Transdisciplinary research for sustainable development – doing research about research

Transdisciplinary research (TDR) projects integrate several disciplines as well as non-academic actors. Researchers claim that TDR projects are key for tackling complex sustainability issues. We study the effects and the factors influencing the effects of TDR projects in transnational research for development between the global North and the global South (North-South), as well as TDR projects conducted within the global North. This article explains our conceptual approach and presents selected findings.

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Unclear effects of transdisciplinary research projects

We are increasingly witnessing a questioning of the capacity of "traditional" disciplinary research to provide the kind of evidence needed for governing transformation processes toward sustainable social-ecological systems (Fritz and Binder 2018). Transdisciplinary research (TDR) integrates several disciplines and non-academic actors into the research process (Lang et al. 2012, Belcher et al. 2016, Hansson and Polk 2018). Given this approach, TD research is claimed to be key for a better understanding as well as the promotion of sustainability in social-ecological systems (Belcher et al. 2016). However, the effects of TDR projects in terms of increased knowledge or actual outcomes on the ground remain hard to evaluate. There is both a lack of knowledge on how the structure, process and context of TDR projects work as well as on the diversity of potential effects of TDR projects. To respond to this lack of knowledge, we are currently conducting a research project (2020–2023) funded by an ETH (Swiss Federal Institute of Technology) grant to explore the following question: what factors influence the effects of transdisciplinary research projects?

To answer this question, we study projects in transnational research for development between the global North and the global South (North-South), as well as projects within the global North. First, we conduct a review of TDR projects published in the academic literature in order to provide a broad overview of effects of TDR projects and the factors influencing them. Second, we accompany a specific North-South TDR project and study its development over time, with a focus on the social networks developing among the different actors involved. We include and compare projects from the global North and North-South projects given a lack of evidence on the differences between both types of projects. TDR projects conducted in different contexts – such as an exclusive global North context or a North-South collaboration context – have typically followed very different approaches: while the North-South research field has traditionally emphasized participation of local actors and the practical applicability of results, North research projects have focused on creating knowledge, often with unclear boundaries for participation of affected actors (Hirsch Hadorn et al. 2006, Hurlbert and Gupta 2015, Norström et al. 2020)

This article presents the conceptual approach of our project as well as selected, work-in-progress findings. We first outline our conceptual model for analysing the input, process and context factors and the effects of TDR projects. We then present findings on the input dimension, with first insights into analyses of networks among actors participating in TDR projects. We conclude by summarizing the results of a systematic literature review, providing an overview about which different effects occur in varying contexts and how the factors in our model interact.

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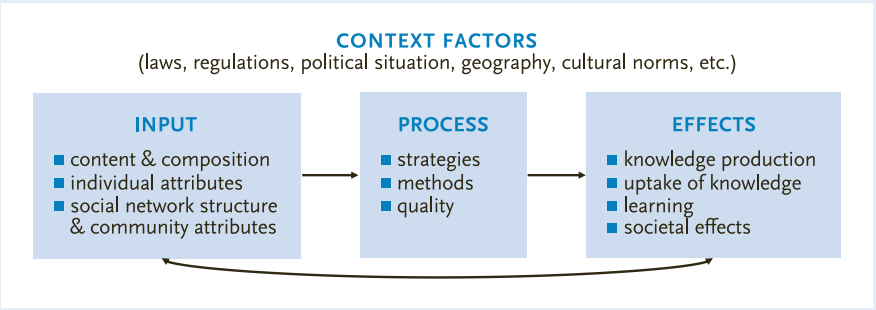

FIGURE 1: Conceptual model illustrating the different elements used to analyse the effects of different transdisciplinary research projects. The model shows that the effects of a TDR project can be influenced by input, process, and context factors. Further, the different elements are interconnected. Context factors can influence not only the effects but also input and process factors. Further, input factors can influence the process. Additionally, the model integrates feedback effects: once achieved, effects can have an influence on input factors.

Our model: input, process, and context factors influence effects

We use the open system model (Kast and Rosenzweig 1972, Katz and Kahn 1978) to structure the factors that potentially influence the effects of TDR projects (see figure 1). The model describes the simple idea that the effects, meaning what is produced through the work of a system, are influenced by an input and a process dimension, as well as by context. The input dimension (left box in figure 1) thereby refers to the resources – broadly speaking – that are put into the system and the process dimension to the procedure of transforming the resources into effects. In our broad input category, we distinguish between the types of actors involved, the disciplines and sectors involved, the community attributes, and the social network structure (Borgatti et al. 2009). We thereby explicitly operationalize different aspects of the two crucial dimensions of TDR projects. The process dimension (middle box in figure 1) includes aspects such as the quality of a process, the strategies applied, and the degree of involvement of actors (Schmidt 2013). Finally, context factors (surrounding box in figure 1) are those external to the system but still exerting an influence on either input, process, or effects. Context factors can be laws and regulations, cultural norms, traditions, geographical factors, or political situations (North 1991).

Regarding effects, many scholars object that current measures describe effectiveness of TDR projects solely in terms of fulfilled project goals or academic publications (Schneider and Buser 2018, Lux et al. 2019, Jacobi et al. 2020). Lang et al. (2012) state that an evaluation of a TDR project should also consider further effects such as learning in terms of acquiring transformational or system knowledge, or increased trust or newly formed relationships (Belcher et al. 2016, Roux et al. 2017). We follow Fritz et al. (2019) who have developed a list with a wide range of effects including among others increased motivation, the uptake of produced knowledge, and network effects. Based on this literature, in our conceptual model we distinguish between four categories of effects including knowledge production, uptake of knowledge, learning effects, and societal effects (see right box in figure 1). We employ this conceptual model defined by the effects, input, process, and context factors, as well as the relations between them, throughout our research process – it serves as our backbone.

The importance of social networks as input and effects

The specific focus on social networks is due to two reasons. First, social networks allow to operationalize the relations of actors across the two key dimensions of TDR projects: the interactions between different academic disciplines and the interactions between researchers and non-academic actors from practice, be it businesses, politics, or non-governmental organizations (NGOs). Second, social networks are interesting as they are potentially both a part of the input into TDR projects ("How do existing networks influence a project?") as well as a part of the effects of TDR projects ("How do projects affect social networks among key actors?"). In line with this is a core assumption that "structure matters" (Borgatti et al. 2009, p. 893), that is, the structure of a social network influences the effects produced by the respective group of actors. Conversely, given types of social networks can be effects of TDR projects, as one of the goals of TDR projects is to strengthen the interactions between actors from different backgrounds. We use social network analysis (Bodin and Prell 2011, Fischer et al. 2017) to quantitatively assess specific types of inputs and effects, such as relationship building, capacity building, as well as actor and disciplinary integration as relational phenomenon (see figure 1). For example, this includes a network of information exchange (Fischer et al. 2017), focusing on which project participants are exchanging (different types of) information. The project we analyze in detail is the project *RUNRES – The Rural-Urban Nexus: Establishing a nutrient loop to improve city region food system resilience*[2] – lead by researchers of ETH Zurich and active in Ethiopia, Rwanda, the Democratic Republic of the Congo, and South Africa. The project addresses two main challenges: the sustainable production of food and the provision of dignified sanitation. >

1 The project *RUNRES (Rural-Urban Nexus Research)* and the whole team behind it were indispensable for the preparation of this article: Abayneh Feyso, Abebe Arba, Behailu Merdekios, Simon Shibru (until 2020), and Kinfe Kassa (Arba Minch University, Ethiopia); Benjamin Wilde, Johan Six (principal investigator), Mélanie Surchat, Leonhard Späth, Pius Krütli (project *Co-PI*), and Rea Pärli (ETH Zurich, Switzerland); Haruna Sekabira (until 2021), Kokou Kintché, Marc Schut (until 2020), Matieyedou Konlambigue, Moustapha Byamungu, Murat Sartas (until 2021), and Speciose Kantengwa (International Institute for Tropical Agriculture, Democratic Republic of the Congo and Rwanda); Alfred Odindo, Ndoda Zondo, Samuel Getahun, Sharon Migeri, Simon Gwara, and William Musazura (University of KwaZulu-Natal, South Africa).

2 www.runres.ethz.ch

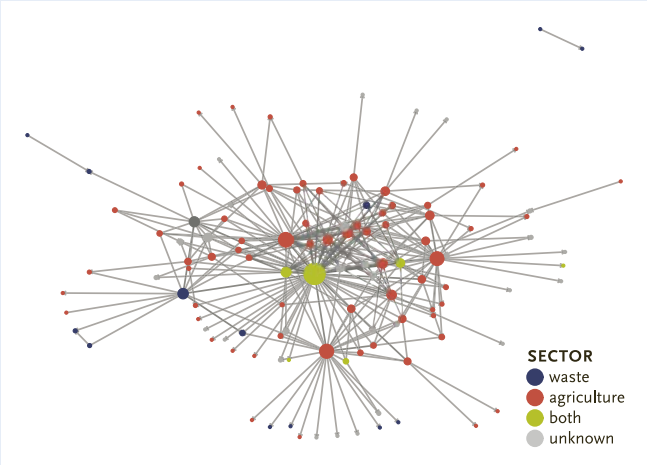

FIGURE 2: Actor network in Rwanda (Kigali and Kamonyi District). Nodes are individual actors and ties represent information exchange between them. The size of the nodes corresponds to the centrality of the actors, which describes how interconnected a node is: the larger a node, the more connections it has with other nodes. Data have been collected via a survey in the initial phase of the *RUNRES* project: actors active in the fields addressed in the project (agriculture and waste) were asked to indicate their relationships with other actors.

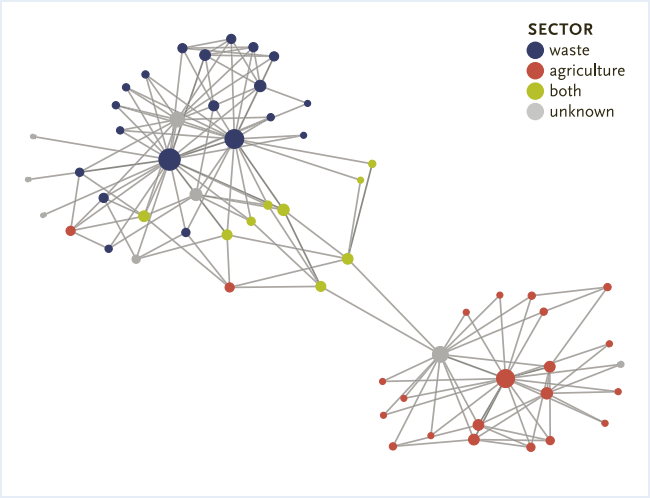

FIGURE 3: Actor network in the Democratic Republic of the Congo (Bukavu and Kabare Territory). Nodes are individual actors and ties represent information exchange between them. The size of the nodes corresponds to the centrality of the actors, which describes how interconnected a node is: the larger a node, the more connections it has with other nodes. Data have been collected via a survey in the initial phase of the *RUNRES* project: actors active in the fields addressed in the project (agriculture and waste) were asked to indicate their relationships with other actors.

In close collaboration with the research team, local actors implement technologies to recover organic and human waste from urban areas to re-circulate organic nutrients back to agriculture in peripheral, rural areas (Wilde et al. 2021). The *RUNRES* project unfolds through two main phases, one from 2019 to 2023 and potentially a second one between 2023 and 2027. Our accompanying evaluation through two waves of social network analysis will run until 2023 and can be also replicated later. Here we present the interim results of work conducted in Rwanda and the Democratic Republic of the Congo during the first phase of the project.

The network displayed in figure 2 represents the different actors in Rwanda. It shows a relatively clear star structure. A star structure is a specific structure of a social network with a small set of actors in the center that have strong interactions among them and some interactions to the large part of actors in the periphery. Such a structure implies a network with only one center, and all actors being more or less densely related to that center. Given the interest of the project to study and establish a sustainable nutrient loop within the food system, we distinguish between actors from the waste and the agriculture sectors, and examine interactions between both. The analysis clearly shows that agriculture actors are more connected and have a higher centrality than the waste actors. Agriculture actors are thus clearly dominant in the existing network and can, given their influence, also play a key role for transforming the system towards more sustainability. The star structure, with some very central actors, might pose a challenge if one very central actor stops operating. Hence, to make the system more resilient, less central actors should be supported more. This also has management implications for the *RUNRES* project (i. e., the process, see figure 1), as it indicates a need to support and activate the waste actors. Regarding the effects, we are currently conducting a second social network survey to assess whether the actor structure has changed through the project in such a way that we have a more equal distribution of centrality of the actors now.

Figure 3 shows the social network among actors involved in *RUNRES* in the Democratic Republic of the Congo. The network shows a clear segmentation between the agriculture and waste sectors, with little information exchange between the two. This suggests that both sectors need to be connected more strongly, something that the *RUNRES* project has been set up to achieve. The management implications are that the project should bring actors from waste and agriculture together in order to build successful innovations in nutrient recycling. In terms of effects, with the ongoing second social network survey we can check whether more exchange is actually happening. It will be specifically interesting to see what types of network relations were strengthened over time – if any – and between which types of actors.

An additional approach from network analysis that is useful for assessing TDR projects are 2-mode networks that combine a network of issues with the information exchange network (see fictitious example in figure 4). With this approach, we frame the problems that the studied TDR projects aim to tackle, as issues. The set of issues can be described as network, as addressing one issue influences one or more other issues (Angst 2019). Based on the project documentation and the inter-

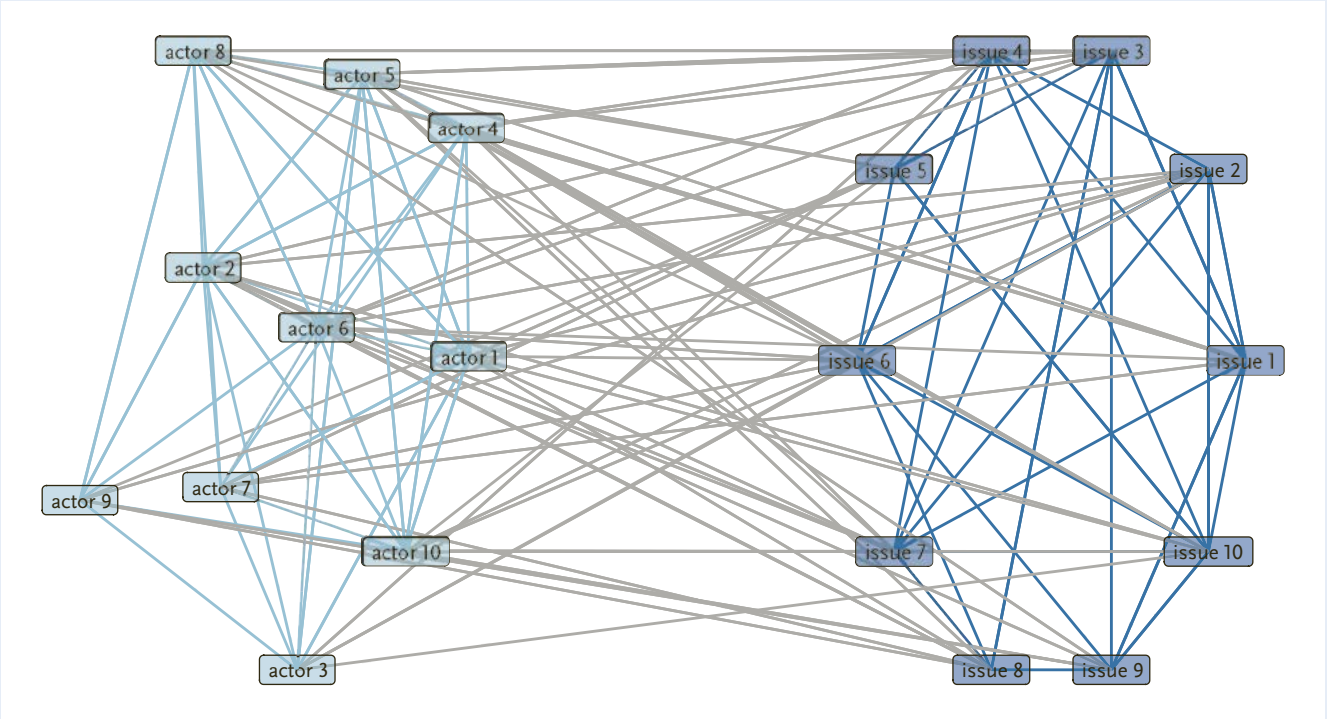

FIGURE 4: Fictitious example of an actor-issue network. It shows the information exchange between the actors (*actor 1–10* in light blue), how the issues are interconnected (*issue 1–10* in dark blue), and which actors are connected with which issues (in grey). Actors are connected with an issue if they are tackling it in their work or through other activities.

views we build an issue network by identifying what issues are key in the case and how they interact. We then ask the project participants to indicate on which issues they were working at the beginning of the project and on which issues they started working due to the project. In this case, 2-mode networks will help to show whether the actors working on connected issues are exchanging information and whether this changed over the course of the project. This will thus provide evidence on whether expertise from participants from different disciplines is integrated to create knowledge. Further, we will identify whether participants gained knowledge on new issues that are connected to their core knowledge by comparing the amount of issues they were working on at the beginning and at the end of the project, which is an indicator for the learning effects (see figure 1).

Different influences and effects in different projects

A literature review allows us to gain a general overview of the effects that North-South and "within North" TDR projects may achieve, as well as of the input, process and context factors that influence these effects. The literature review is based on scientific publications that study effects of TDR projects in terms of both conceptual arguments as well as empirical findings. We coded the literature that reported on 101 TDR projects based on our conceptual model (figure 1): we analyzed which effects are described in the cases and which input, process and context factors influence them. To supplement the review results we interviewed Swiss experts from research and practice having relevant experience with TDR projects. This work led to two review articles. The evidence we can provide is obviously restricted by what is reported in academic literature on the 101 TDR projects, and what is not.

Our first review article provides evidence on the diversity of effects reported for TDR projects and the co-occurrence of these effects, with a focus on the comparison between North-South and "only North" TDR projects. In Pärli et al. (2022) we observe a difference between North-South and within-North projects in terms of which effects are how prominent and how the effects are interconnected. The North-South projects report more on societal effects and the uptake of knowledge, while the North projects show more effects related to knowledge production and tangible research outputs such as academic publications. In terms of the links between the effects, we observe one group of cases focusing mainly on knowledge generation and another group focusing on the uptake of knowledge, societal and learning effects.

In our second article (Pärli submitted) we find that process factors have the strongest influence on effects. For example, the quality and management of the process, the degree of collaboration, and using specific methods or approaches such as an adaptive management approach have a strong influence on effects. Input and especially context factors are less prominent. Based on the evidence reported in the literature we reviewed, all these factors can have positive as well as negative influences on the effects. For instance, more stud- >

ies reported negative influences of limited capacity (in terms of time or financial resources) than positive influences of sufficient capacities. Some effects are more strongly influenced by input, process, or context factors. For example, knowledge generation and learning more generally are more prominently influenced by these factors than effects such as uptake in policy, uptake in science, or data quality which seem to be more independent of all these factors. Finally, the different factors influence not only effects, but these factors also influence each other. For example, we find that the funding system of a project can influence the research process. According to our conceptual model, this means that the context influences the process dimension of a TDR project.

The importance of doing research about research

The use of research results has been identified as critical for facilitating evidence-based environmental management (Giebels et al. 2015). Beyond the potential use of research results by practitioners, research could equally benefit from practice knowledge. Research that integrates knowledge beyond scientific sources could increase the efficiency and societal relevance of research and produce solutions with higher credibility and increased sustainability (Lang et al. 2012, Lieberherr 2015). Our study of how the structure, process, and context of TDR projects work as well as on the diversity of potential effects of TDR projects provides insights into how TDR projects can contribute to transformation processes toward sustainable social-ecological systems. Our interim results show how the structure in terms of the network constellation of actors matters for the process of how a project can work and what effects it can have. We also shed light on the need to coordinate across projects focusing on knowledge generation and those focusing on the uptake of knowledge, societal, and learning effects. Finally, we highlight how fundamental process factors are for effects, which reminds us not to forget the role of procedures in a world that is ever more focused on performance and tangible results.

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