Designing trans-disciplinary projects for sustainable development

Prof. Verena Winiwarter
Dean of the Faculty of Interdisciplinary Studies,
Alpen-Adria-Universität, Klagenfurt

A SHORT HISTORY OF PROBLEM-DRIVEN, TRANSDISCIPLINARY RESEARCH

After the Second World War, things got surprisingly difficult. Even, and actually, in particular, for those who had won the war. The post-war economic boom had very positive effects for some, even for many. In the United States, middle class people headed out to suburbia, while in Europe, they flocked to the beaches of the Mediterranean and started to ski the slopes of the snow-clad mountains. People could afford to, and did buy cars and refrigerators and eventually, airplane tickets to other continents. Agriculture reached new levels of area and labour productivity. But somehow, something went terribly wrong while people had a great time.

A biologist with a wide range of reading wrote a book, which called attention to the side effects of one of the major tools for the new productivity in agriculture, DDT. What had been considered a low-toxic, safe and immensely effective pesticide, she pointed out, had an unwanted side-effect. It killed birds. So many of them, indeed, that Rachel Carson called her book "Silent Spring", alluding to the fact that all the birds we love for their spring song would be dead and gone soon. How people lived had undeniable negative effects on

the environment and these became more and more widespread and could no longer be written off as unavoidable quibbles during the pursuit of progress. Two years earlier, in 1960, Vance Packard had written "The Waste Makers", an early call against consumerism, the lifestyle of want and waste which has come to dominate the world which calls itself "the first". WWII, in particular the nuclear bombs dropped on Hiroshima and Nagasaki had shocked many intellectuals. Paul Ehrlich's 1948 warning about the dangers of human population growth, called "The population bomb" is an early reaction.

So when the famous "Limits to Growth" report, the first model-based assessment of the looming doomsday of resource depletion, was published in 1972, the same year the first UN-led conference on the environment would take place, the debate about the side-effects of high industrialism and unfettered economic growth had already been going on for more than a decade. The Wenner-Gren Foundation sponsored an interdisciplinary symposium on man's role in changing the face of the earth in 1955, and the resulting volume with the same title, edited by William L. Thomas Jr. is an outstanding early document of a multi-disciplinary attempt to assess the status of ecological systems. Eminent scholars such as Lewis Mumford or Carl Sauer were part of this endeavour, which included historical assessments as well as speculation about the future. (Thomas 1956).

Environmental historians have tried to trace the origins of the environmental debate and have unearthed evidence that environmental concerns did not start in the post WWII-U.S., but were a by-product of the havoc created on tropical islands by colonial exploitation (Grove 1995). Others have dug into the writings of philosophers, theologians and other voices from Antiquity and the Middle Ages and have convincingly shown that concerns about environmental degradation have been part of cultures for thousands of years (Hughes 1996).

But there is an important difference between these early concerns and their modern resurgence. In the 1970s, it became clear for the first time that environmental problems involved scientists not just as those who solved them, but also as those who created them by means of technical advances. Science and society had become linked via technology. As Evandro Agazzi has put it: "[…] if we look at technology, we can at most admit a conceptual or an analytic distinction, without any real separation from science, since they are concretely intertwined and, so to speak, consubstantial. (Technology cannot exist without science, and science cannot exist without sophisticated technology.) This in particular justifies the use of the term "technoscience" for designating this new reality. In the second place, we have seen that an appeal to an ethical dimension emerges, with great force, from within technoscience itself; and this is true because the particular form of creativity that characterizes

this domain does not provide us with criteria for steering, directing, limiting, or orienting the growth of technoscience." (Agazzi 1998: 8) In accordance with Agazzi, as an environmental historian, I would argue that a new role of scientists emerged as consequence of a new relation to nature.

The ethical dimension was visible early on in military research. The Manhattan Project, the largest scientific undertaking the United States or any other nation had ever undertaken, enabled the U.S. to build the nuclear bombs they dropped on Hiroshima and Nagasaki. It left many scientists wondering about their role in society. The *Bulletin of the Atomic Scientists* became a widely read, respected publication on science-society issues. During the 1950s, peace had become an important agenda for many of these scientists, Albert Einstein, Linus Pauling and Albert Schweitzer led the way. The Union of Concerned Scientists was founded in 1969. So when scientists became active against the Vietnam War and the ecological consequences of spraying parts of Laos and Vietnam with dioxin-tainted herbicides to defoliate the jungle and thus make air strikes against the Vietcong possible, they had models to follow (Moore 1999: 110ff). David Zierler has shown that the movement of scientists against the military use of Agent Orange and other such dioxin-laden herbicides led by Arthur Galston of Yale University was successful because of favourable political circumstances, but also because the issue of the infamous agents was framed "as a product of a destructive and immoral war and an omen of a future techno-industrial ecological dystopia." (Zierler 2011: 4). Scientists had learned to make such a successful argument and thus, had arrived in the entangled and messy world of war, business and politics and they could not help but start to reflect on their role and place in society.

When the call for action for a new way of interaction with 'laymen' was heeded in the context of ecological crisis in the 1970s, it thus fell on fertile ground. By 1972, Barbara Ward and Paul Dubos could declare that 'laymen' should play a much more prominent part in investigations. They called scientists within their disciplinary boundaries "parochial" and held that perceptive and informed nonprofessionals can contribute as much as technical experts to policies concerning the human environment. The new problems created not by polluted production sites as had been the case during the Industrial Revolution, but by the mass use of the products of the now much cleaner industrial operations, required both social judgement and specialized scientific knowledge (Ward, Dubos 1972). This was indeed, revolutionary. Others had voiced similar concerns even earlier, but it was the situation of the 1970s that made the case for co-operative knowledge production, later called 'transdisciplinary work,' most effectively. Not that the disciplinary academic world would easily succumb, but a path had become visible, and some would gladly travel it.

WICKED PROBLEMS CALL FOR A NEW APPROACH

In 1973, Horst Rittel and Melvin Webber discussed types of problems they called "wicked" rather than "tame" as they saw them evolve in the context of planning. These, they argued, are different from other types of problems. They offered ten defining characteristics. Their list starts with problem definition: "There is no definitive formulation of a wicked problem", because "the information needed to understand the problem depends upon one's idea for solving it. […] The formulation of a wicked problem is the problem! The process of formulating the problem and of conceiving a solution (or re-solution) are identical, since every specification of the problem is a specification of the direction in which a treatment is considered." The second specific quality of wicked problems is that wicked problems have no stopping rule. When dealing with societal problems, "there are no ends to the causal chains that link [the] interacting open systems."

With more effort invested, a better solution might always be reached. The end of the research project (which is ultimately determined by money) and not the arrival at a solution terminates work on the issue. Wicked problems can only be resolved, never solved. This fits with another of their defining characteristics. "Wicked problems do not have an enumerable (or an exhaustively describable) set of potential solutions, nor is there a well-described set of permissible operations that may be incorporated into the plan." Rather, agreement based on trust and credibility leads to common-sense, 'realistic judgement' because ill-defined problems cannot have well-defined solutions.

Rittel and Webber's third proposition is that solutions to wicked problems are not true-or-false, but good-or-bad. If stakeholders with different interests are invested in dealing with a problem, it is highly unlikely that any (re-)solution will yield only winners. There are no objective truths in such cases. Therefore, "[…] none [of the parties involved] has the power to set formal decision rules to determine correctness. Their judgments are likely to differ widely to accord with their group or personal interests, their special value-sets, and their ideological predilections." To complicate things further, "[t]here is no immediate and no ultimate test of a solution to a wicked problem. […] With wicked problems, […] any solution, after being implemented, will generate waves of consequences over an extended – virtually an unbounded – period of time. Moreover, the next day's consequences of the solution may yield utterly undesirable repercussions which outweigh the intended advantages or the advantages accomplished hitherto." On a related note, "[e]very solution to a wicked problem is a "one-shot operation"; because there is no opportunity to learn by trial-and-error, every attempt counts significantly. Every implemented solu-

tion leaves traces. One cannot wipe the slate clean after an intervention into a social system, and as all wicked problems involve interventions into social systems, each solution leaves a unique legacy.

Every problem is unique (proposition 7) and is likely to be the symptom of another problem (proposition 8). This has to do with the hen-and-egg-character of the link between problem and the resolution, in particular, with the choice of how to frame the discrepancy between the desired state of things and the state of things as they are. The choice of explanation determines the nature of the problem's resolution. If social inequality is chosen to be the reason for the deterioration or the problematic state of a natural system, the solution is different than if the design of a technical system ('the polluter') is identified as reason. As the authors put it, "Planners are liable for the consequences of the actions they generate; the effects can matter a great deal to those people that are touched by those actions." This is not just true for planners, but for every scholar involved in sustainability research. It does, to name but one example, matter if the project increases or decreases the choice of options of the population involved. Planners, the authors formulate provocatively," have no right to be wrong" (Rittel, Webber, 1973). This is true also for sustainability professionals, often called in as "experts" to deal with messy, wicked problems.

These impressive, insightful observations on the nature of wicked problems show that as early as 1973, some researchers were thinking hard and fast about their role and its limitations in the messy technological world of nature modified by humans, a world full of what would much later be called 'hybrids' by Bruno Latour (Blok, Jensen 2011).

The early insights about planning have been echoed and refined in the field of sustainability sciences. There is no way to proceed without involvement of all concerned. Funtowicz and Ravetz made this point succinctly in 1991. They called for a methodology adequate in cases where "facts are uncertain, values in dispute, stakes high and decisions urgent" (Funtowicz, Ravetz 1991). In the technologically transformed world we have created, many problems have become wicked.

But problem-driven research involving non-professionals is still considered tangential by some and the methods and practices needed to cross the boundaries between disciplines and between academic disciplines as such and the world outside academia are still considered 'new'. This way of working, sometimes called "Mode-2"-research, remains marginalized. Teaching the conceptual and methodical basis is as yet poorly integrated into academic curricula. Despite very honourable attempts at creating textbooks and other teaching aids, one can easily get through a sustainability-related curriculum without

ever encountering the needed toolbox (but see e.g. Repko 2012, Öberg 2011). While a lot of public money and effort still goes into public understanding of science, from open lab days to long nights of research, from scientists visiting kindergarten and elementary school children and involving them and slightly older pupils into research, much less attention is devoted to training scientists for meaningful interaction with stakeholders. As part of becoming 'responsible scientists', all researchers should receive reflective training in complementary competences involving some basic understanding of how modern, functionally differentiated societies can be conceptualized and what this means for project design and communication settings (Winiwarter et al, 2014).

Despite its relative novelty, there is no scarcity of inter- and transdisciplinary work, nor of studies about interdisciplinarity (work involving scholars with different backgrounds) and transdisciplinarity, sometimes also called transacademic work. Very different types of studies with the common quality that they involve stakeholders, as laymen have come to be called, are considered part of this field. The Swiss td-net, a network of transdisciplinary scholars, maintains a huge bibliography (http://www.transdisciplinarity.ch/d/Bibliography). Even Google Scholar's most limited exact word search yields more than 16.000 documents concerned with "transdisciplinarity".

The goal to involve those about whom research is done has an ethical dimension, not least in medical research, but also in all biographically oriented, qualitative social science, which might violate the personal rights of the subjects. But the ethical issue goes deeper than that, eventually the question arises what the purpose of scholarly endeavours is. To put it differently, should scientists pursue their own research interests as freely as possible? Should they be guided only by the evaluation of their peers, because these are the only people who can be trusted to decide if the planned research is original and worthwhile? The idea behind the freedom of research is that eventually, something useful is likely to come out, but the utility of outcomes cannot be predicted beforehand. While this is, as we have seen, true also in the world of wicked problems, transdisciplinary research is not just evaluated by peers, but those involved have a say in it. Its thematic and methodical ramifications are determined not by seeking the optimal outcome for researchers, but by a compromise between the interest and goals of all involved. Sustainability researchers need to decide if they should orient their work towards abstract research interests or towards people and their needs, wants and problems. Most of their research, as it involves people, will necessarily involve them into the non-scholarly world.

Since the late 1960s, "Action Research" developed as a way for researchers to involve themselves, changing their role in an outspoken declaration

that research should by design lead to benefits for the involved people, who were considered partners rather than subjects (Lewin 1952; Reason, Bradbury 2007). Action research is one important root of transdisciplinary research. The political agenda has become less pronounced, and double benefits, for those involved and for the general advancement of knowledge, have become the aim of such work.

Journals such as 'Futures' discuss how to actually perform successful transdisciplinary research. Many of the articles discuss how "Developments in contemporary society are creating a shifting landscape of knowledge production." (Russell et al. 2008) and how transdisciplinary research can be fostered. Russell sees universities in the role as capacity building institutions, and less as brokers of products (Russell et al. 2008: 460). Julie Thompson-Klein is one of the leading figures in the international debate. In her 2004 article for an issue of Futures entirely dedicated to transdisciplinarity, she not only gives a very brief historical account of the development of the notion and links the core idea of Funtowicz and Ravetz (i.e. that we are living in the age of post-normal science) to the quest for transdisciplinarity. She also states clearly that: "Transdisciplinarity is simultaneously an attitude and a form of action." (Thompson-Klein 2004: 521) Thompson-Klein here points to the reflexive nature of all transdisciplinary work and elucidates what she sees as a fundamental difference between inter- and transdisciplinary work: "Transdisciplinarity does, through the principle of articulation between different forms of knowledge" call into question disciplinary thinking (Thompson-Klein 2004: 524).

While it is impossible to give a full review of the literature here, I would like to highlight the role of transdisciplinary research in the field of sustainability studies. An entire issue of the respected, peer reviewed environmental journal AMBIO was devoted to the transdisciplinary research of a group under the direction of Per Angelstam (Angelstam et al. 2013a). The bilingual journal GAIA is focussed on transdisciplinary research dealing with sustainability questions.

But what has been learned about the type of research needed for the re-(solution) of sustainability problems during the many years since Rittel and Webber started to think about wicked problems?

CHALLENGES INCURRED IN TRANSDISCIPLINARY RESEARCH DESIGN

One challenge, namely to explain what one was doing lacking a proper name for it, has been resolved. The type of research has been named, labelled and defined. Any research involving non-scientists („stakeholders", „partners") on sustainability issues is in all likelihood, based on interdisciplinary research.

It has been defined as "[…] research that includes cooperation within the scientific community and a debate between research and the society at large. Transdisciplinary research therefore transgresses boundaries between scientific disciplines and between science and other societal fields and includes deliberation about facts, practices and values." (Wiesmann et al. 2008: 435)

But this type of research offers an important challenge. Deliberation about facts, practices and values takes time. Transdisciplinary research therefore progresses slowly, to some, agonizingly slowly. Rather than data (derived from lat. datum, given), facts (derived from lat. factum, made) are themselves unstable and insecure. The communication process with stakeholders about what is a relevant fact in a given situation takes time and has the potential to irritate both the researchers and the stakeholders. In their propositions to enhance transdisciplinary research, Wiesmann et al. (2008) point out that "Transdisciplinary research is an appropriate form of research when searching for science-based solutions to problems in the lifeworld with a high degree of complexity in terms of factual uncertainties, value loads and societal stakes. Through bridging different scientific and social knowledge components it can significantly improve the quality, acceptance and sustainability of such solutions. However, deliberation about facts, practices and values are ongoing when bringing results to fruition in the life-world as well as in scientific communities." (Wiesmann et al. 2008: 435)

As Rittel and Webber already pointed out, the process of problem-solving research builds on trust and credibility. These cannot be kick-started at the beginning of a project; they need time to develop and involvement of the researchers not just in their capacity as providers of facts. Their person as such is called to the fore. Researchers face the question if they 'walk the talk'; they are asked if their life somehow reflects what their research proposes. One cannot easily preach water and drink wine as a sustainability expert. This is clearly a challenge, and researchers might be unwilling to take it up.

Yet, even with the most credible and heroic researchers, the communication process remains difficult. The solution is to make the process less of a happenstance, learning-on-the-job affair and bring in experts for the design of communication settings and for their facilitation. This makes projects comparably more expensive and gives them an added problem dimension, as not just the facts and values are questioned, but the process itself is up for scrutiny. Typical questions include: Are the communicative fora designed to be really inclusive? Has care been taken that minorities and those who cannot speak for themselves are adequately represented? The quality of the results is assessed by the quality of the process that led to them. The chances of implementation, the robustness of results in terms of their acceptance by stakeholders, depend

as much on the process which led to them than on the result itself (Nowotny 2000). Some researchers learned that even their upfront selection of facilitators did compromise the result's acceptance. But if one has to deliberate and reach consensus about all potential problems before the start of a project, it will, in fact, never start and become a problem of its own. Each project is unique and has to find its own way of dealing with this issue. Maria Hage et al. have described a framework for stakeholder participation developed for the Netherlands Environmental Assessment Agency. This agency, an intermediary organization between science and policy, is one example of new types of organizations that are set up specifically to tackle the challenges of transdisciplinary work (Hage et al. 2010).

A similar challenge is the processual character of transdisciplinary research. What exactly might be needed, which competences involving which discipline(s) are crucial, cannot be determined upfront. While one can try to put together the best possible team, and actually needs to do this in order to plan, Wiesmann et al. point to an experience many researchers have made and propose a different approach: "In relation to the nature of problems that are addressed in transdisciplinary research, the canon of participating disciplines and competences from the natural, technical and social sciences, and the humanities, as well as from the life-world cannot be pre-defined. It is to be determined during the research process which bodies of knowledge have to be integrated to take into account, produce and integrate systems knowledge, target knowledge and transformation knowledge." (Wiesmann et al. 2008: 436) They call for mutual learning as the way to overcome processual challenges. "Building on approaches of mutual learning that bridge roles and positions without dissolving them is a promising entry point to goal oriented participation." (Wiesmann et al, 2008: 437). Their 8th proposition takes this goal up as a challenge for the organization of such a process, again pointing to the importance of acknowledging the (vested) interest of partners. "At the same time, transdisciplinary work should be organised in a manner that enables a productive balance between structured collaboration and vested interests by participating partners and disciplines." (Wiesmann et al, 2008: 437).

Another challenge results from the fact that researchers gain their credibility as experts in the academic system, which does have its own criteria. One of them is the free flow of communication. Results need to be published in order to be considered valid in the system of academic experts. But stakeholders, even if they are very interested in a resolution of their problems and thus co-operate actively in a project, might not be interested in having the problems published along with the solutions. Privacy as well as data privacy issues and intellectual property rights are real obstacles to transferring from the practi-

cal into the academic context. So, working successfully with stakeholders can compromise the scholarly career prospects of researchers.

Yet another challenge is also connected to publication, but in a different way. Recently, an e-mail letter by an undergraduate student writing about the ill choice of a reading he had been assigned circulated the internet. The student complained that he could not finish a single sentence in the text without consulting a dictionary. The teachers participating in the discussion considered it a normal, actually a necessary part of learning that the student would investigate the vocabulary of the discipline. But stakeholders, clients, partners, the non-professionals sustainability researchers cooperate with, have no need to enlarge their vocabulary. They want their problems tackled and they need to understand the propositions made by the researchers to that end. So the "how" and not just the "what" matters in communication.

If stakeholders are to be reached, more often than not, communication professionals will be involved in designing brochures, websites, even comics, games and other non-scholarly means of disseminating knowledge. Scholars are deeply, and by all means, rightly, worried that the essence of what they have to offer might be lost in this process of translation and transformation. Form and content depend on each other. By changing the form, the content is recontextualized and will be interpreted differently. Also, in a world of increasing diversity of electronic media, scholars face the problem if they should tweet, post on Facebook or use Flickr or Instagram to disseminate pictorial material. Many underestimate the complexity of the issue and frustration lingers.

Money is always scarce. Therefore, researchers have long learned that to compete successfully for project funding, they have to either devote a project specifically to method development, or apply standard methods to a new and interesting problem. A second condition of success in project funding is as counter-productive for inter- and transdisciplinary research: Researchers need to stay within their core competence to survive peer-review.

In transdisciplinary research concerned with wicked problems, methods are never standard. Adapting them to the unique context of the given project implies method development as part of all projects. Researchers are always challenged to step out of the bounds of their disciplinary training and explore new arenas. This calls for specific procedures of evaluation to yield fair judgement, but such procedures are still the exception, not the rule. Wickson et al. (2006) devote a whole section of their paper to the question of assessment of the quality of such research and offer strategic questions for evaluation. They call for assessing if the goals are responsive, as goals may and will shift during the process as result of successful integration of different bodies of knowledge. They further suggest assessing the methodology based on its openness

("evolving methodology"). Other quality criteria they mention are a significant outcome (significance evaluated as the degree of problem-solving), effective communication and common reflexion. (Wickson et al. 2006: 1056f). Overcoming the obstacles of funding in a largely disciplinary world is a big challenge for all researchers involved in transdisciplinary work.

There is no easy way to reach the double dividend envisaged in the design of transdisciplinary projects. Angelstam et al. (2013b) have suggested a distinction between 'communication and dissemination' on the society side and 'collaboration' on the academic side as guideline to negotiate interactions with the two different contexts. They conceptualize their work as a staircase in 7 steps. As can be seen from Fig. 1, they remain very unspecific about the different roles of the two contexts over the duration of the project.

What becomes evident from Fig. 1 is the very complex process that needs to be designed and controlled over the project duration. Wiesmann et al. clad the processual challenge into their 6th proposition: "The quality of transdisciplinary research is bound by sound conceptions of integration and thus requires development of an own form of specialisation. However, transdisciplinary research is not meaningful without sound disciplinary contributions and it has the potential to stimulate innovation in participating disciplines. Bringing this potential to fruition requires an emerging college of peers able to bridge disciplinary and transdisciplinary specialisation" (Wiesmann et al. 2008: 436). The double responsibility of researchers for process and product has been

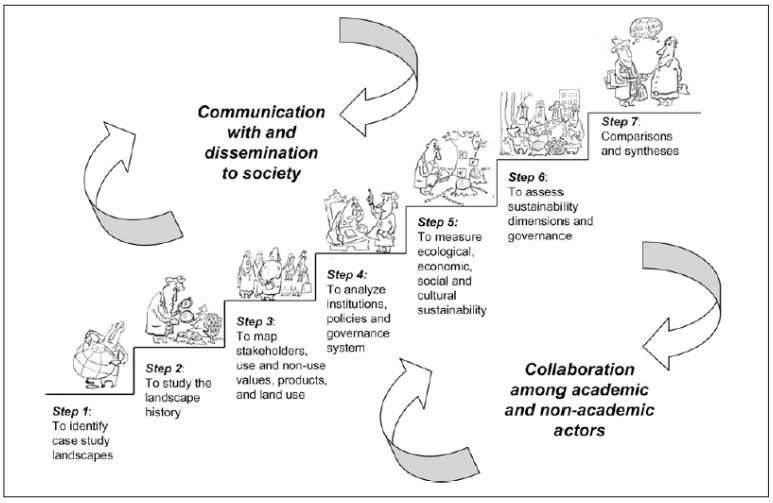

Fig. 1: Envisaging a transdisciplinary project as a stepwise project between the two communicative spaces of research and stakeholders. From Angelstam et al. 2013b

captured in the 'Transdisciplinary wheel' by Carew et al (2010). They distinguish two contexts, that of the researchers and that of the problem they want to address. These contexts need to be understood and embraced as being different, if transdisciplinary research is to meet its goals. Over the course of a research project, attention will change from being focussed on the process to being focussed on the product, and will proceed from a concentration on the problem context to a concentration on the research context.

An idealized project would proceed through different phases as shown in Fig. 3.

Carew et al. have called attention to the many aspects influencing the outcome of a transdisciplinary project. A certain pragmatism, but importantly the values and beliefs and the responsibilities of a researcher shape her or his

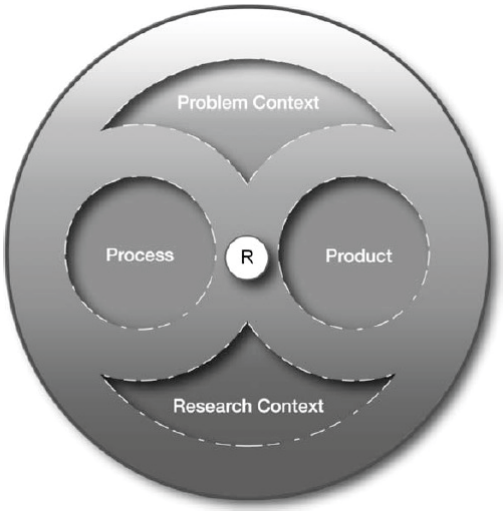

Fig. 2: The Transdisciplinarity wheel as proposed by Carew et al. 2010 (R= researcher/s context)

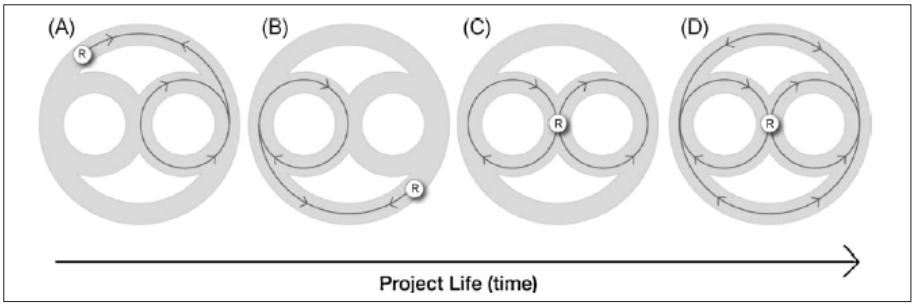

Fig. 3: Traces of the Transdisciplinary Wheel in application. Over the course of the project, both contexts should be fully integrated. (Carew et al. 2010)

intentions. These are then modulated by the capacities of the person or group and in combination lead to their actions, which are designed to result in a product. But the product is shaped by the problem context as much as by the research context. (Carew et al. 2010: 1149ff.)

One last obstacle to transdisciplinary research I wish to mention in this short overview is the attribution gap. Let us assume that a transdisciplinary socio-ecological project in a national park involving local communities using flood-prone areas as grazing grounds for animals lead to knowledge about forms of management enabling a better preservation of biodiversity without compromising the livelihoods of the involved communities. While this does not sound like a particularly wicked problem, other interest groups might experience side effects of such new management, and in particular, existing legal rules for protection of a national park might be an obstacle to the implementation. So, when is the project successful? If it delivers the knowledge gained about biodiversity and herd management to local stakeholders and to the regional government by a dissemination workshop? Is it successful if the national laws on the governance of national parks are changed? The latter might take years, and involve none of the original researchers directly, but many other people. The assessment of the social impact of transdisciplinary research has proven to be very hard to do, although the EU and several national funding agencies have tried to come up with assessment procedures including these ultimate, not proximate,

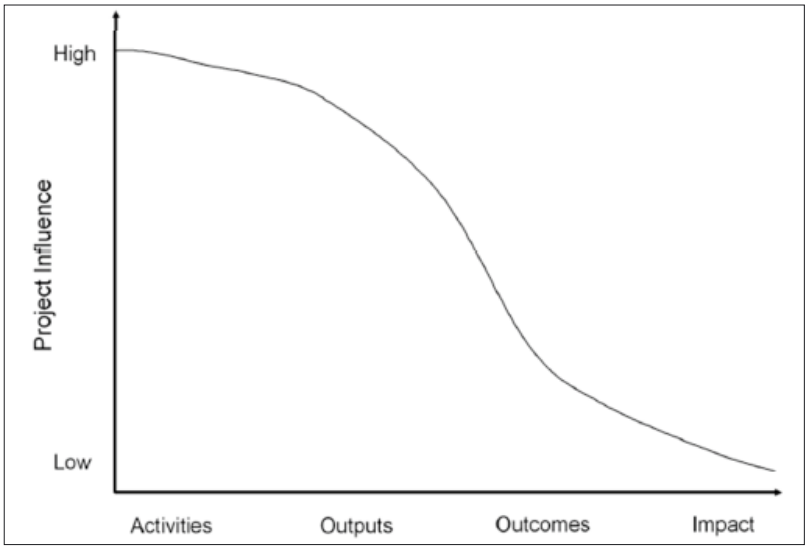

Fig. 4: Project Influence on Outputs, Outcomes, and Impact (Douthwaite et al. 2007: 143)

effects that are the real litmus test of transdisciplinary research. A useful summary of the attribution gap problem is shown in Fig 4. It becomes clear that one challenge researchers incur in such projects is that they have to face the fact that despite their intention to have an impact on society, they have little control over their impact. The academics engaged in basic research are better off in this regard. As they have no plan to have a direct influence on society, they do not have to face the realization that they cannot control it.

CONCLUSION

Some like stew, some like their vegetables and meat on the plate side by side. Some researchers have talents and interests that make them ideally suited to transdisciplinary research. Some are ideal basic researchers, for some it depends on the team and the theme. Within basic research, finding a doable, challenging problem is all that matters for a good proposal. Problems are defined within the bounds of the disciplinary possibilities. This is an important research frontier and basic research is needed for the advancement of learning. Within transdisciplinary research on sustainability issues, messy problems of the outside world await a (re-)solution. Researchers pack their tools and embark on a journey into the unknown together with others. In this toolkit, results and methods of basic research are as important as communication skills and the ability to bridge gaps between disciplines and their different ways of researching, arguing and presenting. But the knowledge of the partners is as crucial. No-one knows a local situation the way the locals know it. They are not right or wrong about it, so researchers are ill-fated if they seek truth in stakeholders rather than academic textbooks, but their perspective is unique, and necessary for problem definition, for seeking pathways and for successful implementation. Mutual learning along the way is necessary to find the path(s) towards a more sustainable future, and those who embark on the journey together will find it worthwhile for many reasons. They will find themselves having contributed to sustainability in a palpable, measureable way. But there is a transdisciplinary academic dividend, too. Laboratories are high-end technical devices to create surprises. The surprises a transdisciplinary project can offer are of a different, less plannable character, they irritate and disturb. This is their real potential for academia: Innovation is always happening at the margins, not in the mainstream. Feeding transdisciplinary research back into the academic system therefore has a huge potential to create paradigm shifts and thus, foster the advancement of learning just as much as basic research does, in a unique and complementary way. The rewards equal the challenges.

REFERENCES

Agazzi, E. 1998. From technique to technology: The role of modern science. In: Society for Philosophy and Technology 4/2, 1-9

Angelstam P. et al. 2013a: AMBIO 2013, Vol. 42

Angelstam P. et al. 2013b: Knowledge Production and Learning for Sustainable Landscapes: Seven Steps Using Social–Ecological Systems as Laboratories. In: AMBIO 2013, 42: 116-128

Blok, A., Jensen, T.E. 2011. Bruno Latour: Hybrid Thoughts in a Hybrid World. Taylor & Francis

Carew, A.L. et al. 2010. The TD wheel: a heuristic to shape, support and evaluate transdisciplinary research. Futures 42, 1146-1155.

Douthwaite B. et al. 2007. Participatory impact pathways analysis: a practical application of program theory in research-for-development. In: Canadian Journal of Program Evaluation, 22(2) 127-159

Funtowicz, S.O., Ravetz, J. R. 1991. A New Scientific Methodology for Global Environmental Issues. In: Ecological Economics: The Science and Management of Sustainability. Ed. Costanza R. New York, Columbia University Press, 137-152.

Grove, R.H. 1995. Green imperialism: colonial expansion, tropical island Edens and the origins of environmentalism, 1600-1860. Cambridge University Press

Hage, M. et al. 2010. Stakeholder participation in environmental knowledge production. Futures 42, 254-264.

Hughes, J.D. 1996. Pan's travail. Baltimore, Johns Hopkins University Press

Lewin, K. 1952. Group Decision and Social Change. In: T. M. Newcomb & E.E. Hartley (Eds.), Readings in social psychology. New York, Holt, 459-473.

Moore, K. 1999. Political protest and institutional change: The anti-Vietnam War movement and American science. In: How Social Movements Matter. Ed. Giugni, M., McAdam, D., and Tilly, C., University of Minnesota Press, 97-118.

Nowotny, H. 2000. Sozial robustes Wissen und nachhaltige Entwicklung. In: GAIA-Ecological Perspectives for Science and Society 9, 1-2.

Öberg, G. 2011. Interdisciplinary Environmental Studies: A Primer. Chichester, John Wiley & Sons.

Reason, P., Bradbury, H. 2007. Handbook of Action Research, 2nd Edition. London, Sage

Repko, A.F. et al. 2012. Case studies in interdisciplinary research. Sage Publications

Rittel, H.W., Webber, M.M. 1973. Dilemmas in a general theory of planning. In: Policy Sciences 4, 155-169.

Russell, A.W. et al. 2008. Transdisciplinarity: context, contradictions and capacity. In: Futures 40, 460-472.

Thomas, W.L. (ed.), 1956. Man's Role in Changing the Face of the Earth. (Published for the Wenner-Gren Foundation and the National Science Foundation.) Chicago, The University of Chicago Press

Thompson Klein, J. 2004. Prospects for transdisciplinarity. In: Futures 36, 515–526.

Ward, B., Dubos, R. 1972. Only One Earth. The care and maintenance of a small planet. Harmondsworth, Penguin Books Ltd

Wickson, F. et al. 2006. Transdisciplinary research: characteristics, quandaries and quality. Futures 38, 1046-1059.

Wiesmann, U. et al. 2008. Enhancing transdisciplinary research: a synthesis in fifteen propositions. In: Handbook of Transdisciplinary Research, Springer, 433-441.

Winiwarter V. with contributions by Barben, D, Schulte-Derne M and Schulte-Derne M. 2014. Empowering Experts. Presentation at the Alpbacher Technologiegespräche, 2014, August 21st, 2014. http://www.fwf.ac.at/fileadmin/files/Images/News_Presse/Veranstaltungsrueckblick/2014/09_Alpbach_Wissenschaft-in-der-Gesellschaft/140822_AlpbachVerena-Winiwarter.pdf

Zierler, D. 2011. The invention of ecocide: Agent Orange, Vietnam, and the scientists who changed the way we think about the environment. University of Georgia Press