary to the disciplinary specialization students acquire in their Major studies. The goal is to have future biologists, anthropologists, economists, geographers, etc., who are not only competent in their respective disciplines but are also able to bring in this competence into inter- and transdisciplinary cooperations on environmental and sustainability issues.

The study programs in General Ecology are therefore conceived as Minors open to students of all faculties and subjects. They aim at enabling students to be aware of and to reflect on their particular disciplinary perspectives and biases, and to learn how they relate to other perspectives. Students should also learn some basic facts on human-nature interrelations from different (environmental) sciences, and they should know certain overarching theories and concepts relevant for human-nature interrelations. The teaching staff is recruited not only from the IKAOe itself but from different faculties as well. However, the conceptual development of the curricula is in the responsibility of the IKAOe, and it has to be approved by the General Ecology advisory board.

Until recently, the university curricula in most countries of continental Europe were not structured in bachelor and master levels, but led within 4 to 5 years to a diploma or licentiate (equivalent to a master’s degree). The system is currently being changed (according to the so-called “Bologna Declaration” of the European ministers of education in 1999), and the curricula are divided in a bachelor level of 3 years and a master level of 1½ to 2 years. The idea is that students with a bachelor’s degree should have general competences in order to do practical professional work in their study field, while the studies on master level should prepare them specifically to do scientific research and to enter a doctoral program.

Prior to the Bologna reform, a total of nearly 350 students from the University of Bern’s seven faculties, with more than 20 different Major subjects, have completed the “old” program in General Ecology (see table 1). The fact that there are relatively few students with natural science Majors is probably due to the restrictive curricula of some natural sciences (e.g., biology and chemistry), which don’t allow the choice of Minors (i.e., students with these Majors who have chosen the General Ecology program did it as extra studies).

By 2006 the study programs in General Ecology were adapted to the Bologna system. They were differentiated in two minor programs, one on the bachelor and one on the master level.

2.4.1. Bachelor Minor in General Ecology

The general study goal of the Minor programs on bachelor level is to provide students with practice-orient-

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The curriculum has a modular structure, which allows students to chose a small, middle or large program (15, 30, and 60 ECTS credit points, respectively). Because of the various curricular restrictions of the faculties’ study orders, this flexibility is necessary in order to open up the program to as many students as possible.

The Bachelor Minor comprises six modules:

- **Module A**: Propaedeutics in General Ecology; an introductory lecture and a proseminar covering classical and recent texts from different disciplines, and training basic academic skills.
- **Module B**: Environmental science approaches; a number of lectures from various natural and social sciences, delivering basic environmental knowledge from these disciplines.
- **Module C**: Interdisciplinary group work; study and written synthesis of articles from different disciplines in groups of 3 to 5 students with different Majors.
- **Module D**: Field trips and discussions with professionals in different fields of environmental practice.
- **Module E**: Choice of lectures and seminars in a specific thematic field.
- **Module F**: A 3-month internship in a practical professional field, including a written study.

For the small program, Module A and part of Module B are required; the middle program requires Modules A through D, and for the large program, all six modules have to be completed.

2.4.2. Master Minor in General Ecology

The general study goal of the Minor program on master level is to provide students with research-oriented methodological and factual competences in General Ecology, which enable them to engage in interdisciplinary research on topics of human-nature interrelations and hereby to

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draw on their own disciplinary knowledge and skills.

The curriculum covers 30 ECTS credit points and consists of four modules:

**Module 1**: Foundations of General Ecology; 3 lectures: general introduction, natural science approaches, social science approaches.

**Module 2**: Analysis of regional environmental situations and environmental problems; 2 seminars and a written literature review.

**Module 3**: Interdisciplinary group research project; 4 students of different disciplines plan and carry out a 9-month research project; the work is accompanied by a seminar on theoretical and practical issues of inter- and transdisciplinarity.

**Module 4**: Choice of lectures and seminars in a specific thematic field.

An important didactic element of this study program is that it takes advantage of the heterogeneity of students in terms of their disciplinary background (subject of bachelor’s degree, Major program they are enrolled in on master level). Especially in the group works students are trained to become aware of the perspectives, biases, strengths and limitations of the different disciplines. They have to reflect on these aspects, discuss them, and find out what the respective contributions of the different disciplines to a specific issue may be.

2.5. Research

The IKAOe’s research activities are characterized by two aspects:

(a) Being a small institute, IKAOe had to define its own thematic focus in the vast field of General Ecology. We chose the topic of responsible environmental action for sustainable development to be our overall thematic focus. It allows the design of inter- and transdisciplinary projects with respect to different environmental and sustainability issues.

(b) Since General Ecology demands interdisciplinary cooperation, IKAOe does research on issues of interdisciplinarity and engages in coordination and consulting activities that aim at improving the quality of interdisciplinary research.

Our research activities are currently carried out within four thematic fields, which relate to the overall topic of responsible environmental action for sustainable development. For about 15 years we have been investigating into two central questions in numerous projects: (1) What conditions – internal or actor-related as well as external or structure-related – support or inhibit desired environmental actions and corresponding learning processes? (2) How can supporting conditions be produced and inhibiting conditions be eliminated?

A helpful theoretical framework for designing concrete research projects an integrating their results has been developed over the years [10] (see Figure 1).

Assimilating the basic assumptions of ecological psychology, the agent-in-environment system is conceived as a system in which the environment’s structure and the agent’s structure co-evolve through continuous perception-action cycles. In principle, the “holistic, developmental, systems-oriented” approach and research methodology worked out by Wapner and Demick [11] can be followed for analyzing such a system. It requires a structural analysis of the system’s components and a dynamic analysis of the feedback loops among them and the trends and driving forces at work. It has also to account for spatio-temporal aspects, e.g., periodicities and localities of agent-environment transactions, or the various time scales of endogenous changes within the environment or the agent. Such an “ecological approach” to the study of human experience and action with its transactional and evolutionary perspective, its definition of agent-in-environment as the unit of analysis, its consideration of cultural and physical contexts appears to be especially suited for constructing a helpful theoretical framework for inter- and transdisciplinary, problem oriented research of environmental and sustainability issues.

![Figure 1. Model framework of human action in context: The agent-in-environment system](image)

IKAOe’s four research fields can be described briefly in the following way:

(a) Acting on local and regional levels: The projects in this field focus on actors on the local and regional level, especially their rationalities, forms of cooperation, and use of institutional frameworks. The leading question is, how these actors. Through their cooperative activities, may contribute to sustainable development and how they can be supported to do so.

(b) Diffusion and effects of technical and infrastructural innovations: Technological innovations have a high potential to foster societies’ progress toward sustainability. It is not enough, however, to develop such technologies, they have also to be adopted by the relevant actor groups, and they have to be used in such a way that the intended and desired effects result. The projects in this field concentrate on different actors’ perspectives of innovative, environmentally relevant technologies and on how to promote learning processes within actor networks that are important for the diffusion of such key technologies.

(c) Education and Sustainable Development: Projects in this field look at how individual and collective actors can be enabled to participate in building a sustainable future. Also, educational and didactic concepts for
formal as well as informal teaching at different levels are developed and evaluated.

(d) Inter- and transdisciplinarity: In this field, questions relating to inter- and transdisciplinary research are investigated; it is asked what the relevant key competences are and how they can be delivered.

In all projects researchers with different disciplinary backgrounds are involved, and in most cases, there are cooperations with other research institutions. In the following I would like to describe (a) some key results of our research on inter- and transdisciplinarity, based on which a handbook for the management of inter- and transdisciplinary research groups and programs was recently published [11]; and (b) a project that investigates the diffusion dynamics of energy efficient building and refurbishment. With these examples I would like to illustrate some specific aspects of inter- and transdisciplinary research in General Ecology.

2.5.1. Requirements of inter- and transdisciplinarity

Theoretical and empirical research as well as our own experiences in managing inter- and transdisciplinary research groups has revealed certain requirements, which have to be fulfilled if the research is to be successful [6]:

Consensus: By means of suitable procedures and methods, the participants need to arrive at a shared view of problems, at common objectives, shared questions and a common approach to dealing with them, and they need to develop a common language. Here, consensus does not mean “agreement” or “authorization” in an everyday meaning, but the development of shared methods, models, and theories that integrate the various disciplinary viewpoints so that what is shared, is shared by all. For example, a shared description of the research subject needs to be developed. Of course, this requires of researchers the ability to overcome their disciplinary perspectives.

Integration (Synthesis): From the beginning, suitable methods and processes need to be combined in such a way that the results of individual sub-projects form a whole, which is more than the simple addition of individual results, and which aims at answering the common questions. Common results and products therefore need to be developed.

Management: Processes of consensus building and integration need to be initiated and monitored; co-operation within such a research group needs to be structured.

Diffusion: The results need to be adequately disseminated, and their reception with the target audience needs to be promoted. As a rule, this audience is neither disciplinary nor purely scientific, just as the channels of dissemination are often different from the disciplinary ones. The knowledge gained needs to be useful to the target audience and their activities.

In transdisciplinary research especially, it is necessary to ensure from the outset the adequate participation of end-users in the research. End-users are those at whom the research products and results are targeted, i.e., who are intended to use the products and results in their professional or everyday activities. They may be equal members of the research team or may be involved as “external participants” who do not belong to the research team, but are nevertheless substantially involved in a project, e.g., as members of a monitoring group (the term “external participants” does not apply to individuals who are the object of studies in the context of surveys, observations, etc.).

2.5.2. Diffusion dynamics of energy-efficient buildings

This ongoing project aims at analyzing and accelerating managerial and organizational adaptation processes that foster the diffusion of pioneering energy efficient technologies in the building sector. Psychological, managerial, and economic theories as well as the results of empirical investigations about antecedents of behavior choices are being synthesized into a simulation model for a middle-sized Swiss city. The model will shed light on dynamic interactions between behavioral factors (e.g., planning, decision making and routines of the relevant actors in the building sector) and contextual factors (e.g., technological innovations, public initiatives, and market conditions).

In this project we apply the Integrative System Methodology (see figure 2). The relevant actors are involved as a “system expert group” in the model building process, which consists of a stepwise procedure involving phases of literature review, empirical data collection, and model conceptualization alternating with validating workshops with the system expert group. This ensures a direct dissemination of the insights of the project and the validity of the dynamic theoretical framework. The framework – represented in the simulation model – will serve as a basis for the development of a “transformation support tool towards energy efficient buildings” for decision makers in the building sector. Based on insights from policy analysis and scenario experiments, this product will portray promising collaboration strategies and management instruments, and provide an assessment instrument for action strategies.

Figure 2. Research approach in the project on diffusion dynamics of energy efficient buildings.

Preliminary results suggest the following tentative messages:

- Convinced and decisive buy owners can influence attitudes and behavior of architects. But "standard" buy owners do not focus on energy relevant aspects
and – in the absence of an overall energy concept – tend to evaluate and decide about energy relevant elements (heating system, windows, insulation etc.) in a fragmented way.

- The cognitive maps indicate that contact and communication with people in favor of and knowledgeable about energy efficiency, as well as the opportunity to visit reference objects and talk to their inhabitants, are very important factors in the decision process.

- The workshops held so far seem to have been very inspiring for the participants. They provide an opportunity to informally share and exchange ideas and perspectives among interest groups that usually do not have contact with each other. These newly formed contacts might have a significant impact on future products of the involved persons.

3. LESSONS LEARNT
   After twenty years of experience in the interdisciplinary field of General Ecology, we may express the following insights or lessons learnt.

- Students who are interested in questions of environment and Sustainable Development find it very attractive to receive a broad, interdisciplinary training. In particular, they appreciate acquiring competences of communication and cooperation that are useful to them not only in academic but in various practical professional contexts. However, the faculties’ curricula are sometimes too rigid and don’t allow for such complementary programs. This is especially true for study programs in natural sciences on the master level.

- The concept to offer the study programs in General Ecology as Minors has proved of value. Students gain an extra qualification, which gives them a specific advantage on the job market without restricting them to environment-related jobs.

- If science is to produce “useful” and “socially robust” knowledge regarding complex problems of societies (such as environmental problems and issues of sustainable development), scientists have to acquire specific competences for inter- and transdisciplinary research in addition to their disciplinary expertise. However, the current academic evaluation and incentive systems do not adequately valuate such competences.

- Universities should establish centers of competence in interdisciplinary teaching and research that are strong enough to act as a counterbalance to the vertical differentiation of the academic system. This means that one or several full professors and their staff should act as the “core faculty” of such a centre, being responsible for designing study and research programs, and for establishing stable cooperations with faculty institutes and extra-academic partners. Such centers should also be protected – by suitable institutional arrangements – against opposing system forces.

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