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Doing research on research: exploring the role of design,
implementation and context in transdisciplinary research
projects

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Summary

Transdisciplinary research is increasingly recognized as a promising approach for addressing complex sustainability challenges by integrating knowledge from different scientific disciplines and stakeholders. Assessing the effects of transdisciplinary research on sustainable development is challenging due to the manifold and interconnected effects produced through nonlinear processes that are contingent on different contexts. This thesis aims to address two major research gaps. The first gap concerns the effects of transdisciplinary projects, including their intended and unintended outputs, outcomes, and impacts. While there is some research on the effects of transdisciplinary research, current success measures for transdisciplinary projects are not sufficient to cover the full range of effects they can have. Additionally, there is a lack of scholarly work focusing on the interactions between different effects. Such interactions are crucial because the pathways of transdisciplinary projects in achieving effects are rarely linear. The second gap concerns the characteristics of transdisciplinary projects which influence the effects that the projects have. It's difficult to make general statements about the effects of transdisciplinary research projects due to the varied ways in which they are organized and implemented. Overall, existing research has found that transdisciplinary projects with a higher amount of interactions with practitioners have had more societal impact, but this came at the cost of academic productivity. However, there are more detailed differences in characteristics which can have an influence on the effects of transdisciplinary projects, such as the type of stakeholders the project works with, the degree of collaboration, or the context in which a project takes place.

To address these research gaps, this thesis examines the effects of transdisciplinary projects within the field of sustainable development and the project characteristics that are influencing these effects. My overarching research question is: how do the design, implementation, and context influence the effects of transdisciplinary projects? This thesis consists of three articles, each examining a different aspect of this research scope.

I first identify and structure the range of effects that transdisciplinary research projects can achieve. I conduct a systematic literature review of 101 transdisciplinary projects to examine the different effects of transdisciplinary projects and their interconnections. I distinguish between projects taking place in North-South research partnerships and projects being implemented in the global North. I chose this comparative approach because the two types of transdisciplinary projects have different institutional origins. North-South projects historically originated to prioritize local stakeholder participation and practical applicability, while North projects have traditionally focused on systemic knowledge creation. Indeed, I find that North-South projects scored higher for societal effects and uptake of knowledge, while projects in the global North produced more tangible outputs, such as academic publications. In terms of interconnections of effects, I find that in North-South projects, there are often linkages between the generation of knowledge and social effects, while this is less often the case for projects in the global North. For both types of transdisciplinary research projects, I find that uptake of knowledge in practice is closely linked to effects like network formation, problem awareness, and trust.

Second, I focus on the characteristics of transdisciplinary research projects and how they influence project effects. I examine how the design, implementation and context influence the effects of transdisciplinary projects. Drawing on systematic literature review and expert interviews, I find that the implementation of a project, such as the quality of the process or the specific methods used, have the strongest influence on the effects of transdisciplinary projects. However, the design, implementation and context also influence each other, and are thus interconnected. The funding system in place for example, which is part of the context, does not only influence the effects of a transdisciplinary project, but it often already influences its design and the implementation.

Third, since there is very limited research on the role of context, I place a special emphasis on this topic, with an additional, more in-depth analysis on how context factors affect transdisciplinary research projects. I develop a working model on context factors and combine the method of realist evaluation with a comparative case study to examine how context factors can affect the effects of transdisciplinary projects. My cases are two regional sub-projects of one large transdisciplinary project on circular bio-economy for sustainable agriculture. While the two cases have the same research design, the same people involved in the planning, and the same funding structure, they are taking place in very different contexts, and have also achieved quite different effects. I find that strongly developed public and private sector and access to a variety of action resources such as political support or laws, supported the uptake of knowledge by stakeholders and in policy. Nevertheless, a strong public sector can also hinder a project's success if the interests of the government are not in line with the interests of the project.

Overall, this thesis contributes to our understanding of the effects of transdisciplinary projects and the project characteristics that influence them, within the field of sustainable development. Acknowledging the diversity of effects and their interconnections is important for evaluating the efficacy of transdisciplinary projects and ensuring their success in addressing complex sustainability challenges. The empirical overview of different effects and project characteristics offers valuable insights that can inform the planning, execution of and reflection on transdisciplinary research projects and guide future research in this area. Further, this thesis illustrates how context factors can influence the effects of transdisciplinary research projects. It highlights the need for an in-depth analysis of context factors when planning but also when evaluating a transdisciplinary research project and it offers a working model to do so.

Zusammenfassung

Die transdisziplinäre Forschung wird zunehmend als vielversprechender Ansatz für die Bewältigung komplexer Nachhaltigkeitsprobleme anerkannt, da sie Wissen aus verschiedenen wissenschaftlichen Disziplinen und von verschiedenen Interessengruppen verbindet. Allerdings ist die Beurteilung der Bedeutung transdisziplinärer Forschungsprojekte für eine nachhaltige Entwicklung oft eine Herausforderung. Die Effekte solcher Projekte sind vielfältig und gehen über die Generierung von Wissen für wissenschaftliche Publikationen hinaus. Sie beinhalten zum Beispiel auch den Aufbau von Kontakten und die Bildung von Netzwerken, die Aufnahme von Wissen in Praxis und Politik oder eine bessere Problemwahrnehmung der Stakeholder. Diese Arbeit zielt auf die Schliessung von zwei Forschungslücken ab: Die erste Lücke betrifft die Effekte transdisziplinärer Forschungsprojekte, einschliesslich aller beabsichtigten und unbeabsichtigten Ergebnisse, Resultate und längerfristiger Wirkungen. Zwar gibt es bereits einiges an Forschung in diesem Bereich, doch die vorliegende Arbeit zielt auf eine Vervollständigung und empirische Systematisierung der verschiedenen Effekte ab. Darüber hinaus mangelt es an Forschung, die sich auf die Wechselwirkungen zwischen den verschiedenen Effekten konzentriert. Diese Wechselwirkungen sind insofern von entscheidender Bedeutung, da die Wege, auf denen transdisziplinäre Forschungsprojekte Effekte erzielen, selten linear verlaufen. Die zweite Lücke betrifft die Merkmale transdisziplinärer Forschungsprojekte, die sich auf die Erreichung der verschiedenen Effekte auswirken. Es ist schwierig, allgemeine Aussagen über die Effekte transdisziplinärer Forschungsprojekte zu treffen, da sie sehr unterschiedlich organisiert und durchgeführt werden. Insgesamt hat die bisherige Forschung ergeben, dass transdisziplinäre Forschungsprojekte mit vertiefter Interaktionen mit der Praxis eine grössere gesellschaftliche Wirkung haben, was jedoch auf Kosten der akademischen Produktivität ging. Es gibt jedoch noch viele weitere Merkmale, in denen sich transdisziplinäre Forschungsprojekte unterscheiden und die sich dann auch auf die Effekte der Projekte auswirken können, wie z. B. die Art der Akteure, mit denen das Projekt zusammenarbeitet, der Grad der Zusammenarbeit oder der Kontext, in dem ein Projekt stattfindet.

Um diese Forschungslücken zu schließen, untersucht diese Arbeit die Effekte transdisziplinärer Forschungsprojekte im Bereich der nachhaltigen Entwicklung und die Projektmerkmale, die diese Effekte beeinflussen. Dabei geht es um die übergreifende Forschungsfrage: Wie beeinflussen die Ausgestaltung, die Implementierung und der Kontext die Effekte von transdisziplinären Forschungsprojekten? Die Arbeit besteht aus drei wissenschaftlichen Artikeln, die jeweils einen anderen Aspekt dieser Forschungsfrage untersuchen.

Zunächst identifiziere und strukturiere ich die empirische Bandbreite der Effekte, die transdisziplinäre Forschungsprojekte erzielen können und wie diese miteinander verknüpft sind. Ich führe dazu eine systematische Literaturrecherche anhand 101 transdisziplinärer Forschungsprojekte durch. Dabei unterscheide ich zwischen Forschungsprojekten, die in Nord-Süd-Forschungspartnerschaften stattfinden und Projekten, die im globalen Norden durchgeführt werden. Ich habe diesen vergleichenden Ansatz gewählt, weil die beiden Arten von transdisziplinären Forschungsprojekten einen unterschiedlichen Ursprung haben. Bei den Nord-Süd-Projekten stand von Anfang an die Beteiligung lokaler Interessengruppen und die praktische Anwendbarkeit im Vordergrund, während sich die Projekte im Norden traditionell auf die

Schaffung von systemischem Wissen konzentrierten. Tatsächlich stelle ich fest, dass Nord-Süd-Projekte bei den gesellschaftlichen Auswirkungen und der Aufnahme des generierten Wissens besser abschneiden, während Projekte im globalen Norden mehr greifbare Ergebnisse, wie etwa akademische Veröffentlichungen, hervorbringen. Was die Verknüpfung von Effekten betrifft, so finde ich bei Nord-Süd-Projekte mehr Verknüpfungen zwischen der Generierung von Wissen und sozialen Effekten, während für Projekte im globalen Norden die Generierung von Wissen weniger stark mit anderen Effekten verbunden ist. Für beide Arten von transdisziplinären Forschungsprojekten stelle ich fest, dass die Aufnahme von Wissen in der Praxis eng mit Effekten wie Netzwerkbildung, Problembewusstsein und Vertrauen verbunden ist.

Zweitens konzentriere ich mich auf die Merkmale transdisziplinärer Forschungsprojekte und darauf, wie sie deren Effekte beeinflussen. Dabei untersuche ich insbesondere Merkmale des Designs, der Implementierung und des Kontextes. Erneut anhand einer systematischen Literaturrecherche und von Experteninterviews habe ich herausgefunden, dass Faktoren in der Implementierung von Projekten, wie zum Beispiel die Qualität des Prozesses oder die spezifischen Methoden, die verwendet werden, den stärksten Einfluss auf die Effekte transdisziplinärer Projekte haben. Darüber hinaus beeinflussen die verschiedenen Faktoren nicht nur die Effekte, sondern auch einander: Die Implementierung von Projekten ist zwar wichtig, wird aber wiederum von Faktoren des Designs oder von Kontextfaktoren beeinflusst. Das Finanzierungssystem eines Projekts beispielsweise, ist ein Teil des Kontexts und beeinflusst nicht nur die Effekte eines transdisziplinären Projekts, sondern kann bereits dessen Design und Implementierung beeinflussen.

Drittens ist die Rolle des Kontexts nur sehr begrenzt erforscht. Daher lege ich darauf mit einer zusätzlichen Analyse einen besonderen Schwerpunkt, indem ich untersuche, wie spezifische Kontextfaktoren transdisziplinäre Forschungsprojekte beeinflussen. Ich entwickle ein Modell für Kontextfaktoren und kombiniere dann die Methode der realistischen Evaluation mit einer vergleichenden Fallstudie, um zu untersuchen, wie Kontextfaktoren die Effekte transdisziplinärer Forschungsprojekte beeinflussen. Bei meinen Fällen handelte es sich um zwei regionale Teilprojekte eines grossen transdisziplinären Projekts zur zirkulären Bioökonomie für nachhaltige Landwirtschaft. Obwohl die beiden Fälle dasselbe Forschungsdesign, dieselben an der Planung beteiligten Personen und die gleiche Finanzierungsstruktur aufweisen, finden sie in sehr unterschiedlichen Kontexten statt und haben auch recht unterschiedliche Effekte erzielt. Ich habe festgestellt, dass ein stark entwickelter öffentlicher und privater Sektor und der Zugang zu einer Vielzahl von Ressourcen wie die politische Unterstützung, gesetzliche Grundlagen oder eine vorhandene Infrastruktur die Implementierung von Projekten und somit die Erreichung von Effekten unterstützen können. Allerdings kann ein starker öffentlicher Sektor auch den Erfolg eines Projekts behindern, wenn die Interessen der Regierung nicht mit den Interessen des Projekts übereinstimmen.

Insgesamt trägt diese Arbeit zu einem besseren Verständnis der Effekte transdisziplinärer Forschungsprojekte und der Projektmerkmale, die diese beeinflussen bei. Die Anerkennung der Vielfalt der Effekte und ihrer Zusammenhänge ist wichtig für die Bewertung der Effektivität transdisziplinärer Forschungsprojekte und um ihren Erfolg bei der Bewältigung komplexer Nachhaltigkeitsprobleme zu gewährleisten. Der empirische Überblick über verschiedene Effekte

und Projektemerkmale bietet wertvolle Erkenntnisse, die die Planung, Durchführung und Reflexion von transdisziplinären Forschungsprojekten ermöglichen und eine Grundlage für zukünftige Forschung in diesem Bereich darstellen. Ausserdem zeigt diese Arbeit, wie Kontextfaktoren die Effekte von transdisziplinären Projekten beeinflussen können. Sie betont die Notwendigkeit einer eingehenden Analyse von Kontextfaktoren bei der Planung und Evaluation von transdisziplinären Forschungsprojekten und bietet ein Modell dafür an.

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Abbreviations

DRC	The Democratic Republic of the Congo
IAD	Institutional Analysis Framework
NGO	Non-Governmental Organization
PAR	Participatory Action Research
PRA	Participatory Rural Appraisal
SDGs	Sustainable Development Goals
SES	Socio-ecological Systems Framework
SNFS	Swiss National Science Foundation
TD	Transdisciplinary research

1 Introduction

In this thesis I explore transdisciplinary research (TD) projects in the field of sustainable development. TD can be defined as research approach that is integrating several disciplines as well as non-academic stakeholders in the research process (Lang et al., 2012). I consider TD to be a research approach which exists alongside disciplinary or interdisciplinary research models. Those type of research are equally important but as Pohl and Hadorn (2007) note, compared to applied or basic research, TD bases understanding of a problem not on “*specific disciplinary paradigms and action perspectives*” (p.37) but rather on a large variety of potential disciplinary and societal perspectives. The synergies of different disciplines as well as the integration of scientific and societal knowledge may produce knowledge necessary for sustainable development. TD is described as beneficial when it comes to producing knowledge which is holistic and applicable for the stakeholders it is created with (Schneider et al., 2019a). However, there are still many unknowns about the effects TD projects can achieve, and how this is influenced by the project’s characteristics. In this thesis I thus ask: *How do the design, implementation and context influence the effects of transdisciplinary research projects?*

This is a cumulative thesis, which includes three scientific articles. As a consequence, there may be slight variations in writing style between the different articles. I have made minor modifications to the original articles, such as adjusting the numbering of figures and tables, but without altering any of their content. Two of the three articles in this thesis are co-authored with other individuals. However, for simplicity reasons I use first-person language in all the other parts of this thesis.

Throughout this thesis, I use the terms global North and global South. The global North typically refers to Europe, the United States, and other high-income countries, while the global South encompasses Africa, Latin America, and most of Asia, which are often characterized by lower levels of economic development and greater inequality (Dados & Connell, 2012; Lees, 2020). These terms are not without their problems as they do not accurately reflect the diversity and complexity of countries and regions within the so-called global North and South. Some countries in the global South are economically prosperous and politically influential, while some countries in the global North experience poverty and marginalization (Khan et al., 2022). Further, the act of dividing reinforces a negative perception, which could hinder the emergence of innovative perspectives on sustainable growth that move away from existing circumstances and contextual factors (Kotze & Dymitrow, 2022). Nevertheless, the terms global South and North are commonly used in academic and policy circles to highlight the significant disparities in economic, political, and social power between different parts of the world (Khan et al., 2022; Lees, 2020). Some scholars prefer to use alternative terms such as majority and minority world. They suggest that this language more accurately reflects the structural power imbalances that exist between different regions of the world (Khan et al., 2022). However, when I started my PhD research, the terms global North and South were more commonly used in my field, and I believe that they helped to facilitate communication within my research community. Similarly, I use the term “North-South research partnerships” to describe collaborations between researchers from the global North and South. While I initially considered using the term “transboundary” to describe these partnerships, I ultimately found “North-South” to be more accurate. It allows to account for the power structures and inequalities that exist between Northern and Southern researchers and

the ways in which these partnerships are shaped by their specific context (Kotze & Dymitrow, 2022).

This thesis is structured as follows: in the remainder of the introduction, I provide a short history of TD and discuss its current status. In the section “Research Gaps and Contribution to the Field” I present the current research field, research gaps and my overarching research question. As research about TD is still a rather new field of research, I also present additional research fields which I draw upon in my research. In the section “Research Design”, I present the overarching research approach and in the “Methods” section I present my positionality statement and discuss the methods I use. In the subsequent section I give a short summary of the three articles comprising this cumulative dissertation before I then present the three articles in one chapter each. Finally, in the section “Synthesis” I present the contributions of this thesis, and recommendations for research and practice. Additionally, I discuss the limitations of this thesis and propose possible ideas for future research.

1.1 A short History of Transdisciplinary Research

Compared to the systematic and empirical approach of modern science, which emerged in the 16th century, TD is still a relatively young field. The term transdisciplinarity can be traced back to a seminar on "Interdisciplinarity: Problems of Teaching and Research in Universities" organized by the OECD in 1970 (Apostel, 1972). Jean Piaget, a psychologist and epistemologist, the mathematician André Lichnerowicz, and Erich Jantsch, an astrophysicist, all brought up the term transdisciplinarity in their contributions. However, they had different understandings and uses for the term.

Piaget and Lichnerowicz both described transdisciplinarity as a mode of research that extends beyond disciplines. While Lichnerowicz focused mostly on transferring mathematical concepts across disciplines, Piaget had a more holistic understanding (Bernstein, 2015). According to Piaget, transdisciplinarity involved the integration of knowledge from different fields into a new, higher-level understanding that would transcend disciplinary boundaries. He described transdisciplinarity as a way to overcome the limitations of disciplinary approaches to gain a more integrated and holistic understanding (Piaget, 1972). Jantsch focused in his contribution on the implications for the university and its future curriculum. He used a different description of transdisciplinarity, focusing more strongly on how universities should be structured. Interestingly, Jantsch demanded that the “transdisciplinary university” should be more political (Jantsch, 1972), a perspective that is again highly relevant today, especially within the field of sustainable development, where research is often normative, and questions of how political research should be arise (Bodin, 2021; van der Hel, 2018). Nevertheless, it appears that the introduction of the term transdisciplinarity at the OECD conference led some of the participants confused. In the conference report they state: *“With all that, I no longer know if what I’m doing is multi, pluri, inter or transdisciplinarity!”* (p.16) (Apostel, 1972).

Although the OECD seminar in 1970 is often cited as a significant moment in the history of TD, it is not its sole origin. In the same year, a doctoral student in the United States published his thesis “Towards Transdisciplinary Inquiry in the Human Sciences” (Mahan Jr, 1970). In line with Jantsch, Mahan believed that universities should move beyond traditional disciplinary boundaries.

Additionally, he contends that social and behavioral sciences were to date “*socially ineffective*”(p.7). Overall, these first mentions of transdisciplinarity, all relate to the idea of unity of knowledge (Lawrence et al., 2022), which goes back to the idea that all knowledge, regardless of its subject area or field of study, is interconnected, and can be integrated into a whole (Schilling, 1966).

However, none of these initial ideas of transdisciplinarity included actual interaction with society (Lawrence et al., 2022; Scholz & Steiner, 2023). The idea of stakeholder engagement in transdisciplinarity emerged around two decades later in the 1990s, as one answer to the complex and interconnected challenges the world was facing (Klein, 2020). Bernstein (2015) even states that “*Themes of sustainability and global environmental crisis were watchwords in moving the heretofore little-used concept of transdisciplinarity to the foreground of debates about science and planning.*” (p.4) In 1987 the Brundtland report defined sustainability along the three dimensions of social, environmental and economical sustainability, and highlighted the urgent need for action to address global challenges (Brundtland, 1989). The United Nations Earth Summit taking place in Rio de Janeiro in 1992 built on the report and an action plan for sustainable development, called Agenda 21 (Sitarz, 1993). While Agenda 21 did not directly mention transdisciplinary research, it emphasized the need for interdisciplinary research, as well as both the importance of participation of targeted people and the interactions between research and decision-makers, to address the complex and interconnected challenges facing the world (ibid).

From that point forward, many scholars describe two streams of transdisciplinary research: the Nicolescu School and the Zurich School¹ (Lawrence et al., 2022; McGregor, 2015). The Nicolescu School, which is based on the ideas of physicist Basarab Nicolescu, believes that traditional boundaries between academic disciplines are not always fixed. There are often interconnected elements between disciplines that overlap, and TD can help to bridge these gaps. According to Nicolescu, TD involves dialogue, mutual understanding, and integration of different forms of knowledge (Nicolescu, 2002a, 2002b). The Zurich School is named after the first International Transdisciplinary Conference which took place in Zurich in the year 2000. It focuses on the idea of TD as joint problem-solving model for real-world problems (Klein et al., 2001) and builds on the concept of Mode 2 research introduced by Gibbons et al. (1994). Mode 2 research refers to a shift in the way science is being practiced, where knowledge production is distributed among a more diverse set of producers, including actors outside of academia such as NGOs and private institutions (ibid). In contrast, Mode 1 knowledge production is characterized by traditional science dominated by university departments and scientific journals, and is seen by some as socially detached, and disciplinarily siloed (ibid). While the Nicolescu School also emphasizes the philosophical and spiritual dimensions of transdisciplinarity, the Zurich School focuses on the practical application of TD, by seeing it as a research approach rather than a theory and by asking what kind of science our world needs now and in the future (McGregor, 2015).

¹ The Zurich school is also named pragmatic transdisciplinarity (Lynch et al., 2021), the Swiss school or the German school (Augsburg, 2014)

Yet, another important development relevant for the evolution of TD comes from the field of participatory research and development studies. Already in the 1940s social psychologist Kurt Lewin, working mostly in the United States and the United Kingdom came up with the term *action research* to describe a cycle of inquiry, action and evaluation which was conducted together with or by the people which are affected by the problem under study (Adelman, 1993). His approach was strongly influenced by his work in social psychology, where he described the importance of understanding the social context in which certain behaviors occur (Lewin, 1946). The ideas and methods developed by Lewin helped to lay the foundations for the development of Participatory Action Research (PAR) in Latin America in the 1970s. The key features of PAR include the involvement of community members, a commitment to social justice, an emphasis on action and change, and a focus on reflection and learning throughout the research process (Torres, 1992; Wadsworth, 1998). Paulo Freire, a Brazilian philosopher, educator and activist, contributed to this movement with his famous book “Pedagogy of the Oppressed” (Torres, 1992). The main message of this book is that education can be a form of liberation, if and only if, it is based on participation and dialogue which empowers individuals to become a part of the societal transformation. His work about the importance of dialogue, participation, and critical reflection, strongly influenced the subsequent development of PAR.

Around the same time, similar developments could be observed in international development cooperation and development studies. One famous example is Participatory Rural Appraisal (PRA) which is a methodological approach for conducting community-based research and development in rural areas (Chambers, 1994). It emerged in the 1980s as a response to the limitations of traditional top-down development approaches that failed to involve rural communities in decision-making processes (Bamberger & Mabry, 2019). The techniques included tools for mapping, ranking, and scoring, as well as methods for conducting focus group discussions, individual interviews, and participatory observations (Chambers, 1994). Robert Chambers is an important figure to consider when discussing PRA and related methodologies. Alongside Paulo Freire, he is widely regarded as one of the foremost thinkers in the field of development studies (Simon, 2006). In an interview, Chambers identified himself as someone who had the time, resources, and privilege to document and publish his observations on participatory methods in the field, rather than as the inventor of PRA (Knowledge Links, 2020). Nevertheless, he has become one of the best-known scholars in development studies. These trends towards greater local participation were also important for so called “North-South research partnerships” or research for development, which are considered as “*backbones of the international development cooperation*” (p.1) (Kotze & Dymitrow, 2022). As of today, both the term and the paradigm of transdisciplinary research are becoming more popular in “North-South” research or research for development (Kotze & Dymitrow, 2022; Saric et al., 2019).

Thus, while in the global North TD evolved as response to complex environmental and social problems that could not be solved by one discipline alone, more participatory approaches were seen as a way to ensure that development and research for development projects were more responsive to the needs of local communities. Two different backgrounds thus led to similar research approaches. The differences between transdisciplinary projects in the global North and “North-South” TD projects, which do not only have a different background but also take place in very different contexts, can inform a series of empirical questions.

1.2 Transdisciplinary Research Today

As described in the previous chapter, TD research has several backgrounds and up to the present day it has continued to evolve and expand as a field of inquiry. This is evident in such examples as new journals with the field of sustainability science, which are more open or sometimes even specifically targeting inter – and transdisciplinary research, such as *Sustainability Science* (since 2008), *Nature Sustainability* (since 2018), or *Global Social Challenges* (since 2022), to just name a few. These journals as well as more established journals such as *Ecology and Society* (since 1997), show a trend of more publications within the field of TD. Figure 1-1 shows the cumulative number of publications of the journals *Ecology and Society* (a) and *Sustainability Science* (b). The share of publications which include the word “transdisciplinary” in the title, abstract or the keywords is increasing over the years for both journals.

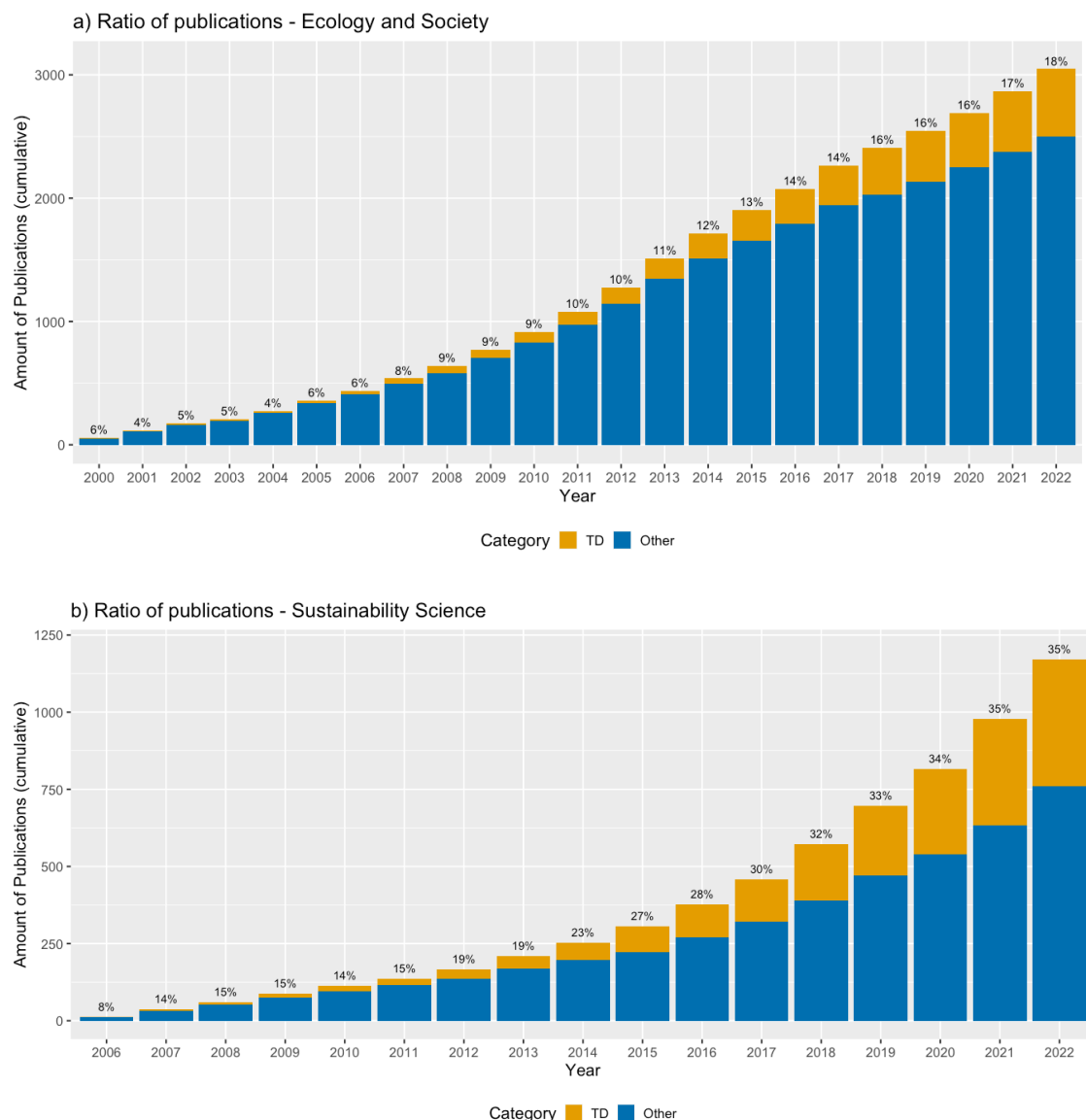


Figure 1-1 Number of total publications (cumulative) for a) *Ecology and Society* and b) *Sustainability Science*. Cumulative means that for each year, the figure shows the total amount of publications that was published up to and including this year. The share of publications containing the term “transdisciplinary” (in orange) compared to all publications is noted above the bar. Source: own representation, data: www.scopus.com

A key driver of the development of TD in recent years is the 2030 Agenda, a global action plan to tackle sustainability challenges (Moallemi et al., 2020; Sianes, 2021). Its 17 Sustainable Development Goals (SDGs) provide an integrated framework for addressing interconnected sustainable development challenges such as poverty, climate change, and environmental degradation. The 2030 Agenda, and especially the debate around its introduction, prompted a call to break down disciplinary silos, and for academia to leave its ivory tower, highlighting the need for inter- and transdisciplinary research to achieve the SDGs (Messerli et al., 2019a; Messerli et al., 2019b; Saric et al., 2019; Schneider et al., 2019b). As a result, many universities and research institutions have integrated the SDGs into their curricula and established research initiatives in order to tackle them (Schneider et al., 2021). One example is the program “Leading Integrated Research for Agenda 2030 in Africa” (LIRA), which was a program running between 2016 and 2021. The LIRA program provided financial aid and training to young African scientists to develop practical and locally relevant knowledge about sustainable urban development by using transdisciplinary approaches. Overall, the 2030 Agenda offers a framework to express concerns and communicate about pressing global challenges, providing a window of opportunity for transdisciplinary research. I suggest that while the Brundtland report and the Rio conference in 1992 were instrumental in kick-starting the transdisciplinary research movement (Klein, 2008), the 2030 Agenda has mainstreamed it and built on existing initiatives. I view the 2030 Agenda as a significant improvement over Agenda 21 in terms of promoting transdisciplinary research in two main ways. First, unlike the 2030 Agenda, Agenda 21 was primarily perceived as a government implementation plan with limited involvement from civil society and universities (Saner et al., 2019). Second, the 2030 Agenda's universal approach, holding all countries accountable for achieving sustainable development, has generated a greater sense of collective responsibility worldwide. In contrast, Agenda 21 had mostly targeted developing countries, resulting in limited global momentum towards sustainable development. The 2030 Agenda's universal scope has thus stimulated a more comprehensive and global approach to sustainable development, leading to more widespread movement worldwide than Agenda 21 (ibid).

Overall, I observe a certain institutionalization of transdisciplinary research (Thompson Klein, 2004; Vienni Baptista & Rojas-Castro, 2019). There are several examples of transdisciplinary research institutes and centers around the world, ranging from the Transdisciplinarity Lab (TdLab) at ETH, founded in 2012 to the “Transdisciplinarity” research group at University of Stellenbosch to the transdisciplinary Methodology Center at Leuphana University in Lüneburg. These institutes are active in teaching (Krütli et al., 2018; Pohl et al., 2020; Vienni Baptista & Rojas-Castro, 2019), advancing methods and theories of transdisciplinary research (e.g. Pohl & Hadorn, 2007), and running transdisciplinary projects or programs (van Breda & Swilling, 2018).

With the growing popularity of transdisciplinary research there is also more research and discussion about how the success of TD projects should be measured. Many scholars state that measuring success solely in terms of academic publications does not do justice to the potential societal relevance of the projects (Belcher et al., 2016; Lang et al., 2012; Roux et al., 2017). While transdisciplinary researchers are still struggling with publication pressure (Rogga & Zscheischler, 2021; Schrot et al., 2020), there are already ideas for such alternative metric systems (Bornmann et al., 2016; Bornmann & Leydesdorff, 2014). Very recently, the Swiss National Science Foundation (SNFS), for example, commissioned a study on the social innovation potential of their

research projects, as they aim to know more about how they could assess their projects in the future (Schuch, 2023).

Furthermore, there is also a growing body of literature about what works, how and when in TD projects. Lawrence et al. (2022) call this “process knowledge” and define it as: “*a special form of knowledge, which involves knowing when and how to apply the range of context-specific tools and methodologies that are needed to practically design, carry out, and evaluate TDR (transdisciplinary) projects*” (p.53). This includes, for example conceptual frameworks or models of TD processes (Jahn et al., 2022; Lam et al., 2021; Lang et al., 2012; Schneider & Buser, 2018; Schneider et al., 2019a) or the evaluation of TD projects (Belcher et al., 2020; Luederitz et al., 2017; Schäfer et al., 2021). A similar type of research is the so-called “accompanying research”. This term refers to research that is conducted alongside a larger project with the aim of providing further insights and recommendations to improve the project's outcomes (Defila & Di Giulio, 2018). Additionally, accompanying research can provide information and experiences for similar projects, especially regarding new and innovative research approaches (ibid). A related discussion is ongoing about the new roles that come with transdisciplinary research. Bulten et al. (2021) describe that researchers in TD projects need to take on new roles and skills alongside their conventional academic roles – a dynamic which can potentially lead to tensions. In their publication “Integrate the integrators!” (Hoffmann et al., 2022) the authors address these tensions. They state that integrators who specialize in leading, managing, monitoring, assessing, and advising others on integration within interdisciplinary and transdisciplinary projects are necessary to support this type of work. They call for the establishment of academic careers for integration experts, and discuss the nature of integration experts and the skills they need.

Overall, there is thus a growing recognition of transdisciplinary research from research and practice. Furthermore, there is emerging research and discussion about what Lawrence et al. (2022) call “process knowledge” thus research about TD. This thesis is contributing precisely to this emerging field, with a specific focus on the effects and characteristics of TD projects.

2 Research Gaps and Contribution to the Field

Based historical development of transdisciplinary research and its current state I identified two overarching research gaps for this thesis. I originally identified these gaps when first developing the funding proposal for this PhD project in 2019. As TD research has gained importance not only as an approach but also as a field of inquiry (Lawrence et al., 2022), the state of the research has changed remarkably during these four years. Thus, for each research gap, I will present the current state of the literature, and then specify how I address it in this thesis in a separate section (2.1 and 2.2)

The first gap concerns the effects of TD projects, meaning all the changes that can be attributed to a project. As described in the introduction, questions regarding the potential effects of TD projects are not yet fully answered. Furthermore, TD projects have different backgrounds, as they emerged differently in the global North and the global South, which might again lead to differences in the effects they achieve. The second gap concerns the characteristics which influence the effects of TD projects. As there is a wide variety of different TD projects, it is difficult

to identify the characteristics which lead to different effects. To tackle these two gaps, this thesis asks the following overarching research question:



How do the design, implementation and context influence the effects of TD projects?

This research question brings the two gaps together. In order to study how the project design, implementation and context influence the effects of a TD project, I first need to identify and structure the range of effects that TD projects can achieve. Thus, to answer this research question, I will first provide evidence on the effects of TD projects, and then in a second step look at the project design, the project implementation, and the context, as well as how these dimensions influence the effects.

2.1 Gap 1: Effects of TD Projects

In line with other researchers (Fritz et al., 2019; Lux et al., 2019; Schäfer et al., 2021), I define effects as all intended and unintended outputs, outcomes and impacts of a research project. Thus, I consider each change in status which can be attributed to the project as an effect. My definition deviates from the positivist perspective on effects which emphasizes observable and replicable changes that can be attributed to specific factors and tested through empiric method (Creswell, 2014). In the case of TD projects, clear counterfactuals are often not feasible, which limits the applicability of traditional positivistic evaluations. Therefore, my definition of effects does not align with a strict positivist perspective, and instead seeks to capture the complex and context-dependent nature of TD projects.

Many scholars state that the current success measures for TD projects are focusing on tangible results such as academic publications or fulfilled project goals (Belcher et al., 2016; Lang et al., 2012; Lux et al., 2019; Roux et al., 2017). However, these might not be sufficient to cover all the effects that TD projects can have (ibid). There is a growing body of literature which identifies and characterizes different effects of TD projects. Already very early in the development of TD research, the concept of three types of knowledge was introduced (ProClim, 1997): System knowledge includes knowledge used to describe a given system or problem (Pohl & Hadorn, 2007). By integrating disciplines and the knowledge of non-academic stakeholders, TD can contribute to holistic system knowledge that could not have been produced without local knowledge, or by one discipline alone. Target knowledge is defined as knowledge about the preferred future or outcome of a certain process (Schneider & Rist, 2014). With regard to target knowledge, TD may increase the applicability of results from for example scenario analysis by including the perspective of concerned stakeholders (Walz et al. 2007). Transformational knowledge describes the measures or tools which can be used to reach the targets, and is thus fundamental when it comes to fostering societal transformation towards sustainable development (Pohl & Hadorn, 2007). The three types of knowledge help to identify and distinguish different types of societal knowledge demand which can be met through a TD project (Pohl, 2022). Moving on to the generation of different knowledge types, TD research is also described to facilitate the uptake or use of produced knowledge in practice, policy, but also again in research (Jacobi et al., 2020; Jacobi et al., 2022; Patel et al., 2022; Schneider et al., 2019a; Tengo & Andersson, 2022). Further, Schneider et al. (2019a) show that TD research also generates impact through social learning, through networks, and through enhancing

competences. Similar categories are framed by Tribaldos et al. (2020) who use knowledge products, learning, and real-world transformations as rather broad categories of effects. Wiek et al. (2014) introduce four overarching categories of effects namely enhanced capacity, usable products, networks, structural changes and actions. Schäfer et al. (2021) present a similar set of categories but additionally also introduce effects related to the continuation of activities outside the project and the transfer to other areas. The transfer of results or learnings from one case to another is also studied in detail by other authors (Adler et al., 2018; Nagy et al., 2020). They find that while transfer of results or learnings from one TD project to another field is an important success criterion for TD research, it is challenging to actually achieve it.

As the pathways of TD projects in achieving effects are rarely linear, the interactions between different effects are crucial (Fritz et al., 2019; Muhonen et al., 2019; Schneider et al., 2019a). Newly produced knowledge might not directly lead to changes in behavior or the formulation of new policies, but might rather function as a first step leading to greater awareness of a problem, or the uptake in the political discourse. One way of illustrating and analyzing these pathways is the tool Theory of Change (ToC). ToCs originated in development cooperation to improve the effectiveness of interventions (Arkesteijn et al., 2015). It involves creating and regularly reviewing a plan for achieving impact, based on hypotheses about how activities lead to change (Belcher et al., 2020). More specifically, most ToCs map how activities lead to outputs, which are then eventually becoming outcomes and impacts (ibid). This approach acknowledges the complexity of societal transformations, which again rarely happen in a linear manner. Scholars started to apply ToC on TD projects and used them for their evaluation (Belcher et al., 2020; Oberlack et al., 2019; Schneider et al., 2019a), but also as a tool for planning and running TD projects (Deutsch et al., 2021). Other scholars have focused more on trade-offs and synergies between effects. Chambers et al. (2021) conducted a cross-case analysis of TD projects and found that the cases which featured strong investment in empowerment did not report any uptake in policy or practice. Furthermore, in their analysis, the production of scientific knowledge had a negative influence on all other effects.

I contribute to the aforementioned research gap regarding effects of TD projects by synthesizing and categorizing different effect categories based on existing research. Until now many scholars either distinguished rather broadly between the societal and academic effects of TD projects or focused on describing the social effects of TD projects. In this thesis I aim to bring the different effects, including knowledge production and uptake, as well as societal effects together and structure them accordingly. Furthermore, I will contribute to this research gap by looking at the empirical prominence of the different effects and by studying trade-offs and synergies. Most of the comparative studies are focusing on projects in the central European context (Jahn et al., 2022; Lux et al., 2019; Newig et al., 2019; Schäfer et al., 2021). While Chambers et al. (2021) include projects across the globe, they do not follow a comparative approach. This thesis additionally addresses this lack in different perspectives by specifically comparing the effects of TD projects that are conducted within the global North and TD projects that are conducted in “North-South” research partnerships.

2.2 Gap 2: Characterization of Different TD Projects

General statements on the effects of TD projects are difficult, as there is a large variety in how such projects are organized and implemented. This reflects in differences in the characteristics of TD projects. Mobjörk (2010), for example, distinguished between consulting TD and participatory TD, and noted that certain TD projects are much more participatory, while others are primarily focused on transmitting information. Several scholars studied how the way a TD project is conducted is linked to its success. Jahn et al. (2022) find that TD projects with more interactions with practitioners had more societal impact, but this was achieved at the cost of academic productivity in terms of publications. Furthermore, they find that the degree of interaction with practitioners was again dependent on the funding context in place. Newig et al. (2019) find that early involvement of non-academic partners had a positive influence on academic and societal outcomes. Furthermore, they also find that the academic performance is lower in projects which involve non-academic partners. However, there are also other dimensions, which might influence the effects of TD projects. Differences can lay in the stakeholders or disciplines involved (Edelenbos et al., 2010) as well as the leadership structure of projects (Chambers et al., 2021) to just name a few.

Schneider et al. (2022) further contribute to the characterization of different TD projects by identifying and describing different context dimensions which can influence the TD process and thus also its effects. While context conditions are often discussed as crucial (Belcher et al., 2016; Lam et al., 2021), most of the previous studies mainly focused on the funding mechanism but did not look at aspects such as the socio-economic or political situation. There is thus a lack of considerations of context factors in characterizing TD projects.

This thesis contributes to this research gap in two ways, first of all by providing a more fine-grid overview of different characteristics that can influence effects. I will build on existing research and contribute more towards the research gap by systematizing and by structuring the different characteristics. I classify the characteristics of TD projects into (1) design, (2) implementation and (3) context. I explain this system in more detail in section 3, when I present my research design. Second, I contribute to this gap by putting special emphasis on how context factors affect TD projects, as this gap remains poorly researched.

2.3 Related Research Fields

Research about transdisciplinary research is still a new research field (Lawrence et al., 2022). For the theoretical and conceptual basis of this thesis, I thus drew inspiration from several other fields, with similar questions and ideas. Below I briefly introduce these different fields of literature.

2.3.1 Policy Analysis and Evaluation

First, I draw on several ideas and concepts from political science. These concepts are especially relevant for my research design, which I present in section 3. Traditionally, the government has been seen as the primary institution responsible for making and implementing public policies, providing public goods and services, and maintaining social order (King & Wood, 1999; Mayntz, 2017). However, in recent years, the role of government has been challenged by a range of factors, including globalization, technological advances, and the increasing complexity of social and environmental issues, what led to a shift to the concept governance (ibid). Broadly speaking,

governance refers to steering human behavior in order to address certain issues, as it is formulated by Bevir (2012):

“Governance refers, therefore, to all processes of governing, whether undertaken by a government, market, or network, whether over a family, tribe, formal or informal organization, or territory, and whether through laws, norms, power or language. Governance differs from government in that it focuses less on the state and its institutions and more on social practices and activities.” (p. 1)

Thus, governance includes a broader set of processes, mechanisms, and relationships that enable societies to manage their affairs and make collective decisions. There has been a growing recognition in political science that governance is a more holistic and inclusive concept than “government,” and that effective governance requires collaboration and partnership among a range of actors beyond the formal structures of government (Mayntz, 2017). This has led to the emergence of new forms of governance, such as public-private partnerships, collaborative networks, and participatory processes that involve citizens, civil society organizations, and private sector actors in decision-making and policy implementation.

I suggest that the shift from “government” to “governance” has similarities with transdisciplinary research, as both aim to promote collaboration and partnership among diverse stakeholders to address complex societal problems. Governance focuses on the importance of collaboration and partnership among a range of actors beyond the formal structures of a government to address complex social and environmental issues (Bevir, 2012). This requires an understanding of the perspectives, values, and knowledge of different stakeholders, including citizens, civil society organizations, and private sector actors, as well as academics and policymakers.

One example of similarities between the two approaches can be found, I contend, in the debate about participation. The democratic dilemma (Dahl, 1994) posits that broad involvement of citizens in policymaking and implementation, on the one hand, and achieving policy outcomes, on the other hand, are mutually exclusive. Contrasting with the view of a trade-off, some scholars state that both dimensions – integration of many actors and successfully implementing goals – can re-enforce each other: for example, policy learning through dialogue should lead to increased credibility and acceptability amongst a wide range of actors, and therefore foster a successful implementation of goals (Fritsch & Newig, 2009; Hansen & Allansdottir, 2011; van de Kerkhof, 2006).

A related concept is legitimacy, which broadly refers to the acceptance or recognition of an authority as valid by the people it governs (Weber, 1978). Particularly relevant for the research design of this thesis are the analytical dimensions of legitimacy, first introduced by Scharpf (1999). While input legitimacy focuses on the democratic principles and describes the degree of citizen involvement in decision making, output legitimacy takes a utilitarian approach by concentrating on what was obtained in a certain process and whether it was effective (Scharpf, 1999). Throughput legitimacy as the least studied dimension represents the quality of the process in terms of factors such as efficiency, transparency, or accountability (Schmidt, 2012). It thus bridges the input and output sides by trying to explain the black box between the configuration of policy making processes in terms of stakeholder participation (input) and their effectiveness

(output) (Schmidt, 2012). Lieberherr and Thomann (2020), for example, find that accountability dilemmas or conflicting interests appearing during the implementation of a Swiss forest policy had negative consequences for policy implementation.

2.3.2 Natural Resource Governance

Next to general theories and concepts of governance, an important context for the emergence of this thesis is the field of natural resource governance. Natural resource or environmental governance can be defined as steering human behavior in order to address an environmental issue or to manage natural resources (Partelow, 2016). Typically, scholars focus on common-pool resources such as forests or fisheries, which require coordination and collaboration between many different stakeholders and their interests (ibid). Governance can be used as analytical concept to explain the use and management of natural resources through formal or informal rules which guide interactions between resource users. I suggest that the literature of and the concepts from natural resource governance offer insight that could be “borrowed” for studying TD projects. I build concepts from natural resource management mainly in Article 2 and Article 3, where I study the role of design, implementation and context of TD projects. As with the management of natural resources, TD projects bring together a variety of different actors, meaning researchers from different disciplines as well non-academic researchers, all of whom are jointly trying to tackle a wicked problem. While combining natural resource governance and transdisciplinary research is not yet very common, it is by no mean a new idea, already as early as 2008 Newig et al. (2008) state that they regard the *“the participation of non-state actors in public decision-making and transdisciplinary research”* (p.381) as an effective method to tackle complex problems arising from human-nature interaction.

One very important scholar in the field of natural resource governance is Elinor Ostrom. Ostrom was known for her work on the governance of common-pool resources such as forests, fisheries, and water basins. She developed two frequently used frameworks in the field of natural resource governance, the institutional analysis framework (IAD) and the socio-ecological systems (SES) framework. I work with these frameworks in Article 2 and 3. The IAD framework can be used to analyze the effectiveness of institutions in governing common-pool resources (McGinnis, 2011; Ostrom, 2011). The framework identifies a set of variables that can be used to analyze the rules-in-use within a particular institutional context, including the attributes of the resource system, the attributes of the resource users, the governance system, and the system’s biophysical and social environment. The SES framework is a broader framework for understanding the complex interactions between social and ecological systems in the governance of common-pool resources. The framework emphasizes the importance of recognizing the feedbacks and interactions between different components of the system, including the resource system, the resource users, the governance system, and the external environment (Ostrom, 2009). Both frameworks have been frequently used to design and evaluate governance systems for natural resources (Berninsone et al., 2018; Leenhardt et al., 2017; Ortiz-Riomalo et al., 2023) as well as to understand the context of a TD project (Guimarães et al., 2018).

Further, the literature on natural resource governance or also participatory or collaborative governance is helpful to study TD projects because it offers empirical evidence on whether and how collaboration between diverse actors can work. This literature thus served as source of

inspiration for my overarching research question. Overall, the results of so called “new modes of environmental governance” are mixed (Bäckstrand et al., 2010). Lubell (2004) for instance find that collaborative environmental institutions were successful in fostering consensus, but did not show more cooperation than non-collaborative institutions. Bakker and Cook (2011) have found that the inclusion of local communities through participatory processes has fostered the implementation of goals of water management projects. Conversely, Brody (2003) finds that including a wide variety of actors in planning processes does not consistently lead to higher quality of management plans. Other studies on co-management of natural resources even conclude that some cases of co-management can have negative outcomes, especially on poor and powerless actors, or in instances when actors’ worldviews are too diverse (Berkes, 2009).

3 Research Design

In this thesis, I explore different aspects of transdisciplinary research, namely the effects of TD projects, and how they are influenced by the design, implementation and context of the project. Figure 3-1 presents the conceptual framework of the thesis exemplified through the idea of the open system model (Kast & Rosenzwe.Je, 1972; Katz & Kahn, 1978). The open system model proposes that actions of an organization consist of inputs, which are resources entered into the system, throughput which describes the process of transforming the inputs to outputs, which are the results produced. Additionally, the open system model contains feedback effects, and acknowledges that there are environmental factors, which are external to the system but still influence it (Kast & Rosenzwe.Je, 1972; Katz & Kahn, 1978). The open system model plays an important role for this thesis and serves as conceptual framework. As the input dimensions, the design of a TD project, represent the resources which are entering a project, such as the disciplines or stakeholders involved in a project. The project implementation represents the process of transformation, thus in the case of TD projects, working together to jointly achieve effects, which correlate to the output dimension in the open system model.

The open system model shows many similarities to the aforementioned concepts from policy analysis and natural resource governance (section 2.3.1), such as the three analytical dimensions of input, throughput and output legitimacy (Scharpf, 1999). Further, Ostrom’s institutional analysis framework (IAD) and socio-ecological systems framework (SES) (Ostrom, 2009, 2011), as presented in section 2.3.2 both share the open system models emphasis on feedback loops and the need to incorporate context factors, as factors which are external to the project (McGinnis, 2011).

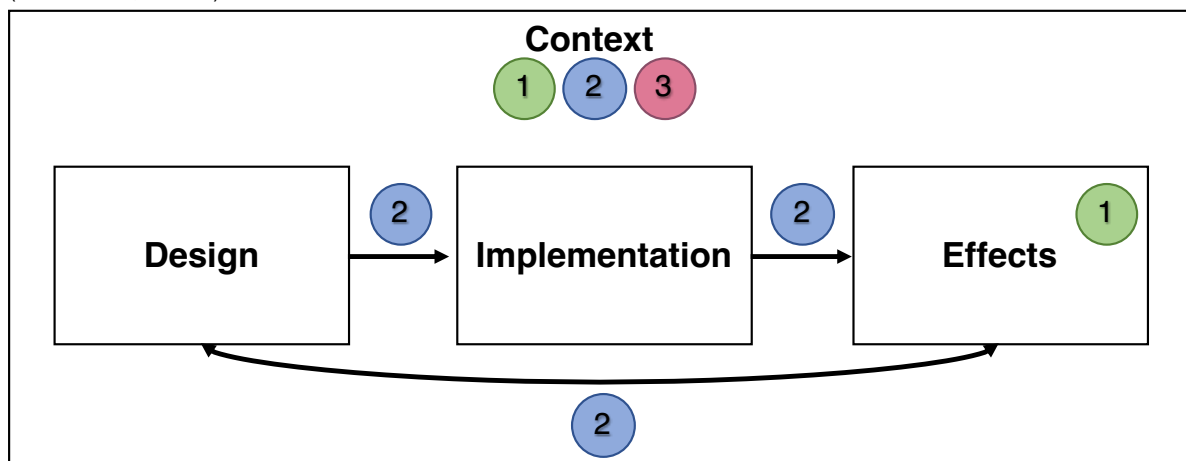


Figure 3-1 The Conceptual Framework of this thesis based on the open system model. The numbered circles represent the articles and show which article target which part of the framework. Article 1 focuses on the effects but compares them according to different context. Article 2 takes an overarching approach by looking how all the different elements influence the effects. Article 3 focuses solely on context.

The circles represent the three articles of this thesis and show on what element they focus on. More details, including the research questions of the articles are also described in Table 3-1. As demonstrated in the research question, Article 1 focuses on the effects of TD projects and studies them in different contexts (in the global North and in the global South). It thus contributes to the goal of identifying effects as well as to exploring the role of context. Article 2 has a broad scope, and asks how different factors influence the effects of TD projects. It thus focuses on all the

different characteristics (Design, Implementation and Context), and investigates how they influence the effects. Here it is important to note, that I used a slightly different terminology in Article 2. More specifically I called the factors input, process, and institutional factors, instead of design, implementation and institutions. However, the meaning is exactly the same. Article 3 focuses solely on the role of the context by asking how the context factors affect TD projects. Together, the three publications thus cover all elements of the conceptual framework and all the dimensions of my research question.

Methodologically, I use a literature review in combination with quantitative description for Articles 1 and 2 while Article 3 is based on a comparative case study. Thus, the three publications, which I present in Table 3-1 complement each other, cover different areas of the overall research question, and rely on different methods. The first two publications have been published in peer-reviewed journals, while the third publication is currently under review.

Table 3-1 Overview of the publications

	Research Question	Publication
1	How do effects of N-S TD projects differ from the effects of TD projects in the global North?	<u>Pärli, R.</u> , M. Fischer, E. Lieberherr. 2022. What are the effects of transdisciplinary research projects in the global North and South? A comparative analysis. <i>Current Research in Environmental Sustainability</i> 4: 100180.
2	How do different factors influence the effects of TD projects?	<u>Pärli, R.</u> 2023. How input, process, and institutional factors influence the effects of transdisciplinary research projects. <i>Environmental Science & Policy</i> 140: 80-92.
3	How do context factors affect TD projects?	<u>Pärli, R.</u> , M. Byamungu, M.Fischer, S.Kantengwa, K.Kintche, M.Konlambigue, E.Lieberherr, J.Six, B.Wilde, L.Späth. 2023. "The reality in the DRC is just not the reality in Rwanda" – How context factors affect transdisciplinary research projects. <i>Research Policy</i> . Submitted.

4 Methods

4.1 Positionality

A researcher's positionality can influence the way research is conducted as well as the results (Berger, 2013; Bourke, 2014). Especially in qualitative research, it is thus crucial to describe and reflect upon one's positionality. I see four areas where my positionality informed the way I conducted research.

First, my epistemological stance influenced my research design, including data collection and analysis. I position myself as a critical realist "with a pinch" of social constructivism. While I recognize the existence of objective realities, I also acknowledge the subjective interpretations and social constructions that shape our understanding of these realities. This perspective informs my approach to research design and data analysis by emphasizing the importance of contextualizing findings. In line with the idea of critical realism I use different methods in my articles to gain a more complete picture of the empirical world, while also exploring the underlying structures and mechanisms that are not directly observable. The constructivist influence is particularly evident in Article 3 in which I deliberately draw on interviews with as many different perspectives as possible.

Second, I studied environmental sciences at ETH Zurich, and I have little experience outside of research. During my studies, I frequently encountered participatory and transdisciplinary methods. Combined with limited experience outside of academia, this may have resulted in a bias towards the benefits of collaboration. This influenced my research especially at the beginning of the work on my PhD thesis where I had the normative assumption that "TD works" and I just wanted to show how exactly it worked. Through deeper engagement with existing literature and scoping interviews I developed the research question as it stands, which is more analytical and aims to discover the effects of TD projects and the factors that influence them. Especially scoping interviews with non-academic stakeholders that were involved in TD projects helped me to better understand selected non-academic perspectives.

Third, I grew-up and studied in Switzerland, a high-income country. However, during my PhD project I was collaborating with a research project that is taking place in Rwanda, the Democratic Republic of the Congo (DRC), South Africa and Ethiopia. While it is implemented by local research institutions together with stakeholders, ETH Zurich coordinates the project. For my PhD project, I have collaborated with the subproject in Rwanda and in the DRC. My identity as a Swiss citizen working for the organization which coordinated the overall research project has afforded me certain privileges and perspectives that may influence my research, particularly in terms of power dynamics, cultural differences, and language barriers. Overall, I am aware of the limitations of my own positionality and have made an effort to conduct my research with respect and openness to diverse perspectives. I have also continuously reflected on my position and privileges throughout the process. Although it is challenging for me to fully understand and articulate how my position and privileges may have influenced my research, I can provide two examples to illustrate this influence. The first example pertains to language barriers. For the case study work conducted in Rwanda and the DRC, I conducted interviews in English or French. While all of my interview partners were fluent in either English or French, these languages were not their mother tongues, and the same applies to me. I assume that this language barrier sometimes made it

difficult to express certain opinions effectively. However, by not relying on a translator, I was able to ask additional questions during the interview process and minimize the risk of information being lost in translation. The second example relates to social desirability. As a Swiss person working for the organization overseeing the overall project, I acknowledge that some of the answers provided by the interview partners may have been influenced by social desirability bias, leading to overly positive responses. To address this concern, I made efforts to clarify the confidentiality of the information shared and explained my role clearly (e.g., emphasizing that I was not employed by the project).

Fourth, my role in the described research project was that of an observer. Nevertheless, as the project is currently running and I was taking part in meetings and workshops, there was always the risk of becoming too involved, and not maintaining objectivity. This issue of being an insider and an outsider at the same time is frequently discussed in ethnology (Bourke, 2014; Kerstetter, 2012). However, there is no agreement on which position is better, as both positions have their benefits and challenges (Holmes, 2020). Tempering this bias is the fact that I was never involved in strategic decision making. I also always explained my role especially when interacting with stakeholders, creating transparency around my role and positionality.

4.2 Systematic Literature Reviews and Quantitative Description

For the first two publications of this thesis, I collected data through a systematic literature review. I included scientific publications which look at the effect of TD projects and followed the PRISMA guidelines to identify the relevant publications (Moher et al., 2009). I used a variety of synonyms for transdisciplinary research combined them with search terms for sustainable development. I selected publications described cases of transdisciplinary research projects, which were published in English between 2010-2021. This resulted in 101 publications which were relevant for Article 1 and 115 publications for Article 2. Literature reviews are often used to critically analyze and synthesize existing literature on a particular topic. They are often deployed in combination with content analysis, which is a research method that involves analyzing and interpreting text data in order to identify patterns, themes, or trends in datasets (Mayring, 2004). Content analysis can be applied to a variety of sources, such as in my case scientific publications. It is a systematic approach to analyzing data that allows researchers to identify key concepts and themes. More specifically, I used deductive as well as inductive coding (Robson, 2002) to identify different effects of TD projects (Article 1) and how they are influenced by the design, implementation and context of the projects (Article 2)².

I conducted a systematic literature review, where I analyzed more than 100 cases of TD research projects. I coded the cases for effects (Article 1) and additionally for influences between effects and factors related to design, implementation and context (Article 2). In Article 1 I use descriptive statistics and a clustering algorithm to identify which effects were achieved how prominently and which effects are often co-occurring. In Article 2 I use quantitative description by counting how often which factors related to design, implementation and context were linked to effects.

² As already described in section 3 I used a slightly different terminology in Article 2 than in the rest of this thesis. However, the terms can be used synonymously.

Additionally, I use semi-structured interviews with experts in TD research from research and practice, to allow for further elaboration of the results.

To analyze the data I use quantitative description, which is a method of describing data or phenomena using descriptive statistics or numerical values (Gerring, 2012). More concretely I looked at prominence of certain elements and how they group together (clustering method based). With the emergence of more causal research, quantitative description is often diminished and characterized as having low scientific value (Gerring, 2012; Munger et al., 2021). However, many scholars do not agree with this. One argument as to why descriptive research is useful notes that it forms the basis for causal theory testing. Furthermore, in order to control for external validity, meaning whether a certain treatment for example also works in a different setting, description is needed to describe the new context (Egami & Hartman, 2022). Quantitative description serves the twinned goal of conceptualization and measurement (Gerring, 2012). However, it is also critical to find the right balance between abstraction and nuance in description.

The approach of quantitative description is also interesting in the light of theory skepticism. In his article “Fuck Nuance” Healy (2017) states that the focus on developing new theoretical frameworks by being more and more nuanced can sometimes lead to a neglect of empirical research and a lack of attention to the contextual factors that shape social phenomena. Besbris and Khan (2017) state that descriptive research, which involves providing detailed and accurate descriptions of social phenomena, can be just as valuable as theory in helping us to understand the social world.

4.3 Realist Evaluation

In the third publication, I study how the context influences TD projects using the concept of realist evaluation. Realist evaluation is an approach to evaluation that seeks to understand how, for whom, and under what circumstances interventions work. Specifically, it assumes that interventions are complex and depend on the context in which they are implemented (Pawson et al., 2004; Pawson et al., 1997). Realist evaluations use a context-mechanism-outcome configuration to identify causal mechanisms and context conditions that lead to specific outcomes (Douthwaite et al., 2017; Jagosh, 2019). To illustrate this Gill et al. (2014) use the example of how gravity affects a tennis ball to show how the same mechanism can lead to different outcomes depending on the context. Given the complexity of TD and the potential for context to shape effects, realist evaluation is an appropriate approach to study how the context influences the effects of TD projects. In line with the context-mechanism-outcome configuration, I examine how the context influences the effects of TD projects, which will be the mechanism under observation. Realist evaluations are particularly useful to test new approaches or approaches that seem to have good results for unclear reasons, or to evaluate programs that will be applied in a different context (Pawson et al., 2004; Pawson et al., 1997). While transdisciplinary research is a relatively new approach to research, there are claims about its effectiveness, as well as open questions regarding how it is affected by the context it takes place in.

4.4 Comparative Case Study

To conduct the realist evaluation about TD research, I use a comparative case study approach. A case study design is appropriate to address complex real-world situations with many uncontrollable variables (Yin, 2003). Thus, case studies are often used to evaluate programs, policies, or interventions, and commonly used in many different fields, for example social or political sciences or development studies. Moreover, a case study is a suitable research strategy to answer 'how' questions (Robson, 2002). There are many different types of case studies. A comparative case study involves the systematic comparison of at least two cases in order to study one phenomena across time or space (Bartlett & Vavrus, 2016). Comparative case studies can be used to identify the factors that are responsible for producing differences in outcomes in respective cases. Comparative case studies look at variance in terms of similarities and differences based on Mill's method of difference (Mill, 1889). There are two main types of comparative case studies: a "most similar systems" case study or a "most different systems" case study (Blatter & Haverland, 2012). The former involves comparing cases that are similar in many respects, but differ in terms of a key variable of interest. The goal is to control for as many extraneous variables as possible in order to isolate the effect of the key variable. The latter, on the other hand, involves comparing cases that are different in many respects, but share a common characteristic or variable of interest. The goal is to identify the factors that account for the common characteristic or variable, even in the presence of many differences between the cases. For the third publication, I use a comparative case study based on the most similar system design, as I am interested in how differences in the context affect TD projects if all the other influential variables are very similar.

Comparative case studies also work well with evaluations in general, and specifically with realist evaluations (Gilmore et al., 2019; Koenig, 2009; Robson, 2002). While a comparative case study can be used to identify the factors that lead to a difference in the outcomes of the different cases, the concept of realist evaluation is used to understand the underlying mechanisms of why the context influences the outcomes. I suggest that by combining these two approaches I can gain a more nuanced understanding of how interventions or programs work, and how they can be improved.

One challenge in case study research, especially with small-N case studies, lies in the generalizability of findings (Yin, 2013). Case study research does not aim for statistical generalizability but instead focuses on analytical generalizability, which can be described as "*the extraction of a more abstract level of ideas from a set of case study findings*" (p.325) (Yin, 2013). In this thesis, I aim to achieve analytical generalizability by focusing on a systematic analysis of contextual factors in Article 3. Through a rigorous examination of context factors, case study research can uncover broader themes, patterns, and theoretical insights that may have relevance beyond the specific cases investigated (Mookherji & LaFond, 2013). The comparative analysis conducted in this study further enriches the exploration by highlighting differences between cases. Additionally, realist evaluation (see section 4.3), which I employ in the case study setting, is helpful in achieving analytical generalizability as it seeks to facilitate the transferability of findings to other contexts by providing detailed explanations of the mechanisms and contextual factors identified in a specific case or study (Pawson et al., 2004; Pawson et al., 1997)

4.5 Approach towards Causality

Causality in qualitative research differs from that in quantitative research (Bennett & McWhorter, 2016). In quantitative studies, causality is often understood through statistical associations and establishing cause-and-effect relationships using randomized control trials, experimental designs, or statistical modelling (Bamberger & Mabry, 2019; Robson, 2002). In qualitative research, describing causality requires a nuanced approach due to the nature of qualitative data and the absence of controlled experimental conditions (Bennett & McWhorter, 2016). While qualitative research may not establish causality in the same way as quantitative research, it offers an opportunity to understand underlying causes and mechanisms (ibid). I briefly present the various ways in which I approach causality in this thesis.

In Article 1, I work with correlation by examining the co-occurrences of effects. Therefore, I do not directly include a causal analysis. However, by grouping items that tend to co-occur, I identify associations between different effects. This approach, as described in section 4.2, can provide insights into the underlying structure or organization of the data. In the case of Article 1, it also serves as a basis for comparison between TD projects with different backgrounds. In Article 2, I take a different approach. I examine the influences of different characteristics of TD projects and their effects, drawing on existing studies and working with the causal influences described by the authors, who employ different approaches to assess causality. I discuss the limitation of this approach in the respective article (see section 6.5). In Article 3, I adopt a more explanatory approach to causality. I use realist evaluation, which seeks to understand not only whether an intervention works but also why and how it works (Pawson et al., 2004; Pawson et al., 1997). Realist evaluation recognizes that interventions do not have the same effect in all contexts and that causality is contingent upon specific mechanisms operating within those contexts (Gilmore et al., 2019). Thereby, I assess causal influences based on the perceived causal influences reported by the interview partners.

5 Article 1

What are the Effects of Transdisciplinary Research Projects in the Global North and South? A Comparative Analysis

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Abstract

Transdisciplinary research (TD) integrates knowledge from different scientific disciplines as well as from research and practice. Research and practice therefore describe TD as a well-suited means for addressing complex sustainability challenges. However, the effects of TD on sustainable development are difficult to assess, as such projects produce manifold, interrelated effects through nonlinear processes, contingent on different contexts. In this article, we use a systematic literature review of 101 TD projects to assess the different effects of TD projects and their interrelations. We distinguish between North-South TD projects and TD projects within the global North. Due to differences in terms of historical development and context, we expect to observe differences in the effects they achieve. We find that North-South projects scored higher for societal effects and uptake of knowledge, while projects in the global North produced more tangible outputs such as academic publications. In terms of interrelations of effects, N-S projects emphasize inclusion more strongly than global North projects, due to an increased awareness of differences between different project participants. However, effects related to uptake of knowledge, learning, and societal effects are often interrelated for both types of projects. This article improves our understanding of the prominence of different effects of TD projects, the interrelations between effects, and the differences between N-S and North projects. Acknowledging this diversity of effects is important not least for evaluating TD projects.

Keywords

Transdisciplinary Research, Sustainable Development, Project Effects, North-South Research Partnerships, Evaluation

5.1 Introduction

Society faces a range of highly complex and multifaceted sustainability challenges such as biodiversity loss, nutrient loss in soils or environmental pollution. In this context, both researchers and practitioners are increasingly questioning the capacity of “traditional” scientific research, that is, research with a purely disciplinary focus, to provide the evidence needed for supporting the transformations to address major sustainability challenges (Colglazier, 2015; Fritz & Binder, 2018; Lang et al., 2012; Sachs et al., 2019). By contrast, both the integration of disciplinary knowledge from different fields such as agronomy and engineering as well as inputs from practice such as from farmers, utilities and fertilizer companies (Belcher et al., 2016; Lang et al., 2012) is crucial to support a transformation, such as e.g., from synthetic fertilizer use to the use of recycled nutrients to optimize soil fertility. Transdisciplinary (TD) research tackles these dimensions by aiming at the integration of knowledge from different scientific disciplines, on the one hand, and from research and practice, on the other hand (Belcher et al., 2016; Lang et al., 2012). As such, TD has the potential to produce holistic and applicable system, target, and transformation knowledge and thus to support the transformation toward sustainable development (Schneider et al., 2019a).

The existing literature contains only scarce empirical evidence on the contribution of TD projects to addressing sustainability challenges. We observe three major research gaps. First, TD projects produce diverse effects ranging from knowledge production to pure academic outputs, to the creation of trust between the participants involved. Various scholars have developed frameworks, schemes, and evaluation approaches to describe this diversity of effects. Authors such as Jahn et al. (2022) and Tribaldos et al. (2020) for example provide important insights into different styles of TD collaborations and context conditions (such as the sustainability problem a project is addressing or the institutional background) that influence the effects. However, evidence on what effects are most prominent in TD projects is scarce (Fritz et al., 2019; Muhonen et al., 2019; Schneider et al., 2019a). Second, research shows that the pathways for achieving effects through TD projects are multifold and rarely linear (Fritz et al., 2019; Muhonen et al., 2019; Schneider et al., 2019a). Nevertheless, the relations between the different effects or their commonalities have not been sufficiently studied. Only Chambers et al. (2021) have specifically analyzed trade-offs and synergies between different effects, but they do not consider differences between different research contexts.

Third, TD projects have different traditions and are highly contingent on their contexts. One important context condition is the one between TD projects conducted in a North-South (N-S) research partnership and projects conducted in the global North (North projects). The N-S research field has traditionally placed a strong emphasis on the participation of local stakeholders and the practical applicability of results (Bradley, 2008; Brutschin & Wiesmann, 2008; Hirsch Hadorn et al., 2006; Saric et al., 2019). In contrast, North research projects have focused on creating knowledge, without taking a participatory approach until recently (Mobjörk, 2010; Scholz & Marks, 2001; Scholz & Steiner, 2015). Beyond these different foci, N-S and North projects also take place in very different contexts (N-S projects typically being implemented in the South), which arguably influences their effects.

Given the lack of knowledge on effects of TD projects in different contexts, we pose the following research question: *How do effects of N-S TD projects differ from TD projects in the global North?* By answering this question, we contribute to the literature by assessing the prominence of different effects of TD projects as well as the interrelations of these effects in different contexts. Based on a literature review and evidence from 101 TD projects, the article presents which effects are how prominent in TD projects, and how the effects interrelate and create potential synergies and trade-offs between them (Fritz et al., 2019; Muhonen et al., 2019; Schneider et al., 2019a). Both pieces of information are crucial to an appropriate evaluation of TD projects (Belcher et al., 2016). Further, the article presents important differences and similarities between the effects of N-S projects and TD projects within the global North. For better comparability of the cases and a thematic focus of this article, we limit ourselves in this review on TD research in sustainable development.

In the next section, we delineate different categories of effects and their interrelations and outline the different research traditions in both North and North-South contexts. We then outline our methods before presenting our results based on a literature review, descriptive statistics and a clustering approach.

5.2 Conceptual Background

To contextualize the core research gaps we address in this article, we present the state of the art on 1) the different types of effects and their interrelations and 2) TD projects in the global North vs. within North-South research.

5.2.1 Types of Effects and Interrelations between Effects

From a traditional academic point of view, effects of projects are typically defined as tangible outputs such as academic publications or fulfilled project goals. In order to capture the effects of TD projects, several authors call for a broader perspective on the different potential effects (Jacobi et al., 2020; Lux et al., 2019; Schneider & Buser, 2018). We thus follow Fritz et al. (2019) who propose the general term “effect” to describe the wide diversity of results of TD projects, ranging from increased motivation to uptake of produced knowledge to network effects. A variety of schemes and frameworks describe the effects of TD projects at different levels of abstraction. They range from rather broad categories of societal and academic outputs and impacts (Newig et al., 2019) to overarching impact categories such as learning, and real-world transformations (Chambers et al., 2021; Tribaldos et al., 2020). Other authors include effects such as the creation of networks or increased decision-making capacity (Fritz et al., 2019; Luederitz et al., 2017; Wiek et al., 2014).

One category which is present in the literature is knowledge production. Lang et al. (2012) argue that beyond fulfilling project goals, an evaluation should also consider different types of knowledge production in terms of acquiring system, target, or transformation knowledge (Belcher et al., 2019; Belcher et al., 2016). System knowledge includes knowledge used to describe a given system or problem (Pohl & Hadorn, 2007). By integrating disciplines and knowledge of non-academic stakeholders, TD research can lead to holistic system knowledge. Target knowledge is defined as knowledge of the preferred future or outcome of a certain process (Schneider & Rist, 2014). TD can increase the applicability of results from, for example, scenario

analysis by including the perspective of concerned stakeholders, which creates target knowledge (Walz et al., 2007). Furthermore, using TD approaches to generate target knowledge helps to identify stakeholders' underlying values and motivations (Karrasch et al., 2022). Finally, transformation knowledge describes the knowledge, measures or tools to reach the targets (Pohl & Hadorn, 2007). These different types of knowledge can be summarized as knowledge production. TD research can also foster uptake of knowledge. This includes the uptake in practice but also in policy and research. Due to the involvement of stakeholders and different disciplines, TD projects generate knowledge applicable for practice that is then potentially taken up by a target group (Hansson & Polk, 2018; Schneider et al., 2019a; Schneider & Rist, 2014). Another category of effects includes traditional, tangible outputs of research processes in the form of publications or reports for academic participants and stakeholders (Kaufmann & Kasztler, 2009; Koier & Horlings, 2014; Mitchell et al., 2015). These can be called products, and include for example publications but also outreach material. Furthermore, studies describe effects related to learning, such as capacity building or increases in problem awareness (Fritz et al., 2019; Muhonen et al., 2019; Tribaldos et al., 2020). Lastly, scholars argue that TD projects also generate impact through societal factors, such as by fostering networks or increased trust (Chambers et al., 2021; Schneider et al., 2019b; Wiek et al., 2014). We describe these as societal effects.

As TD projects involve multifold and rarely linear pathways for achieving effects, interactions between different effects are crucial (Fritz et al., 2019; Muhonen et al., 2019; Schneider et al., 2019a). Newly produced knowledge might, for example, first increase the problem awareness of project participants and then eventually lead to changes in behavior. At the same time, research shows that projects which focus on certain effects of TD projects might struggle to achieve other effects (Chambers et al., 2021; Schneider et al., 2019a). Chambers et al. find several trade-offs between different effects of TD projects. One example is that they find that TD projects which were successfully producing scientific knowledge often failed in achieving other effects such as uptake in policy.

5.2.2 TD Projects in the global North and South

TD projects in a N-S context differ from projects in the global North, given different historical developments of research traditions. Disciplinary research in international development has traditionally started with problems perceived by the researchers and resulted in solutions propagated by them. This changed around the 1970s, when experience showed that integrating the perspective of local stakeholders through participation can increase the uptake of project results (Brutschin & Wiesmann, 2008; Hirsch Hadorn et al., 2006). Approaches such as participatory rural appraisal or participatory action research (PAR) evolved as a response to the recognition that traditional, top-down approaches to research for development efforts were largely ineffective (Chambers, 1994; Wadsworth, 1998) and, hence, PAR encourages researchers and extension officers to act as facilitators in an equal partnership with the local stakeholders (Chambers, 1994). The evolution of N-S research partnerships led to an integration of "northern ideas" of TD, focusing on creating knowledge for society and the "southern ideas" of participation and equal partnerships (Hirsch Hadorn et al., 2006). Research suggests (Brutschin & Wiesmann, 2008; Khan et al., 2013) that TD projects within N-S research partnerships focus on effects potentially more relevant and applicable for the stakeholders

involved, and tend to take context specificities into account (e.g., focusing on societal effects rather than products). By contrast, the literature indicates that projects within the global North might not focus as much on effects applicable for stakeholders and on context conditions (Hirsch Hadorn et al., 2006). Furthermore, due to the additional transnational dimension, N-S research projects offer opportunities for joint learning, capacity building, and exchange for both partners to a degree that might not be possible in projects within the global North (Bradley, 2008; Ott & Kiteme, 2016). Research also shows that N-S research partnerships may come along with power imbalances as mostly organizations in the global North manage the funds and coordinate the projects (Blicharska et al., 2017; Ott & Kiteme, 2016; Tribaldos et al., 2020; Zingerli, 2010). Such imbalances and implicit hierarchies complicate collaboration as well as the effective and efficient implementation of projects (Blicharska et al., 2017). Furthermore, translation issues or differences in research culture can complicate the research process in N-S partnerships and potentially influence their effects (Bréthaut et al., 2019; Schmidt & Propper, 2017).

5.3 Methods and Data

We answer our research question of how effects of N-S TD projects differ from TD projects in the global North by focusing on two dimensions: the prominence of the effects as well as their interrelations. We analyze both dimensions for N-S projects versus projects within the global North. We rely on a literature review based on cases of TD projects. In the subsequent section, we first present how we identified relevant articles. Second, we elaborate how we coded them according to our coding scheme. Third, we specify how we applied descriptive statistics to the data from the literature review to study the frequency of effects, and how we used a clustering approach to study the interrelations of effects. Finally, we present how we compared the effects between N-S projects and North projects.

5.3.1 Identification of the Literature

Following Bramer et al. (2018), we first identified the key concepts needed to address the research question. These key concepts are TD projects and their effects, as we are aiming to identify links between them. The focus on TD research projects for sustainable development provides a third concept. Second, we use a broad range of search terms related to the three concepts of TD research projects, effects, and sustainable development. Table 5-1 shows the final selection of the search terms. The terms for each concept were combined with the Boolean operator OR while we combined the three concepts with AND operators. A search in the Web of Science and Scopus databases of articles and reviews written in English and published in 2010 or later resulted in a total of 745 publications³. For all search terms, we used a title-abstract search. We explicitly excluded searching the keywords, as publications that only mention our search terms in the keywords but not in the abstract or title were often only marginally related to our focus.

³ The final search was conducted on March 4th 2020

Table 5-1 Final selection of search terms

TD Research Project	Effects	Topic
Title-Abs (OR)	Title-Abs (OR)	Title-Abs (OR)
transdisciplinary *	Output	Sustainability
"research-practice integration"	Impact	Sustainable Development
"collaborative research"	Evaluation	
"community-based research"	Assessment	
"community-led research"	Effic*	
"participatory action research"	Effect*	
"community-based action research"	"achiev* of objective"	
"co-production of knowledge"	"achiev* of goal"	
"knowledge co-production"	"goal achiev*"	
"transdisciplinary co-production"	"achiev* of objective"	
"co-producing knowledge"		
"co-creation of knowledge"		
"knowledge co-creation"		
"co-creating knowledge"		
"mode 2 research"		
"mode 2 science"		
"mode-2 research"		
"mode-2 science"		
"postnormal science"		
"post-normal science"		
"transformative research"		
"transformative science"		
"living lab*"		
"Real-world lab*"		

Based on our definition of TD research, we included search terms that describe research approaches covering several disciplines and non-academic stakeholders. We checked the robustness of our search approach by asking three experts in the field of TD research to check our list of search terms for completeness. To identify articles dealing with effects of projects, we included a range of related search terms. Alongside terms directly related to effects, we included terms related to evaluation and goal achievement as well as to the three levels of the logic model—output, outcome, and impact—that is often used in project evaluation (Savaya & Waysman, 2005). We followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement (PRISMA) to describe the process of project selection (Moher et al., 2009). Figure 5-1 shows the process of project selection during the literature review.

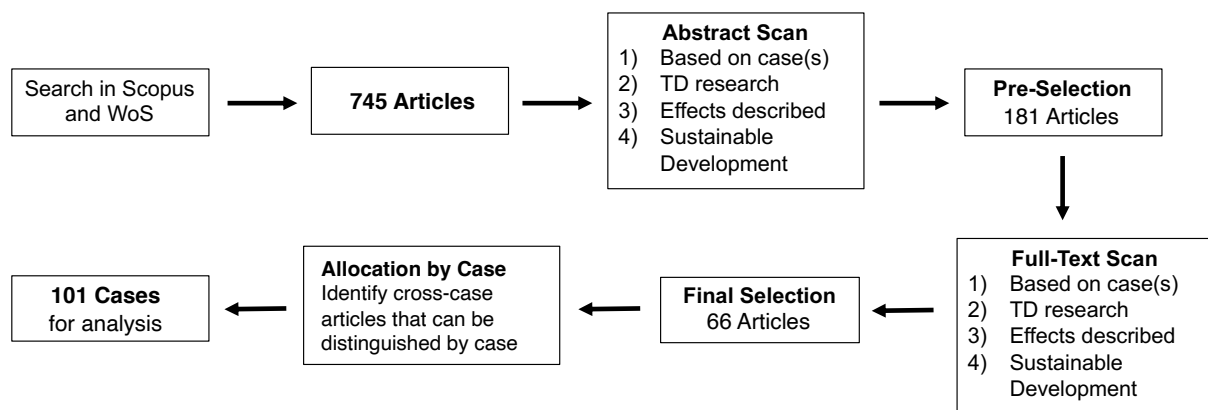


Figure 5-1 Overview of the process of the systematic literature review based on the PRISMA statement

All steps were conducted by the first author of the article in exchange with the coauthors. We first conducted an abstract scan to assess whether the article was relevant, based on the following conditions: 1) The article reports on at least one TD project; 2) The project uses a TD approach according to our definition: TD projects integrate processes across several scientific disciplines and across research and practice (Belcher et al., 2016); 3) The article presents some information about project effects; 4) The project relates to sustainable development. Examples for articles not included in our sample are theory papers with no description of any empirical results from one or several projects, or papers based on general expert opinions but not on the experience from one or several projects (violating condition 1). Furthermore, some articles described collaborative processes with no researcher involvement (violating condition 2). We also excluded articles in which the authors applied TD research, but the publication presented the results of the TD project rather than reflecting on the effects of the TD approach (violating condition 3). Following Newig et al. (2019) we excluded articles that used the term “sustainability” only to describe long-term effects (e.g., long-term effects of a medical treatment) (violating condition 4).

The abstract scan according to these four conditions led us to exclude 564 articles, resulting in a set of 181 articles. We then used the same four conditions again for a full-text scan, leading to a final selection of 66 articles. Fifteen articles include several cases of TD research projects. We split these articles into single cases. Studies including multiple cases but providing overall and synthesized results are considered as one case. This resulted in a final set of 101 cases: 50 N-S projects and 51 North projects.⁴ The cases show a high variety of topics, ranging from agriculture or natural resources to sanitation or energy. We present a numbered list of cases in the appendix (Table A 1). There is a minimal overlap of two papers included in our set of cases with the literature used in the “conceptual background” section to deduce the different categories of effects.

5.3.2 Coding of the Literature

As introduced previously (see Conceptual Background) existing approaches for categorizing the effects of TD projects (e.g. Jahn et al., 2022; Tribaldos et al., 2020) have different abstraction levels. For this study we use a mix of different approaches by summarizing specific effects within broader categories of effects. In the extant literature we identify five categories of effects that TD projects may produce: knowledge production, uptake of knowledge, products, learning and societal effects, summarized in Table 5-2. The table presents the effects belonging to each category and refers to the respective literature (or the indication that it is an inductively defined effect, respectively). An example of a text segment for each effect can be found in the appendix Table A 2.

⁴ To distinguish between North and N-S projects, we considered the location of the affiliation of the involved researchers and practitioners and not their nationality. We distinguished between the “global South” and “global North” based on the classification from the United Nations (2015a)

Table 5-2 Overview coding of effects

Category	Effect (Abbreviation)	Description	Deductive (Literature) vs. Inductive (In situ)
Knowledge Production	System knowledge (K_System)	System knowledge includes knowledge used to describe a given system or problem by integrating disciplines and the knowledge of non-academic stakeholders.	(Pohl & Hadorn, 2007)
	Target Knowledge (K_Target)	Target knowledge is defined as knowledge of the preferred future or outcome of a certain process. This includes, for example, scenario analysis or the development of specific target values (e.g., scenario analysis).	(Schneider & Rist, 2014; Walz et al., 2007)
	Transformation Knowledge (K_Transform)	Transformation knowledge describes the measures or tools that can be used to reach the targets and is thus fundamental when it comes to fostering societal transformation toward sustainable development (e.g., management practices, planning tools, technologies).	(Luederitz et al., 2017; Pohl & Hadorn, 2007)
Uptake of Knowledge	Uptake in Practice (Uptake_Pr)	The uptake of knowledge or technologies by the involved stakeholders. This can include applying a technology or using the produced knowledge to change processes.	(Fritz et al., 2019; Luederitz et al., 2017; Polk, 2014; Wiek et al., 2014)
	Uptake in Policy (Uptake_Po)	Uptake in policy is considered a key aspect of TD projects. We considered observations on the uptake of results into political dialogue and its impact on the development of new policies.	(Fritz et al., 2019; Luederitz et al., 2017; Polk, 2014; Wiek et al., 2014)
	Uptake in Science (Uptake_S)	This effect describes the re-uptake of insights in science gained through research projects. This includes results in the form of data and produced knowledge but also new methods or strategies in conducting research.	(Fritz et al., 2019; Wiek et al., 2014)
	Change in Practices (Change)	Change in practices includes direct behavior change induced through the research (e.g., changing the harvesting schedule).	(Fritz et al., 2019; Wiek et al., 2014)
	Durability (Durability)	The effect of durability describes whether the project includes long-term uptake or changes. This includes follow-up projects but also when other institutions take over the projects.	(Douthwaite et al., 2017; Wyborn et al., 2019)
	Transfer of Results (Transfer)	The effect of transfer includes the transfer of learning from the project to another geographical or thematic focus.	(Fritz et al., 2019; Luederitz et al., 2017)

Products	Academic Outputs (O_Academic)	Academic outputs include publications, presentations at conferences, or other ways of spreading produced knowledge through academic channels.	(Kaufmann & Kasztler, 2009; Koier & Horlings, 2014; Mitchell et al., 2015)
	Outreach Outputs (O_Outreach)	Outreach outputs include any form of outreach conducted during the project (brochures, movies exhibitons, etc.).	(Kaufmann & Kasztler, 2009; Koier & Horlings, 2014; Mitchell et al., 2015)
Learning	Problem Awareness (Prob_Awar)	Problem awareness includes the increased awareness of a certain problem and the need to act. It can also include becoming aware of another perspective regarding a certain problem.	(Chambers et al., 2021; Fritz et al., 2019; Tribaldos et al., 2020; Wiek et al., 2014)
	Capacity Building (Capacity_A;Capacity_S)	Capacity building includes the increase in technical skills and competencies as well as intra- and interpersonal skills and competencies. We considered the capacity building of stakeholders (Capacity_S) as well as of the academic participants (Capacity_A).	(Chambers et al., 2021; Fritz et al., 2019; Luederitz et al., 2017; Tribaldos et al., 2020; Wiek et al., 2014)
Societal Effects	Building Trust (Trust)	Building trust describes the perceived increase in trust between different project participants but also trust in research results.	(Jacobi et al., 2020; Lux et al., 2019; Schneider & Buser, 2018; Wiek et al., 2014)
	Networks and Relationships (Network)	This effect includes the forming of new relationships and the forming and strengthening of networks throughout the project.	(Fritz et al., 2019; Schneider & Buser, 2018)
	Inclusion (Inclusion)	This effect includes whether the different project participants felt included in the research process and whether they felt the project was relevant to them.	Inductive

We used the software MaxQDA for coding the projects. The coding procedure was the following: For each case, we first collected descriptive data on the thematic area of the study, on whether case was part of a single project study or of a cross-project comparison, and whether the case was a N-S or a North case. We then specifically searched for text segments that provide information on project effects and chose one or several codes to specify the observed effects. We only considered text segments from the results and the discussion parts of the papers to ensure that the coded segments were actually based on observations and data and not just on assumptions that are often formulated in conclusions. During the coding process, we also found text segments fitting our definition of an effect of a TD project but not fitting one of our effects that we had already developed deductively (Robson, 2002). Such segments were inductively coded into additional effects (Robson, 2002). In the end, we derived one additional effect - "inclusion" - during the coding procedure. For each project, we thus had a binary coding of whether any of the 17 effects were present or not. While only the first author did the actual coding, the second and third author were involved in the pretesting and continuous discussions of questions during the coding procedure. We conducted a pretest with a selection of 10 publications each to iteratively compare the coding results and adapt the coding system accordingly.

5.3.3 Descriptive Statistics and Cluster Analysis

For the analysis of the data from the literature review, we first used descriptive statistics to analyze the prominence of the effects. More specifically, we displayed which effects were observed in what share of the studied cases. Second, we analyzed how different effects are interrelated with each other. More specifically, we studied which effects often appear together and thus potentially influence each other. Therefore, we relied on a partitioning around medoids (PAM) clustering approach to group the effects into clusters, beyond dyadic relations between effects (Schubert & Rousseeuw, 2019). As a distance measure we relied on the Jaccard similarity index. The Jaccard similarity index indicates the share of cases where any two effects co-occurred, as compared to the share of cases where only one of both effects was described (Choi et al., 2010). The PAM clustering algorithm groups the different elements around medoids, which are the elements that have the smallest dissimilarity to all other elements in the cluster (Schubert & Rousseeuw, 2019). The results of the clustering thus show which effects group together based on their appearance in the studied cases. Effects that are grouped in the same cluster thus have minimal dissimilarities. The PAM clustering is a hard clustering algorithm, compared to fuzzy clustering approaches, where one element can belong to different clusters; hard clustering, in contrast, sorts each element in one distinct cluster (Miyamoto & Umayahara, 2000). We used the average silhouette method to determine the optimal number of clusters (Kaufman & Rousseeuw, 2009) and found that for both the N-S and the North cases, six clusters was optimal (see Appendix, Figure A 1, Figure A 2). All of these measures were applied to the set of N-S cases (N = 50) and North cases (N = 51), allowing for a comparison between them.

5.4 Analysis

5.4.1 Effects and their Prominence

Figure 5-2 presents how prominently the five different categories of effects were present in TD projects. More specifically, Figure 5-2 shows the share of projects (between 0 and 1, representing 0% and 100%, respectively) for which the individual effects within the five categories were

reported. Additionally, Figure 5-2 distinguishes the share of N-S cases (upper part, in green) and North cases (lower part, in blue). The black horizontal lines indicate the average share for each category of effects.

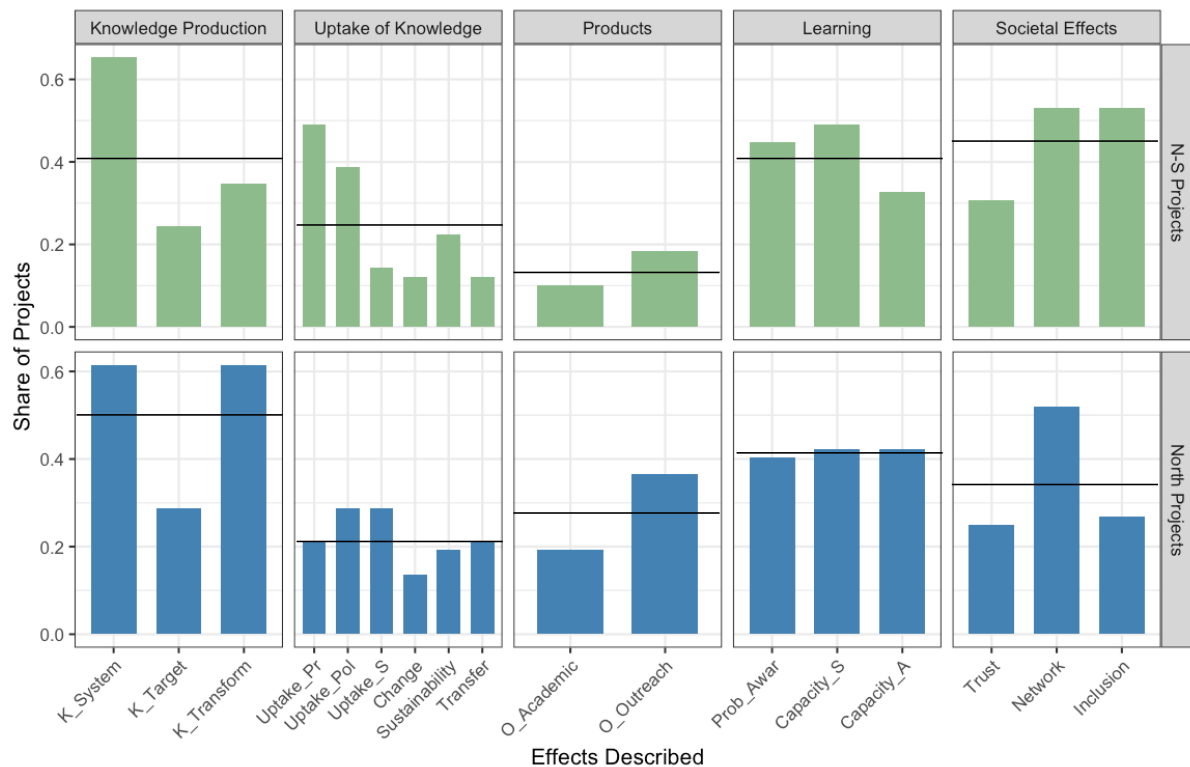


Figure 5-2 Overview of effects described in N-S and North cases grouped by effect category

5.4.1.1 Knowledge Production

We find that for both N-S and North projects, high shares of TD projects report effects of knowledge production. For the North projects, knowledge production is the category with the highest average share, while for the N-S projects it is the second most prominent category, together with learning. The average share of knowledge production is higher for cases in the global North due to a much higher share of studies that reported on transformation knowledge. For North cases we find transformation knowledge in more than 60% of the cases, while less than 40% of N-S cases report this effect. For system and target knowledge we do not observe major differences between N-S and North projects.

5.4.1.2 Uptake of Knowledge

On average, N-S cases scored slightly higher in the uptake of knowledge category (25% vs. 22%). Among the individual effects within that category, uptake in practice is more than twice as prominent in N-S cases (~50%) than in North cases (~20%). The same pattern, with slightly smaller differences though, can be observed for the effect of uptake in policy. One assumption about why the level of knowledge uptake in practice and policy is higher for N-S projects could be due to the development of TD research in N-S projects. With the development of approaches such as participatory action research North-South research projects started to place a strong focus on driving change and the needs of the stakeholders (Brutschin & Wiesmann, 2008; Khan et al., 2013). Thus, we assume that the research questions tackled in N-S TD projects tend to be more specific, context-sensitive, and concrete, which facilitates direct uptake.

Cases within the global North scored around twice as high for the effects of uptake in science (29% vs. 14% in N-S cases) and transfer (21% vs. 12% in N-S cases). The higher uptake in science and the higher level of transfer could potentially be due to researchers from the global North being cited more prominently (Amarante et al., 2022; Haelewaters et al., 2021; Liverpool, 2021). In general, as compared to non-TD projects, generalizability of results of TD projects is more difficult due to their often very context-specific design (Polk, 2014; Wanner et al., 2018). The focus on the participation and inclusion of local stakeholders of TD projects (as shown in Figure 5-2) might lead to a lower generalizability of results and thus less uptake in science and less transfer. The last two effects of the category uptake of knowledge — change and durability— showed no important differences between N-S cases and North cases. Both effects scored below average in the uptake of knowledge category.

5.4.1.3 Products

Projects in the global North also produce more effects in the products category. This category contains outputs for outreach as well as academic outputs. Outreach outputs are produced more prominently than academic outputs in both N-S TD projects as well as North TD projects. We thus observe that independent of the type of TD project, academic outputs are less present than outreach outputs. In one of the North cases (Case 23) the authors specifically find that the academic performance of TD projects is lower than in projects without non-academic participants. Jahn et al. (2022) describe a trade-off between the production of scientific knowledge in the form of papers (i.e., academic outputs) and the inclusion of stakeholders (allowing for outreach outputs).

5.4.1.4 Learning

All three effects within the learning category are similarly prominent. Still, we observed some differences between the N-S and the North projects. While N-S cases scored slightly higher for problem awareness and the capacity building of stakeholders, the largest difference lies in the share of studies reporting capacity building for academic partners that scored around 10% higher for North projects. Overall, we can state that for both N-S and North projects, capacity building is a relevant effect for both stakeholders and academic partners. Furthermore, we observe from our cases that capacity building does not only include concrete methods or technical skills but especially also the acquisition of soft skills. This acquisition of soft skills is illustrated by the following example from Schöpke et al. (2017) (Case 13-14):

“speaking one’s own mind in public, better communication, creativity, organisation, leadership, an increase in self-reflexivity and the feeling of responsibility as well as the ability to work in a team and the understanding for political work.” (p. 16)

5.4.1.5 Societal Effects

The N-S cases have a higher average than the North cases for the category of societal effects. While the difference is negligible for the effect of relationships, it is largest for the effect inclusion (53% vs. 27 in North cases). We interpret that this effects researchers who are working on N-S research projects with participants from different countries and with different cultural and societal backgrounds, as is the case with most N-S projects, could have an increased awareness for differences and potential conflicts. This awareness could then again have a positive effect on inclusion (Bradley, 2008; Ott & Kiteme, 2016).

5.4.2 Interrelations of Effects

Besides the prominence of the different effects within the five effect categories, we studied how the different effects are interrelated by their coappearance in the same projects. We separately applied this method to both the set of North projects (N=51) and N-S projects (N=50). Figure 5-3 shows the first two dimensions of a cluster plot with six clusters for the N-S projects. The clusters are numbered and colored accordingly. We see overlaps between some of the clusters for the N-S projects. This indicates that the identification of clear clusters is difficult because there are no large differences in the dissimilarities between certain effects.

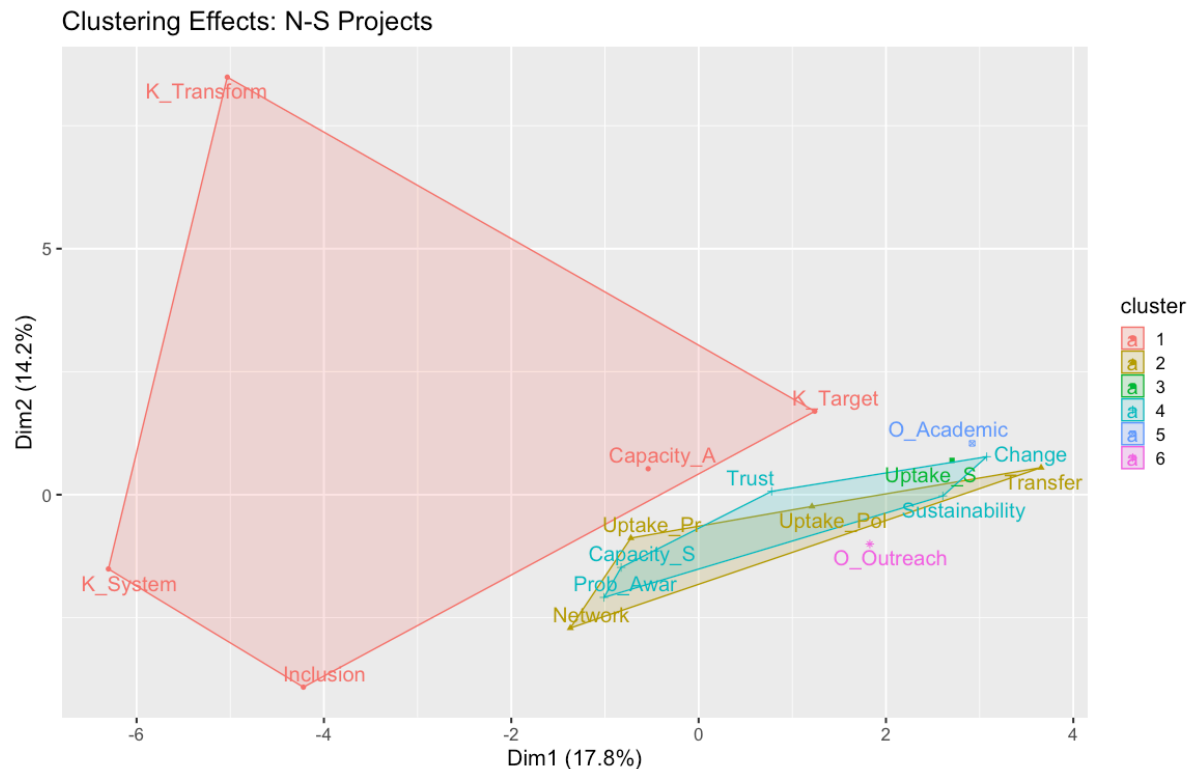


Figure 5-3 Cluster results of the effects of N-S projects

The first cluster (1) does not overlap with any other clusters and thus describes a separate set of effects. It consists of the three effects of the knowledge production category (system, target, and transformation knowledge) and the effects of inclusion and academic capacity building. The relation between the effects from the knowledge production category and inclusion indicates that within N-S projects, stakeholders might be strongly included in the production of different effects of knowledge production. This is in line with the literature on the evolvement of TD research in N-S projects (Brutschin & Wiesmann, 2008; Hirsch Hadorn et al., 2006). Approaches such as participatory action research have a strong focus on change and aim to put the stakeholders and their needs in the center (Khan et al., 2013). Furthermore, we assume that TD projects emphasizing inclusion might provide an opportunity to academic participants for capacity building. Furthermore, academic capacity building is connected to knowledge production as N-S projects often involve students in the research project as a way of building local research capacity. This is illustrated by an example reported by Ambole et al. (2019) (Case 101; see Table A 1):

“Another significant outcome of the project is the participation of graduate students from the respective host universities as field research assistants in the project studies. In Kenya, one graduate student successfully defended her thesis that was based entirely on the field work in Mathare. By working with students, the researchers fulfilled one of their research objectives of building local capacity for doing transdisciplinary research.”
(p. 215)

Cluster (2) consists of the effects uptake of knowledge in practice and policy, transfer, and networks. The finding that these four effects cluster together is in line with other studies which emphasize the role of networks and relationships for the uptake of knowledge (Crona & Parker, 2011; Henry & Dietz, 2011; Pärli et al., 2021).

Cluster (4) consists of the problem awareness effects, the capacity building of stakeholders, changes in behavior, the durability of the projects, and trust. This cluster is interesting as it consists of effects from the uptake of knowledge, learning, and societal effects categories. A possible explanation for this mix of effects in the same cluster is that capacity building and trust are crucial to build problem awareness, which then might be relevant for changes in behavior and the durability of the project. As already described, we found the link between capacity building and problem awareness in the literature (Locritani et al., 2019; Msengi et al., 2019). Also, regarding the interrelation between trust, problem awareness, and change we find similar patterns in the literature. Scholars find that trust in research is an important factor for belief in climate change (Hmielowski et al., 2014) and climate-friendly behavior of individuals (Cologna & Siegrist, 2020), which can be interpreted as problem awareness and change. Further, Hacker et al. (2012) find that the long-term adoption of health-related interventions by stakeholders was coupled with their capacity. They also find that a lack of trust is a barrier to both the building of capacity as well as the durability of the interventions.

The role of time in the building of trust is also frequently mentioned in the literature (Berkes, 2009; Levin & Cross, 2004; Weichselgartner & Kasperson, 2010). The overlap of cluster (4) with cluster (2) that contains two further effects of uptake of knowledge (uptake in practice and uptake in policy) suggests that the effects of uptake of knowledge and societal effect and learning are connected.

Finally, there are three individual effects that each form their own cluster (3, 5, 6), suggesting that these effects do not clearly link to others. The respective effects—academic outputs, outreach outputs and the capacity building of academic participants—are not mentioned very often for N-S projects (see Figure 5-2), which might explain why they do not cluster with other effects (see Figure 5-3).

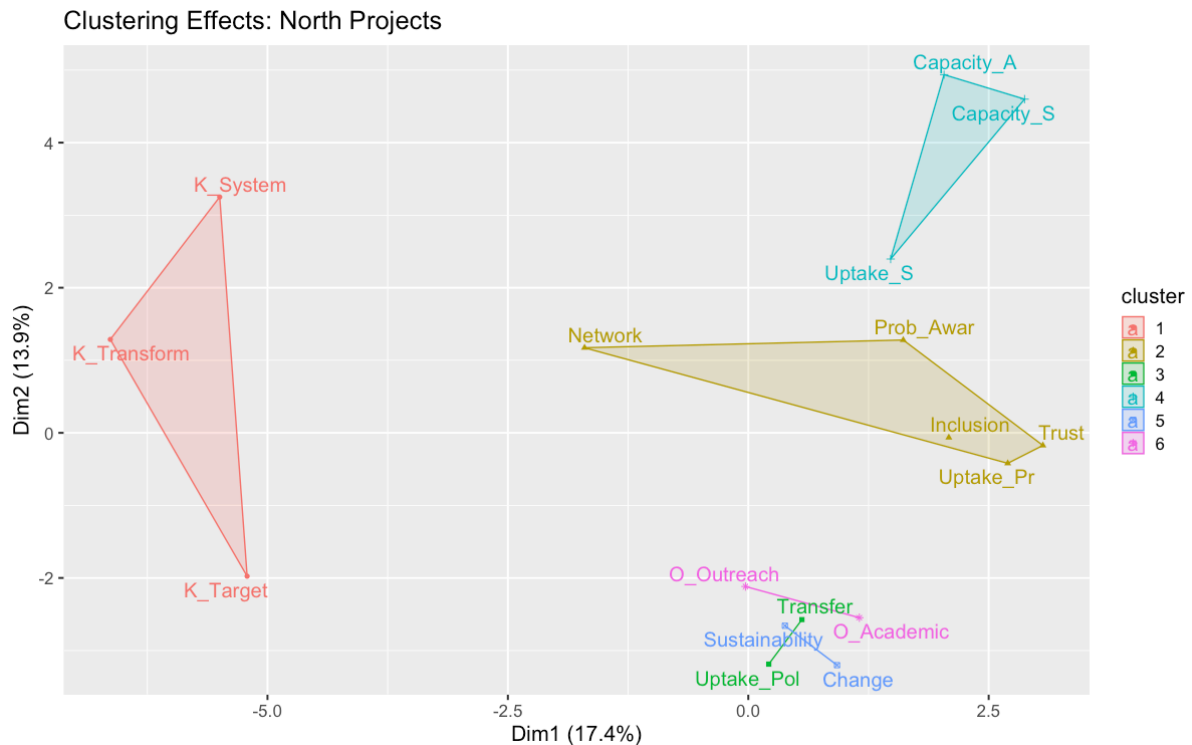


Figure 5-4 Cluster results of the effects of North projects

Figure 5-4 shows the cluster plot for the North projects. The clusters of effects are different from the clusters observed in Figure 5-3, suggesting differences in the interrelations of effects between North and N-S projects. Cluster (1) covers the three effects of the knowledge production category: system, target, and transformation knowledge. While this finding shows that the three types of knowledge are often jointly produced within one project, we also observed they are not connected to other effects, such as to effects from the uptake of knowledge category. This indicates a potential disconnection between knowledge production and its uptake. One explanation could be that transformation and target knowledge produced in TD projects are highly specific and context dependent. Evidence from several cases (1-4; see Table A 1) suggests that it is challenging to develop solutions that fit the needs of stakeholders while being generalizable for the re-uptake in science (Wiek et al., 2015).

In cluster (2), uptake of knowledge in practice is linked to effects mostly from the societal effects category, namely inclusion, networks, and trust as well as to problem awareness from the learning category. Based on this we suggest that societal effects and learning support the uptake of knowledge for practitioners. Our interpretation maintains that the different beneficial effects are interrelated. Evidence from our coded articles suggests that, for example, uptake of knowledge depends on the network present (Henry & Dietz, 2011), problem awareness (Locritani et al., 2019; Msengi et al., 2019), and the level of trust in the researchers and the research produced (Cologna & Siegrist, 2020). The literature further describes interrelations between, e.g., trust and fostering problem awareness (Hmielowski et al., 2014).

Cluster (3) contains the effects of uptake of knowledge in policy and transfer. Knowledge that is applicable enough to be taken up in policy also has a higher chance of being transferred to other areas of applications (e.g. different sector). This is nicely illustrated in one of the cases: Hansson

and Polk (2018) (Case 35-39; see Table A 1) show how new ways of working together developed through the TD project were subsequently taken up in policy and transferred to other municipal planning processes:

“The most important outcome of the project is a new forum for dialogue and collaboration across sector and administrative borders, including new ways of working together among the municipalities, as well as between and among the regional and national agencies. This new way of working together has created new conditions, structures, contacts, and networks where trust and mutual understanding have been established between a diverse group of civil servants, politicians, and researchers. The concept USC [Urban Station Communities; name of a TD project in mobility and urban planning] is now used nationally, and has been integrated in ongoing municipal planning processes.” (p. 138)

Cluster (4) consists of the effects of the capacity building of stakeholders, academic participants, and the uptake of knowledge in science. We assume that capacity building in North projects often happens jointly between stakeholders and academic participants and that the learning of academic participants might be taken up in their future research. This is nicely illustrated by Nguyen et al. (2014) (Case 22; see Table A 1):

“By facilitating the sharing of a rich variety of views and for integrating knowledge among stakeholders, the emergent hybrid knowledge provided farmers with information on the scientific and economic rationale underpinning their decision-making processes; it provided scientists with new ideas for research and researching processes that could lead to a wider adoption of results.” (p. 179)

Cluster (5) covers the products category, as it combines academic and outreach outputs. It thus seems that in North projects, there are often concrete outputs planned for all project participants—that is, for both academic participants as well as stakeholders.

Finally, cluster (6) includes the effects change and durability, both from the category uptake of knowledge. Our interpretation is that once projects led to actual changes in behavior, effects were also more likely to be sustained beyond project termination. However, both effects were only observed in fewer than 20% of the North projects, which shows that this relation, while promising, is still rare.

When comparing the similarities between the clustering of the effects of N-S and North projects, we observe two different and one similar pattern. First, for projects within the global North, the three effects of the knowledge production category form one single cluster, while for the N-S projects, the three effects of knowledge production are combined with learning and societal effects. This indicates that N-S projects probably place a higher emphasis on inclusion during the production of knowledge, which might then, as a learning experience, increase capacity building of academic participants. Our finding for the North projects is in line with Chambers et al. (2021) who also find that scientific knowledge was negatively correlated with all other types of effects. They suggest that projects that mainly aim to fill knowledge gaps might neglect other

effects especially related to implementation, such as collective action or institution building. This is again in line with our results for both, N-S and North projects: Neither effects of the knowledge production category nor effects from products are clustered with any effects of the uptake of knowledge category. Second, we observe differences for the effects of change and durability. While both change and durability cluster together in a single cluster for North projects, both are integrated with learning and societal effects for the N-S projects. Third, the effect of the uptake of knowledge in practice is, for both types of projects, in the same or a very close cluster as the effects of networks, problem awareness, and trust. This finding shows that these effects are potentially interrelated in both N-S and North projects. Investing in trust-building as well as forming new and strengthening existing networks might thus be effects that reinforce each other and are beneficial for knowledge uptake in TD projects in general.

5.5 Conclusion

This article explores the differences of effects of TD projects in a N-S setting and TD projects conducted in the global North only. For both contexts, we have analyzed the prominence of effects and as well as the interrelations between effects. Drawing on the extant literature, we identified five categories of effects (knowledge production, uptake of knowledge, products, learning, societal effects) that we used for coding 101 TD projects reported on in the academic literature. We then used descriptive statistics and a clustering approach to analyze how prominently the different effects occur and how the effects relate to each other.

Our analysis suggests that N-S and North projects indeed have different effects. While N-S projects appear to focus more on societal effects, North projects score higher on products, that is, tangible outputs such as academic publications or outreach material. We also observe that North projects more prominently lead to knowledge production, especially the production of transformation knowledge. This result is surprising given that transformation knowledge is strongly linked with TD research and N-S research approaches such as participatory action research (Brutschin & Wiesmann, 2008; Pohl & Hadorn, 2007). As transformation knowledge is about ways to reach targets and is thus key for bringing about transformation toward sustainable development (Pohl & Hadorn, 2007), this finding has implications for improving TD research. Nevertheless, the more prominent knowledge uptake in practice and policy in N-S projects shows that North projects can still improve on how they actually use transformation knowledge.

We also observe differences in how effects are interrelated in N-S as compared to North projects. We conclude that N-S projects emphasize inclusion more than North projects do due to a higher awareness of differences between the different participants. This could imply that it is beneficial for North projects to foster inclusion of the different participants to avoid conflicts or misunderstandings, even if participants in North projects seem more homogenous from the outset. For both the N-S and the North projects, we found that the effects from the knowledge production category are not strongly related to effects related to the uptake of knowledge. This trade-off was also recently described by other authors who found that the production of knowledge and the involvement of stakeholders is often conflicting (Chambers et al., 2021; Jahn et al., 2022; Newig et al., 2019). However, we also found that for both N-S and North projects, effects belonging to the uptake of knowledge, learning, and societal effects categories are often interrelated.

Our study contributes to the literature in several ways. First, we build on and contribute to the extant literature on transformation toward sustainable development (Fritz et al., 2019; Muhonen et al., 2019; Schneider et al., 2019a) by studying the diverse and interrelated effects of TD projects. By comparing the prominence of different effects of TD projects, we provide an overview of where TD projects perform well and where there is room for improvement. By studying how different effects are interrelated, we confirm, on the one hand, trade-offs already described by other authors. On the other hand, we show that societal effects, learning, and the uptake of knowledge might reinforce each other. Second, by studying how the effects of TD projects differ between N-S and North projects, we contribute to the dialogue on different types of TD projects. We show that there are differences regarding how prominently the effects are achieved and how they are interrelated. This provides insights as to where North projects can learn from N-S projects, and vice versa.

The present study also has several shortcomings. First, it is based on secondary literature only, that is, on findings from publications on TD projects. Thus, we could only analyze the effects described by the authors of the articles. We can, of course, not be certain whether effects that were not described were actually not present or just not reported in the publication. Furthermore, we omitted the effects which were not or not sufficiently achieved by a project, even though they belonged to the project objectives. While some of the studied projects reported such effects, it was not possible to gather generalizable data. Theoretical as well as empirical studies comparing the specified aims of TD projects with those achieved might provide more insights into potential challenges of TD projects. In addition, we only included scientific publications but no gray literature such as, e.g., project reports, in our review. Finally, some effect categories were difficult to assess. On the one hand, it was sometimes difficult to understand how and based on what perspective the authors assessed effects such as the uptake of knowledge. On the other hand, as the effects are often strongly interrelated, it was sometimes difficult to disentangle effects where the authors were describing effects from the categories of learning or knowledge production. With this study, we are only able to describe first patterns of the prominence of different effects of TD projects, their interrelations and the differences of N-S and North projects. Interpreting these patterns further and identifying the underlying reasons requires further research. Future empirical studies on the importance of the different effects based on the perception of academic participants and stakeholders could shed more light on how TD research might contribute to the transformation toward sustainable development.

This article provides the basis for a better understanding of the effects that TD projects have, how they relate to each other, and what differences exist between N-S and North projects. Insofar as TD is claimed to be beneficial for producing holistic and applicable system, target, and transformation knowledge and thus for potentially fostering a transformation toward sustainable development (Schneider et al., 2019a), our systematic analysis provides robust grounds for being able to, first, evaluate how TD projects contribute to sustainable development and, second, to discover ways North projects can learn from N-S projects, and vice versa (Keitsch & Vermeulen, 2020; Saric et al., 2019).

6 Article 2

How input, process, and institutional factors influence the effects of transdisciplinary research projects⁵

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Abstract

Transdisciplinary research projects integrate several disciplines and practice stakeholders into the research process. Both of these interactions are described as important in addressing complex and interconnected sustainability problems. In addition to knowledge generation, transdisciplinary research projects have other effects. For example, they may facilitate the adoption of solutions, whereas traditional research projects focus on the presentation of results. However, there is considerable diversity in transdisciplinary research projects in terms of their design, research process, and surrounding institutions, making it difficult to unravel what type of transdisciplinary research project works well to reach which effects. This article uses a systematic literature review and expert interviews to study how different input, process, and institutional factors influence the effects of transdisciplinary research projects. The results show that process factors, such as the quality of the process or the specific methods used, have the strongest influence on the effects of transdisciplinary projects, whereas institutional factors are less prominent. Furthermore, different factors influence not only the effects but also each other and are thus interconnected.

Keywords

Transdisciplinary research, Sustainable development, Systematic literature review

⁵ As already described in section 3 I used a slightly different terminology in Article 2 than in the rest of this thesis. However, the terms can be used synonymously.

6.1 Introduction

Society faces various complex sustainability challenges, such as climate change and the loss of biodiversity. The literature on sustainability governance and the governance of natural resources has argued that successful governance of such sustainability challenges requires, among others, the integration of different actors representing different sets of knowledge, interests, and resources (Kumar & Banerjee, 2012; McGee & Jones, 2019; Olsson et al., 2006). Such integrative and collaborative approaches are also in line with the 2030 Agenda, which aims to foster “collaborative partnerships” between the different actors involved in the implementation of the Sustainable Development Goals – SDGs (United Nations, 2015b).

The literature identifies two types of interaction as key to addressing the complex sustainability challenges that society faces. First, the exchange between research and practice is claimed to be crucial for asking relevant research questions and for being able to benefit from research results (Belcher et al., 2019; Belcher et al., 2016; Colglazier, 2015; Giebels et al., 2015). Second, researchers and practitioners are encouraged to engage in interactions to overcome their disciplinary and sectoral silos, as complex sustainability challenges are highly interconnected (Klein, 2020; Liu et al., 2018). Scholars, as well as civil society, increasingly question the capacity of “traditional” disciplinary research alone to provide the kind of evidence needed to address current and future sustainability challenges (Fritz & Binder, 2018; Sachs et al., 2019). Transdisciplinary research (TD) is a research mode that includes both described interactions (Schneider et al., 2019b). TD projects are research projects that integrate several disciplines and non-academic stakeholders into the research process (Lang et al., 2012). An exemplary TD project could consist of an interdisciplinary research team of agricultural scientists, economists, and political scientists who collaborate with a public agency and directly affected farmers, who jointly work on pesticide reduction by developing and testing alternative farming practices and evaluating potential policies.

In addition to the accumulation of knowledge, TD projects have other effects, such as improved acceptance of solutions in practice or policy, increased awareness of problems, and social effects, such as the creation of new relationships (Jacobi et al., 2020; Lux et al., 2019; Schneider & Buser, 2018). These effects have rarely been considered in standard evaluation methods and are not sufficiently considered when discussing the importance of TD projects (Belcher et al., 2016; Roux et al., 2017; Walter et al., 2007). However, these less tangible effects might be essential for research to unfold its impact. Research finds that social, institutional, and economic effects are often interdependent (Schneider et al., 2019a). Illustrated by the above example of a TD project, stronger relationships between different farmers could lead to greater dissemination of the knowledge produced through the project and could lead more farmers to adopt more sustainable practices. The range of TD projects is extensive (Belcher et al., 2016; Lang et al., 2012). TD projects can differ in the types of stakeholders involved, how researchers and stakeholders work together, and external factors, such as the political system in which a research project occurs. This diversity of factors and effects makes it difficult to evaluate which characteristics of the TD research design are important to achieve certain objectives (Belcher et al., 2016; Hansson & Polk, 2018). Therefore, I formulated the following research question: *How do different factors influence the effects of TD projects?*

To answer the research question, I employed a mixed methods approach, combining a systematic literature review with semi-structured expert interviews. The systematic literature review included 115 cases of TD projects in the field of sustainable development reported in the literature. Based on these cases, I identified relevant input, process, and institutional factors and their influence on the effects of TD projects.

To describe the diversity of TD projects, I identified three factors. First, the effects of TD projects might depend on the input, including factors related to the project structure, such as the type of actors and disciplines involved or their social network structure (Edelenbos et al., 2010). Second, the project implementation process differs between TD projects, including the methods they use, the degree of collaboration between the participants of the research projects (Crawford & Bryce, 2003; Pfadenhauer et al., 2017), and the quality of the process, including factors such as transparency, efficiency, and accountability (Schmidt, 2012). Third, institutions, broadly defined as human-made constraints on and incentives for behavior that structure societal, political, and economic interactions (North, 1991), are factors external to the TD projects that influence their effects.

This article contributes to a better understanding of how complex sustainability challenges can be tackled by TD projects and takes a broad perspective on the influence of input, process, and institutional factors on the effects of TD projects to detect common patterns across different projects. This study first contributes to the needed evidence on which factors influence which effects of TD projects and whether these factors support or hinder the success of TD projects (Belcher et al., 2016; Hansson & Polk, 2018). Second, this research contributes to disentangling the complex interactions between the different factors (Schneider et al., 2019a) and thus to the identification of starting points on how TD projects can be implemented more effectively. Third, this research provides a practical contribution by proposing, on the one hand, a holistic analysis scheme for TD projects and, on the other hand, concrete management recommendations.

6.2 Analytical framework

To structure the factors that potentially influence the effects of TD projects, I use the open system model (Kast & Rosenzweig, 1972; Katz & Kahn, 1978). The model describes that the effects, i.e., what is produced through the work of a system, are influenced by the input and process dimensions. The input dimension refers to what is put into the system. The process dimension refers to the transformation of resources into effects. Furthermore, the model includes institutions as factors outside the system, but with an influence on it. The open system model uses the term environmental factors, a concept similar to that of institutions. However, the concept of institutions distinguishes between formal and informal constraints and incentives (North, 1991). Figure 6-1 summarizes the analytical framework.

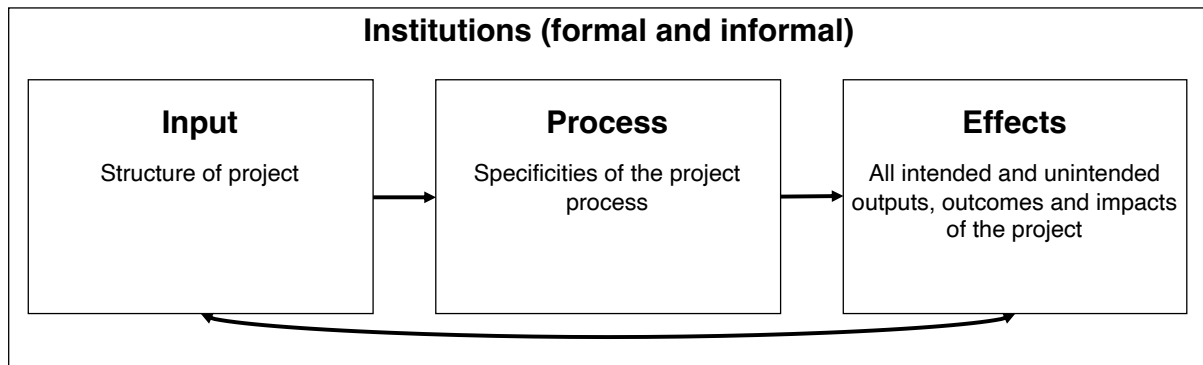


Figure 6-1. Analytical framework based on the idea of an open system model.

As shown in Figure 6-1, the effects are influenced by input factors, which describe the structure of the project, and process factors, which include the specificities of the research process. Institutions that summarize external factors to the project influence not only the effects, but also the input and process factors. Furthermore, in line with the open system model, the different factors are interconnected (Katz & Kahn, 1978). For example, input factors may, on the one hand, be influenced by institutions while on the other hand have influence the process. Furthermore, the effects might, over time, influence the input of the system.

Other frameworks are used to describe and analyze how TD research generates change. One example is the literature on theory of change (ToC). ToC is a tool that is often used to describe impact pathways (Belcher et al., 2020; Schneider et al., 2019a). Recently, scholars have started using ToC to plan, run, and evaluate TD projects (Deutsch et al., 2021; Oberlack et al., 2019; Schneider et al., 2019a). However, the present study does not identify impact pathways that consider how different effects influence each other over time. The focus of this study is to identify the different factors that influence effects. Compared to ToCs, I also consider the influence of input factors and institutions.

6.2.1 Effects

There is a lack of clarity around the terminology used to describe the effectiveness of TD projects. The terms output, outcome, and impact, for example, are dominant in project and policy evaluation, but are not used consistently. Furthermore, the boundary between them is not always clear (Fritz et al., 2019; Schäfer et al., 2021). To avoid confusion, I follow Fritz et al. (2019) and Schäfer et al. (2021), who use the term effect. For this study, I use the term “effect” as an umbrella term to describe any kind of intended or unintended output, outcome, or impact of a TD research project. With this overarching term, I thus include immediate but also longer-term effects. Compared to other studies, for example those using ToCs, I do not consider the temporal sequence or pathways between the different effects.

Many scholars describe that the success of research projects is measured solely by tangible effects, such as academic publications or the achievement of project goals. This leaves out other effects that TD projects may have. Based on the literature, I describe four different categories of effects. First, in the category of knowledge production, I include the production of system, target, and transformation knowledge (ProClim, 1997). Second, I introduce the category uptake of knowledge, which includes the uptake of knowledge produced during a TD process in practice and policy. TD research deals with real-world problems and aims to generate transformation

knowledge that can be used by different actors (Schneider et al., 2019a). An example of knowledge uptake in practice are changes in practices based on management recommendations. For uptake in policy, this could be the introduction or adaptation of new policies, strategies, or laws. Third, I classify effects related to improved competencies of stakeholders or researchers as learning (Fritz et al., 2019; Jacobi et al., 2020; Schneider et al., 2019a). Fourth, I present the category of social effects, such as building networks or improving relationships (Fritz et al., 2019; Lux et al., 2019).

6.2.2 Input factors

The input dimension includes different factors that describe the design of a project. In the literature, I find four overarching categories of input factors. First, TD projects can be differentiated based on the stakeholders involved. Edelenbos et al. (2010), for example, distinguished between researchers (scientists) and administrative (bureaucratic, governmental agency) and civil society stakeholders. As partners, both administrative and civil society stakeholders bring different knowledge bases: researchers rely on scientific models and methods, with stringent quality checks and peer reviews. Bureaucratic knowledge is based on administrative and government practices, which emphasize strategic choices and policy usefulness. Civil society knowledge is embedded in experience and local practices, with a focus on what is socially acceptable in a certain context (Edelenbos et al., 2010). Knowledge of stakeholders in the private sector is based on entrepreneurial results, often with a cost–benefit focus (Considine & Lewis, 2003). The interplay of different stakeholders in a project may have varying effects on project results, and thus influence the output dimension. Edelenbos et al. (2010) found that researchers and bureaucrats worked synergistically due to institutionalized relationships in Dutch water management. On the contrary, they found that the inclusion of stakeholders alongside researchers and bureaucrats was problematic due to different logics, for example, in terms of decision making or problem definition. A similar debate exists about interaction across disciplines and thematic silos: cooperation between researchers from different disciplines requires opening up to other research ideas and other views on a problem and how to solve it (Huutoniemi, 2016). At the same time, people prefer, according to the concept of homophily, to exchange with people who are similar to themselves (McPherson et al., 2001). Thus, it naturally follows that the crossing of thematic silos requires more effort in terms of coordination and time to foster mutual understanding. Interestingly, Locatelli et al. (2021) even found that researchers who were highly interdisciplinary in their research interacted less with scientific communities from other disciplines.

Second, social networks and structures are crucial concepts for the input dimension (Wasserman & Faust, 2012). One core assumption is that “structure matters” (Borgatti et al., 2009); that is, the structure of a social network influences the effects produced by the respective group of actors. Bodin and Crona (2009), for example, argue that an actor’s access to information depends on the social network. This implies that if certain actors involved in solving a problem are excluded from a certain information-sharing network, they may not be able to base decisions on evidence, which might reduce the quality of problem-solving.

Third, different demands, skills, and abilities often significantly shape projects (Jepsen & Eskerod, 2009; Missonier & Loufrani-Fedida, 2014). Research shows that personality traits strongly affect how a team works together, as well as the effects of projects (Hu & Judge, 2017; Soomro et al.,

2016). Moreover, intrinsic and extrinsic motivation is important for creativity (Amabile, 1997) and knowledge-sharing (Hung et al., 2011), which can both be considered relevant for the effects of TD projects. Therefore, the different individual attributes of project participants could influence the effects of TD projects.

Fourth, interactions between different stakeholders, and thus the specificity of the group dynamics of the project, may shape its process and its effects. Ostrom (2009) described interactions between stakeholders as “community attributes”, including attributes such as trust, reciprocity, or shared understanding. Community attributes have, given by the project in place, a significant influence on the effects of management processes (McGinnis, 2011).

6.2.3 Process factors

I distinguish three categories of process factors, including process quality, methods, and strategies used. First, the factors summarized under the category quality of the process might influence the effects. I draw on an example from policy studies, where process refers to quality and includes whether the implementation of a policy is efficient and transparent and whether there are accountability dilemmas (Schmidt, 2012). The quality of the process is, on the one hand, often influenced by the input dimension (e.g., involving more stakeholders leads to a less efficient process), and, on the other hand, it may influence effects. As an example from policy studies, Lieberherr and Thomann (2020) found that conflicting interests, appearing during the implementation of a Swiss forest policy, had negative consequences on policy implementation. Therefore, factors that belong to the category quality of the process include efficiency, transparency, and the presence of accountability dilemmas. Another factor that I group into category quality of the process is the intensity of stakeholder involvement. Mobjörk (2010) distinguished between consulting transdisciplinarity and participatory transdisciplinarity based on how and to what extent researchers and stakeholders collaborate. In participatory transdisciplinarity, stakeholders are actively involved in the process of knowledge production, while in consulting, transdisciplinarity is limited to informing stakeholders and receiving their feedback. Stauffacher et al. (2008) adapted Arnstein’s “ladder of participation” to describe the degree of stakeholder involvement during a TD project, ranging from informing stakeholders to empowering them through strong collaboration and shared responsibilities. Schneider and Buser (2018) compared 16 TD projects and found that in addition to fluctuations during the research process, the level of involvement and the effects of the project are linked. They stated that especially when the project was aimed at producing transformation knowledge, a higher level of participation was beneficial.

Second, the methods used may influence the achieved effects (Crawford & Bryce, 2003). Using scenario analysis with affected stakeholders, for example, will produce target knowledge rather than system knowledge (Schneider & Rist, 2014). In natural resource management, a popular approach is community-based monitoring, where local communities support the evaluation of conservation actions (Barr et al., 2012; Björkman & Svensson, 2009; Conrad & Hilchey, 2011; Hacker et al., 2012). These studies describe the training of local collaborators as a tool to improve data quality. Furthermore, training is relevant for researchers: several studies show the importance of training in TD methods (Chang et al., 2020; Pearce et al., 2018)

Third, Pfadenhauer et al. (2017) described the importance of implementation strategies, such as strategies that support the implementation process (e.g., professional facilitation and translation). In organization studies, scholars have, for example, found that providing opportunities for informal exchange within an organization was perceived as necessary, leading to increased levels of information exchange and collaboration between employees (van der Heijden et al., 2010). Overall, the concept of psychological safety describes how fostering a safe environment for teams or groups might benefit their performance (Baer & Frese, 2003). Another process strategy is iteration. Iterative decision-making and management is the core idea of concepts such as adaptive management, mostly known to be related to nature conservation or natural resource management (Williams, 2011). In this field, several studies show the benefits of adaptive management practices, among others, including the positive influence of flexibility in management on the adoption of the measures developed by the project (Brownson & Fowler, 2020; Canter & Atkinson, 2010).

6.2.4 Institutional factors

I distinguish between two categories of institutions. First, formal institutions include legal, economic, or political rules, for example, laws or property rights (Yami et al., 2009). Second, informal institutions describe actors' generally accepted rules of the game or common beliefs about goals and trust, which are based on different logics and social norms in a given context (Ostrom, 2007; Thomann et al., 2018). Although both types of institutions often significantly influence behavior, they are not set in stone (Roland, 2004). Some institutions, such as incentives through price allocation, change rather quickly; more informal, socially embedded norms take much longer to change (Williamson, 2000). Based on examples from policy studies, I expect that institutions are fostering or hindering TD practices in different ways (Edelenbos et al., 2010; Fritz & Binder, 2018; Lubell et al., 2014). Edelenbos et al. (2010) described that policy makers could not use the results of a collaboration with citizens, as these were not in line with the existing structure and decision-making processes. In addition to their influence on the effects, institutions are also interrelated with input and process factors. Newig et al. (2019) found that institutions, such as research funding schemes, influence the composition of TD teams and the research process.

6.3 Methods and Data

6.3.1 Data collection

To answer the research question, I conducted a systematic literature review in combination with expert interviews. For the literature review, I followed the method of Bramer et al. (2018). First, I identified the key concepts needed to address the research question. I searched for studies that describe the effects of specific TD projects within the field of sustainable development to assess relevant input, process, and institutional factors and how they are related to which effects. Therefore, the related concepts were TD research project, effects, and sustainable development. Second, I searched for synonyms and related terms for each concept by reviewing the relevant literature and using dictionaries. The final selection of search terms resulted in 745 articles. Third, I used a set of selection criteria, which I first applied to the abstracts and then to the full texts, and identified 77 articles describing one or several specific TD projects (case). This resulted in 115 cases of TD projects, which I used for the analysis. For the selection of articles and cases, I

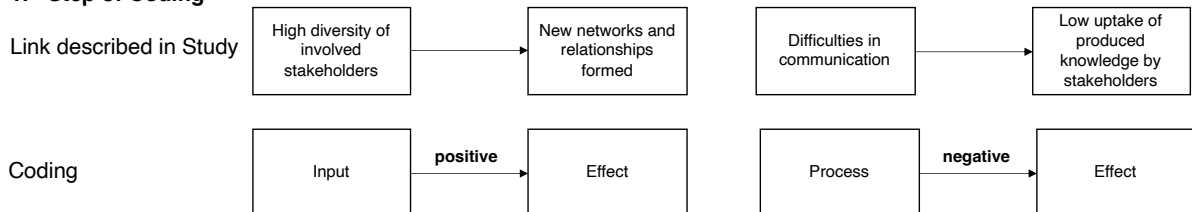
followed the PRISMA guidelines on reporting for systematic reviews (Moher et al., 2009).⁶ Within the conditions, the selected cases showed high variety in terms of their topic and other factors. An overview of the selected cases is provided in the appendix (Table B 2).

6.3.2 Coding of the literature and analysis

First, I deductively developed a set of categories for effects and input, process, and institutional factors based on the analytical framework. This set served as a starting point for further analysis of the cases (for details, see Table B 1 in the appendix). For coding, I used an inductive approach, which means that I adapted different categories and identified factors for each category based on the data. Furthermore, I used an iterative coding process: whenever I defined a new factor, I verified the already coded cases again. The factors are, of course, always based on the descriptions of the authors, and different authors used different scales to describe them. For some factors, high and low levels of the factor were described as influential (eg, high or low levels of motivation). For other factors, the articles only described whether the factor (e.g., involvement of students in the project) was present. I therefore decided to only look at the presence of factors. For the analysis, I used descriptive statistics based on the idea of quantitative description (Gerring, 2012; Munger et al., 2021). Overall, I analyzed how often each input, process, and institutional factor was described to influence which effects of TD projects.

I employed MaxQDA software to code the literature. In the first round of coding, I focused on the links between factors (input, process, institutions) and effects. I screened the results and discussion sections of each of the 77 articles for text that described a link between a factor and an effect. Figure 6-2 gives an example of the coding process. Positive and negative influences were included, which was a normative evaluation of how a factor influenced an effect. A positive influence means that an input, process, or institutional factor is beneficial for the effect of a TD project, while a negative influence means that the factor hinders or reduces an effect. Figure 6-2 gives an example of both a positive and a negative influence of a factor on effects. In the second round, I described the effects and specified the specific input, process, or institutional factors. I only considered perceived or measured ex post effects that were described in the articles, but not the effects that the authors expected to be achieved.

1. Step of Coding



2. Step of Coding

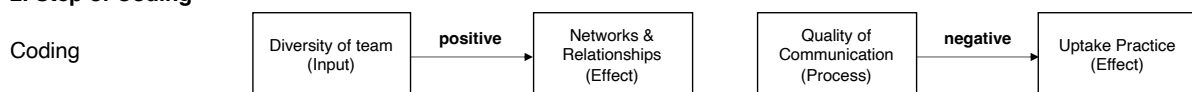


Figure 6-2 Description of the coding process based on an example.

⁶ More details about the specific search terms and the process and the selection criteria are explained in the appendix 0

During the coding process, I inductively added two additional effects, namely “Inclusion & Relevance” in the category Social Effects and “Quality of collected Data” in the category Knowledge. Furthermore, I introduced the effect “General Success”, as it was not always possible to specify on which effect a factor had an influence, for example, when a factor was used to explain why a project was overall successful or not. Table 6-1 describes the final list of the effects developed and their categories.

Table 6-1 Overview of the final selection and description of effects.

Category	Effects	Description
	General Success	Describes the overall success of the project
Knowledge	Generated Knowledge	System, target, or transformation knowledge. This includes data, academic or non-academic publications, management recommendations, developed tools, etc.
	Quality of collected Data	Perceived quality of collected data
Uptake	Uptake Practice	Uptake of knowledge produced through the project by stakeholders; this includes changing current practices, implementing new management practices, etc.
	Uptake Science	Uptake of project results in science (articles) or input for further scientific purposes, capacity building of researchers (e.g., new methods used)
	Uptake Policy	Uptake of generated knowledge in policy; this includes the uptake in the formulation of new strategies, policies, or laws, the uptake in practices of public administration, influencing the political discourse, etc.
Learning	Learning Stakeholders	Includes capacity building of stakeholders involved
	Problem Awareness	Increased problem awareness
Social	Networks & Relationships	Built networks and strengthened relationships, increased trust
	Inclusion & Relevance	Level of inclusion and relevance for stakeholders

Table 6-2 shows the input factors that resulted from the inductive coding process. Compared to the deductively developed categories presented in the theory section, I adjusted the categories based on the data. First, I combined the Social Network Structure & Community Attributes into one category, as it was often difficult to distinguish between the two categories. Second, I introduced the category Composition & Content to structure different input factors related to the stakeholders and the disciplines involved.

Table 6-2 Overview of input factors.

Category	Input Factor	Description
Content & Composition	Structure of Team	Involvement or non-involvement of specific researchers and stakeholders (e.g., focus on women, youth, or a specific group of stakeholders)
	Interdisciplinarity	Level of interdisciplinarity of the TD project – high or low
	Transnational Cooperation	Cooperation between researchers and non-academic stakeholders from different countries
	Diversity of Team	Diversity of the team in terms of the background of researchers and stakeholders
	Involvement of Students	Involvement of Master or Bachelor Students in the TD Project
Individual Attributes	Motivation for TD	Motivation for TD projects from researchers and stakeholders – high or low
	Qualifications & Skills	Presence or absence of specific qualifications and skills (technical and content-related skills, but also soft skills) of project participants
	Resources of Stakeholders	Presence or absence of sufficient resources (time, money, personnel) of stakeholders for the TD project
Social Network Structure & Community Attributes	Knowledge Brokerage & Reputation	Knowledge brokers available or not, access to important people available or not
	Shared Values & Understanding	Presence or absence of shared values and understanding between project participants
	Power Distribution	Equal or nonequal power distribution between project participants
	Defined Responsibilities	Responsibilities between the project participants sufficiently or not sufficiently defined
	Previous Contact & Experience	Previous contacts or experience in the field exist or not

Table 6-3 displays the theoretically derived categories of process factors, Strategies, Methods, and Quality, and the respectively developed process factors. I developed them inductively during the coding of the cases.

Table 6-3 Overview of process factors.

Category	Process Factor	Description
Strategies	Safe Space & Privacy	Presence or absence of safe spaces for project members to exchange freely; privacy within the project – high or low
	Informal Exchange	Presence or absence of informal exchange between project participants
	Contracts & Incentives	Presence or absence of contracts, agreements, or incentive structures
	Emphasizing	Presence or absence of methods or strategies that entail 'put yourself in other shoes', e.g., as used in Design Thinking.
	Adaptive Management	Presence or absence of adaptive management approaches, including approaches that are adaptive to learnings from the projects as well as the needs and interests of the project participants
	Visualization of Information	Visual tools (graphics, photographs, video, etc.) to communicate information used or not used
Methods	Co-creation	Use of methods that actively involve stakeholders and researchers in the research process
	Participatory Tools	Use of participatory methods such as workshops that foster engagement through participation compared to tools that are mainly used to inform stakeholders
	Training	Use of specific training to increase technical, content-related, or soft skills of stakeholders or researchers
	Stakeholder-Led Activities & Monitoring	Use of activities where stakeholders are in the lead, such as farmer-led field trials or monitoring programs
Quality	Degree of Collaboration	Intensity of collaboration between different researchers and stakeholders – high or low
	Quality of Communication	Quality of communication between the different research participants – high or low
	Quality of Management & Planning	Quality of project management and project planning (e.g., specific planning for project synthesis) – high or low
	Available Time & Efficiency	Availability of time is sufficient or limited, efficiency or inefficiency of the TD research process
	Translation	Presence or absence of translation, quality of translation – high or low
	Transparency	Transparency within the TD project – high or low

Table 6-4 shows the factors from the categories Formal Institutions and Informal Institutions that I identified by coding the data.

Table 6-4 Overview of institutional factors.

Category	Institutional Factor	Description
Formal Institutions	Administration	Administrative constraints or opportunities in the form of rules, regulations, level of compliance, or level of bureaucracy
	Funding	Amount of funding, specific funding conditions, support through funding programs, etc.
	Political & Economic Priorities	Political or economic priority of the subject of the TD project within a country, region, or organization – high or low
Informal Institutions	Existing conflicts	Presence or absence of already existing (political) conflicts and tensions
	Academic Culture	Publication pressure, academic incentive system
	Cultural Norms & Differences	Specific cultural norms, values, and traditions; cultural differences or similarities between different project members

6.3.3 Expert interviews

To complement the data from the review, I conducted five expert interviews with researchers and practitioners who participated in more than two TD projects. I based the interview guideline that I used for all the interviews on the analytical framework (see appendix B.2). I started by asking the interviewees about the effects of TD projects and asked them to use experiences from TD projects in which they were involved to illustrate their statements. Furthermore, I systematically asked them how, again based on their experience with TD projects, these effects were influenced by input, process, and institutional factors. I analyzed the interview data based on the same coding scheme as in the literature review. Table 6-5 gives an overview of the experts interviewed and the identification that I use to present the interview results.

Table 6-5 Overview of interviewees.

Organization & Role	Identification
Head of a research group conducting TD research within the field of sustainable development (energy, land use, sustainable cities)	R1
Researcher with extensive experience conducting TD research within the field of sustainable development (land use, sustainable agriculture)	R2
Researcher with extensive experience conducting TD research within the field of sustainable agriculture	R3
Manager of a national park, responsible for research activities	P1
Project leader of an NGO within the field of sustainable agriculture	P2

At the time of the interviews (March–May 2020), all the interviewees worked for different (research) organizations or other organizations in Switzerland in the field of sustainable development. Switzerland’s researchers and research funders are active in conducting and funding TD projects of national and international scope. The Swiss National Science Foundation (SNFS), for example, funds specific research programs that are interdisciplinary and TD programs focusing on important challenges for Switzerland⁷. Furthermore, the Swiss Academies of Arts and Science

⁷ <https://www.snf.ch/en/ELxP53n5RBBa08a2/funding/programmes/national-research-programmes-nrp>

has established a network for TD research⁸. Swiss research institutions also have extensive experience within the field of N-S research partnerships. Together with the SNFS, the Swiss Agency for Development and Cooperation has established a special research funding scheme to support TD N-S research partnerships⁹. I therefore assume that interviewees working for Swiss organizations take a comprehensive perspective which is at least comparable to other researchers and practitioners working for European organizations. Of course, researchers and practitioners from other contexts (e.g. global South) might have a different perspective.

6.4 Results

First, I provide a general overview based on the literature review. Then, I present the results for input, process, and institutional factors, separately based on the literature review and then on the interviews. Whenever I refer to a case from the literature review, I note the respective case number (appendix, Table B 2).

6.4.1 Positive and negative influences on effects

Figure 6-3 shows the reported positive and negative influences of different input, process, and institutional factors on effects. In general, process factors are reported to have the most positive influence on effects. Institutional factors, compared to process and input factors, are mentioned more often for negative influences than for positive ones.

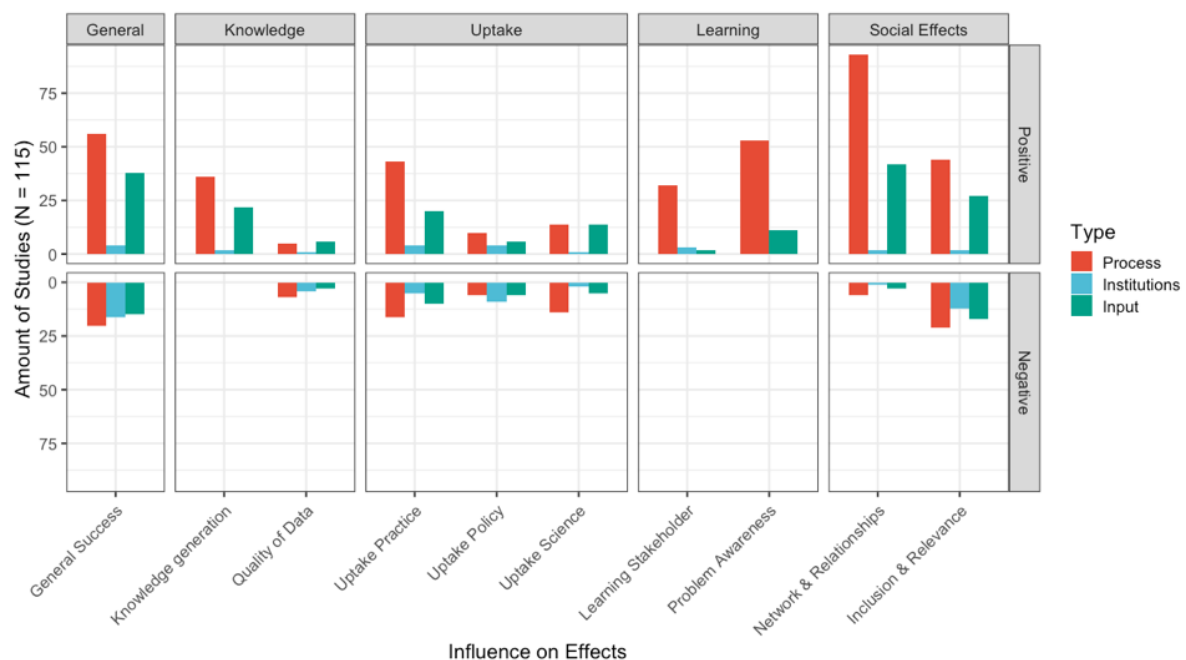


Figure 6-3 Reported positive and negative influences of input, process, and institutional factors on different effects.

Regarding positive influences, some effects are described to be influenced more often by input, process, or institutional factors than others. For example, the effects of the category Social Effects or Learning and the effect “Generated Knowledge” are, based on the analysed studies, more prominently influenced than the factors “Uptake Policy”, “Uptake Science”, and “Quality of collected Data”. Influencing the uptake of knowledge in policy and science seems to be more

⁸ <https://transdisciplinarity.ch/en>

⁹ <https://www.sor4d.ch>

difficult than social or learning effects. However, “Uptake Practice” is often described to be positively influenced by input and process factors. Regarding the reported negative influences, “Uptake Policy” is described to be affected by institutional factors, while “Uptake Science” mostly by process factors.

6.4.2 Input factors

6.4.2.1 Literature review

The first part of Figure 6-4 shows the share of reported of negative and positive influences of each input factor. The second part shows the share of reported negative and positive influences on the different effects. Table B 1 in the appendix shows the reported degree of influence of each input factor on each effect. When a specific influence of a factor on a specific effect is referred to, I provide the number of observations for the effect in brackets.

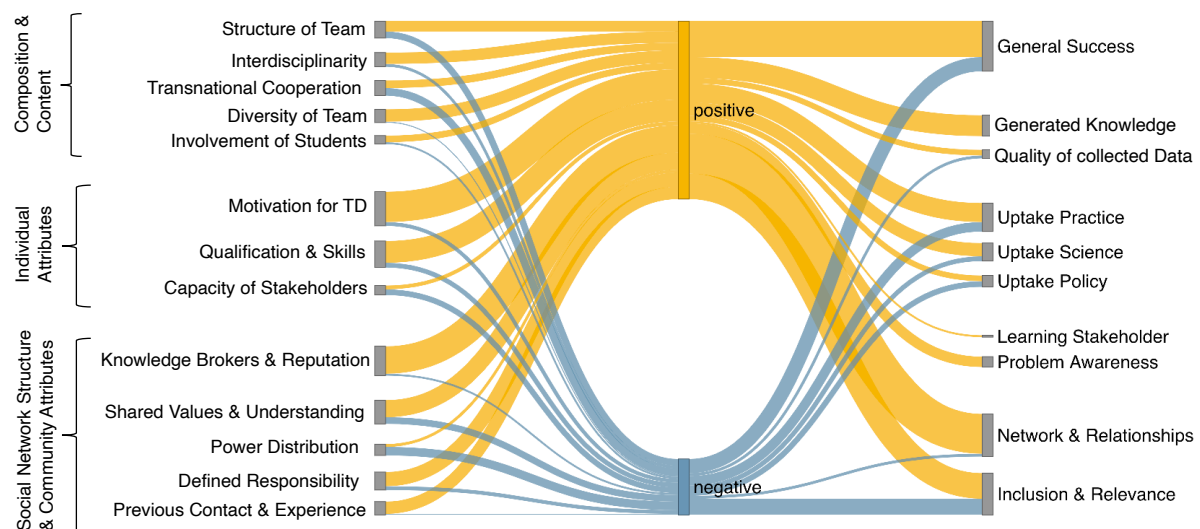


Figure 6-4 Reported positive (in yellow) and negative (in blue) influences of input factors on the different effects. The first part of the graph indicates the share of reported influences of the different input factors, and the second part of the graph shows how often the different effects are reported to be influenced.

All factors have reported positive and negative influences on the effects. The most frequently observed input factor is “Motivation for TD” followed by “Knowledge Brokers & Reputation” and “Qualification & Skills”. For the factors “Capacity of Stakeholders” and “Power Distribution”, the negative influences exceed the positive. This means that more studies reported negative influences of limited capacity (in terms of time or financial resources) than positive influences of sufficient capacity and that power dynamics were mentioned more often as problematic (e.g., power imbalances) than beneficial (equal power dynamics). Regarding transnational cooperation, the share of studies reporting negative influence of transnational cooperation in projects is the same as the share of studies reporting positive influences.

The effects most often reported as influenced by input factors are “General Success”, “Inclusion & Relevance”, “Network & Relationships”, and “Uptake in Practice”. While for “Network & Relationships” only a minor share of input factors has negative reported influences, this share is greater for “Uptake in Practice”. For the effect “Inclusion”, the amount of observed negative influences is almost as high as the positives. Regarding the specific reported connections

between input factors and effects (see Table B 4 in the appendix), the most influential input factor “Motivation for TD“ has, in addition to influence on “General Success” (10), the highest share of influences on effects “Network & Relationships“ (5), “Uptake Science” (5), and “Inclusion & Relevance” (5). The factor “Knowledge Brokers & Reputation” has the most links with “Uptake Practice” (7) and “Networks & Relationships” (7), followed by “Uptake Policy” (6).

“Inclusion & Relevance” – the effect that is most often described as negatively influenced – is affected by a variety of different input factors. Most often, it is reported to be influenced by “Structure of Team” (8) and “Defined Responsibility” (6). The level of inclusion might depend on whether you involve all stakeholders who have a stake in a certain matter and how clearly the responsibility between the different project participants is distributed. Related to this, Hansson and Polk (2018) reported a dilemma between involving as many concerned stakeholders as possible and the degree of interaction:

“This led to a high degree of legitimacy between a limited number of individuals.” (Case 36-41, p.140)

The input factor "Capacity of Stakeholders" was mentioned in comparatively few studies (8). Since stakeholders often do not have enough time and resources to work on projects, this factor is often mentioned as exerting negative influences on various effects. This is described as follows by Brink et al. (2018):

“Many municipality representatives had to continually justify their participation to their superiors, and were required to prioritise issues that were more urgent.” (Case 49, p.778)

6.4.2.2 Interviews

Regarding input factors, there are similarities and differences between the results of the interviews and the literature review. Regarding the literature review, the motivation for TD research was a frequently mentioned factor. For example, a research interviewee (R3) mentioned that the motivation of researchers to work with stakeholders is key for the relationships built within the project and the level of inclusion. Moreover, the two interviewees from practice emphasized that the motivation of researchers to really work with them, rather than just informing them about their research, was crucial in order that their organizations could also profit from the TD projects. One interviewee described how she experienced projects in which researchers were mainly interested in pushing their research agendas and publishing their results. She explained that the results of such projects were not applicable to the work of her organization. Her organization is now trying to find project partners that are interested and motivated to include the perspective of stakeholders (P2).

Furthermore, several interviewees (R1, R2, and P1) noted the importance of knowledge brokers. In particular, one interviewee strongly emphasized the role of knowledge brokers in TD research projects (R2). She explained that knowledge brokers or “boundary people” who can empathize with different worlds and build bridges between research and practice, but also different topics and backgrounds, are essential for TD projects as they can foster “shared values and understanding”. She explained that such knowledge brokers often have an interdisciplinary

background, such as geography or environmental sciences. She described that sometimes it was more difficult to bridge different disciplines than stakeholders and researchers. In her experience, specialized researchers struggled to communicate with researchers from a very different field, while exchanging with stakeholders from a similar field was easier due to a common understanding of an issue.

A factor that is not prominent in the literature review, but is mentioned by all interviewees, is the participation of students. Two interviewees (R1 and R2) mentioned that they observed differences between projects that included bachelor and master students and those that did not. In their experience, the participation of students in TD processes led to high levels of inclusion of the stakeholders involved, as students are often very engaged in finding solutions with and for the stakeholders (R1 and R2). The two interviewees from practice (P1 and P2) also described the involvement of students as very beneficial. One interviewee explained that in her experience, students often connected more easily with stakeholders, as they were very open-minded and less likely to “throw around academic terminology” (P1). Another research interviewee (R3) mentioned that it is crucial to introduce students to TD methods and applications, as these experiences could motivate students who remain in research to use such approaches.

6.4.3 Process factors

6.4.3.1 Literature review

Figure 6-5 shows the share of reported negative and positive influences for each process factor. Furthermore, it shows the share of reported positive and negative influences on the different effects. Table B 4 in the appendix shows in more detail which process factors influence which effects.

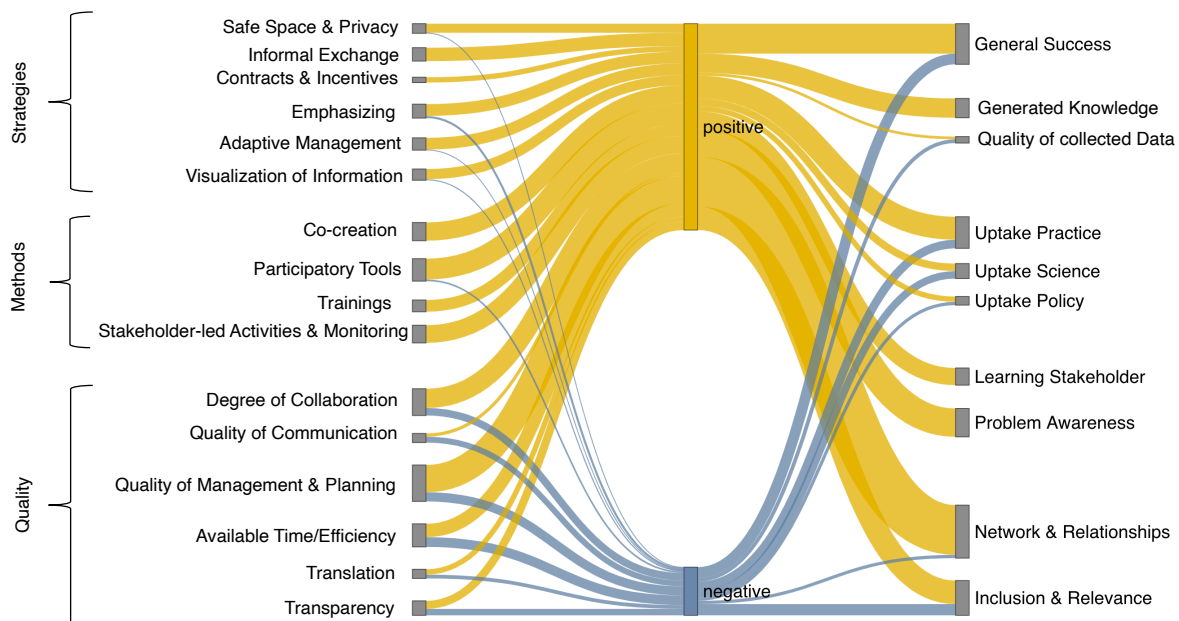


Figure 6-5 Reported positive (in yellow) and negative influences of process factors (in blue) on the different effects. The first part of the graph indicates the share of reported influences of the different input factors, and the second part of the graph shows how often the different effects are reported to be influenced.

The three process factors most often described “Quality of Management & Planning,” “Degree of Collaboration,” and “Availability of Time/Efficiency” are all in the category Quality. Compared to process factors related to Methods or Strategies, the Quality factors also have a higher share

of negative influences on effects. The effects that are, next to general success, most often reported to be influenced by process factors, are the same as for input factors: “Network & Relationships” and “Inclusion & Relevance,” followed by “Uptake in Practice.”

When looking more specifically at which effects are reported to be influenced by the most prominent process factors (Table B 4), I observe that the quality of management could be crucial to the general success of projects (18). In the analyzed studies, it also often influences the effects “Networks & Relationships” (14), “Inclusion” (7), “Uptake Practice” (7), “Uptake Science” (7), and, to a slightly lower degree, “Uptake Policy” (5). In particular, the effects attributed to TD projects that go beyond knowledge production require relevant structures and management practices. Additional efforts also require appropriate time resources. I also find this issue in the cases studied. One case emphasizes the additional time needed for TD projects as opportunity costs.

“[P]rojects demand a long initiation period to build an effective team, appropriately align the research to the local context, and ensure that there is adequate opportunity for receiving and processing feedback from research users. These investments can often be viewed as opportunity costs to producing conventional research outputs, commonly resulting in tensions and competing priorities within and between team members.” (Balvanera et al., 2017) (Case 105, p.16)

Although not as prominent among process quality factors, the “Quality of Communication” is still an interesting factor. I observe more cases in which a low quality of communication has hindered the achievement of effects than cases where a high quality of communication has fostered it. This might mostly indicate that a good quality of communication is perceived as normal, and only cases where communication is difficult are reported. The quality of communication is most often associated with “Inclusion” (6). One case shows that communication difficulties can lead to low inclusion and low relevance for the participants.

“These partnerships were described as having poor engagement processes and being either ignorant of (or prejudiced about) indigenous culture and cultural protocols—attributes that were believed to exclude indigenous people as genuine decision-makers. Perhaps as a result of this, participants explained that the information these partnerships produced was often hard to understand, often used “another language”, and was not considered locally relevant, reliable, user friendly, or practical.” (Robinson et al., 2016) (Case 107, p.122)

Another quality factor described as positively (if in place) or negatively (if not in place) influencing the effects of TD projects is “Transparency”. “Transparency” is most often reported to influence the effects “Uptake Practice” (5) and “Network & Relationships” (4). Similarly to “Transparency,” the process factor “Contracts & Incentives” mainly influences “Network & Relationships” (4).

Looking at process strategies, another factor related to transparency is “Safe Space & Privacy.” Several studies have found that using methods with which participants could express their opinions anonymously, such as surveys, can actually ensure that participants could express their opinions freely and with less influence from existing power structures (Lund et al., 2014; Siew et al., 2016).

Furthermore, the use of an adaptive management approach, that is, iterative processes that adapt to the needs of participants, is often described to positively influence the effects of TD projects, especially the effect “Inclusion” (9).

Regarding methods used in TD projects, according to the studies cases, they often influence the effects of the categories Social Effects and Learning. “Co-Creation” and “Participatory Tools” are most often connected with “Network & Relationship” (9, 13), while “Training” with “Learning Stakeholders” (6) and “Stakeholder-Led Activities & Monitoring” with “Problem Awareness” (11).

6.4.3.2 Interviews

Regarding process factors, the results of the interviews do not point toward one prominent factor, but rather a variety thereof. This is similar to what I observed for the results of the literature review. All interviewees focused on different process factors that, according to them, are important. For example, an interviewee specifically mentioned and emphasized the importance of safe spaces. She explained that when she worked with farmers in South Africa, she would not attend all focus groups to ensure that farmers had the opportunity to exchange freely without feeling pressured by the presence of the “white, western scientist” (R3).

Two interviewees from practice (P1 and P2) emphasized the benefits of an adaptive management approach. Both explained that adaptive project management increases the feeling of project ownership and inclusion, as it can, if necessary, adapt to changing goals and needs. One of the researchers interviewed (R1) fully agreed that research processes in TD projects should be dynamic and adaptive, but also mentioned that this was often very time-consuming and required a lot of flexibility from researchers. Related to this, she also explained that, in her opinion, researchers tend to use methods that they already know and which they like, which might not always be the methods that are the best fit for the research question and the TD process in general.

6.4.4 Institutional factors

6.4.4.1 Literature review

Figure 6-6 shows the share of reported negative and positive influences of each institutional factor. Furthermore, it shows the share of reported influences on the effects. Table B 4 in the appendix shows in more detail which institutional factors influence which effects.

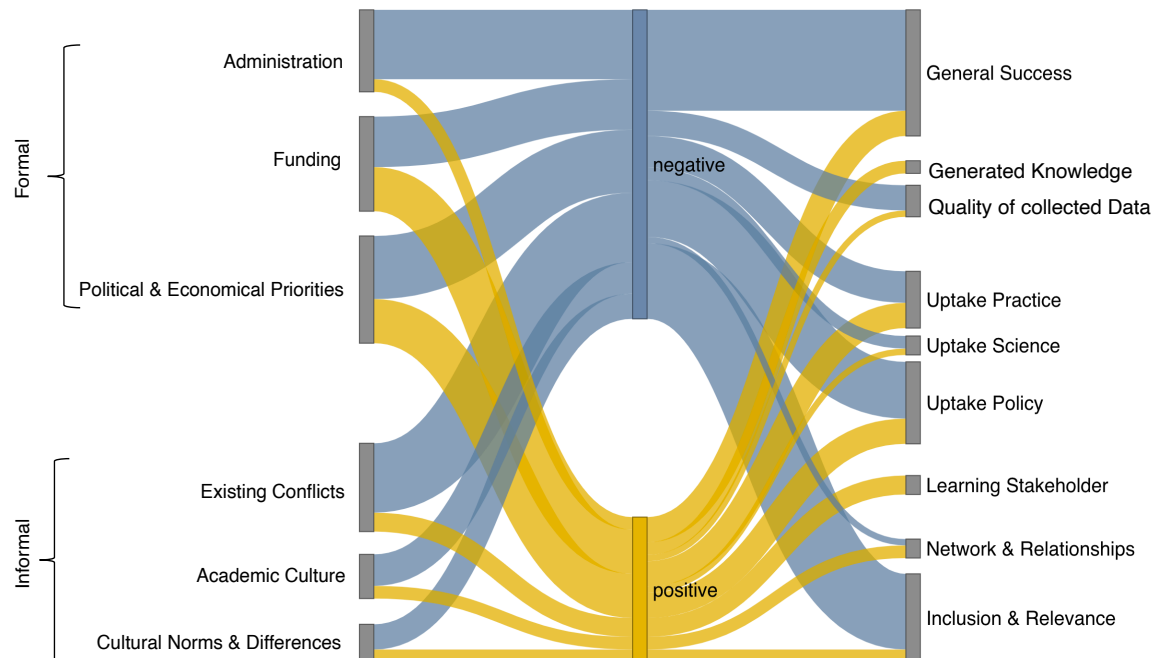


Figure 6-6 Reported positive (in yellow) and negative (in blue) influences of institutional factors on the different effects. The first part of the graph indicates the share of reported influences of the different input factors, and the second part of the graph shows how often the different effects are reported to be influenced.

The share of reported negative influences exceeds that of positive influences. Furthermore, all institutional factors are more often described to influence effects negatively than positively. The higher share of negative influences is most prominent for “Administration,” followed by “Existing Conflicts,” while less pronounced for the other factors. In addition to the general success of projects, institutional factors are often described to influence the effects “Uptake Policy” and “Inclusion & Relevance.” While the effect “Inclusion” is reported to be affected by all the institutional factors, I find that “Uptake Policy” is influenced most often by “Political & Economical Priorities” (7) and “Administration” (5).

6.4.4.2 Interviews

In the interviews, institutional factors were generally discussed in terms of their influence on TD projects rather than specifically on effects. As for the literature review, one prominent theme mentioned by all research interviewees is the political stability of the context of the project and whether the project tackled a contested topic. Two researchers (R1 and R3) reported that working in unstable political contexts or on contested topics was often more difficult, and they shared the impression that, as researchers, they had the opportunity to at least raise the topic.

All interview partners mentioned the academic culture. The two practice interviewees mentioned that they sometimes felt that the researchers were pressured to publish and therefore had limited

time to include the perspective of practice (P1 and P2). For researchers, the main topic was the academic incentive system.

“Action-oriented research agendas need breadth and depth or knowledge. It needs a large amount of different expertise because many different topics come together. However, the current academic culture only rewards depth.” (R3)

Another interviewee (R2) pointed out that the current academic culture is especially challenging for PhD students, who often have to publish a certain amount of papers in a certain time. In her opinion, participating in a TD project while doing a PhD was too overwhelming for many students (R2).

The role of funding was also discussed in all interviews with researchers. Two of them (R1 and R3) described that the joint development of research questions in a TD manner was often difficult, as funders expect well-defined research questions in grant proposals. This example shows that there are not only links between the different factors and effects, but that the influence of institutions might already start at the input or process level. However, these influences could also be positive. Two interviewees (R1 and R3) reported their experiences with more adaptive funding schemes. One has experienced a project with a funded inception period of six months, designated to co-develop the project together with practice partners (R3). Another interviewee (R1) reported on a funding agency that uses an adaptive grant writing process with frequent feedback from the agency. Instead of concrete research questions, the funding agency expected examples of what such processes and questions could look like. Both researchers were in favor of such alternative funding approaches.

6.5 Discussion

This study shows that according to the cases analysed, a variety of factors positively and negatively influence the effects of TD projects. Overall, process factors are the most prominent in influencing the effects of TD projects. Process factors from the category Methods or Strategies mostly have positive influences on the effects of TD projects. An example is the use of “Adaptive Management” approaches that are flexible enough to adapt to the needs of both researchers and stakeholders. The process factor “Adaptive Management” was also highlighted by the interviewees as very important, but time consuming. In natural resource management, adaptive management strategies have already been successfully applied and studied (Brownson & Fowler, 2020; Canter & Atkinson, 2010). This study provides the first evidence that it is also beneficial for TD projects. Process strategies such as “Informal Exchange” and “Emphasizing” are, according to this research, very beneficial for “Networks & Relationships”. In line with several authors (Brinkerhoff, 2002; Kleinsmann & Valkenburg, 2008), I find that improved relationships are an important foundation for building shared values while trying to emphasize that the positions of others might increase the shared understanding. Furthermore, several process factors of the category Quality foster but also hinder the uptake of knowledge in practice, policy, and science. Increased applicability, and therefore uptake of knowledge, is a key argument to explain the importance of TD projects (Schneider et al., 2019a). Based on these observations, I argue that using the appropriate methods and strategies can be extremely beneficial for TD projects, but

that they still need a solid process quality to ensure that the used Methods and Strategies may actually result in the desired effects.

Regarding input factors, the factor most often reported is “Motivation for TD”. That the motivation of researchers for TD projects is beneficial for their effects might be self-evident and in line with existing research on motivation (Amabile, 1997; Hung et al., 2011). However, both practice interviewees mentioned that they had worked with researchers who seemed not that interested in working with stakeholders, which for them led to unsatisfactory results. This leads to open questions about where the motivation to work in TD projects comes from and whether it can and should be fostered or not. Well-aligned with the literature on knowledge brokerage (Hering, 2016; Wittmayer & Schapke, 2014), I find that “Knowledge Brokers” is an often reported input factor that mainly influences knowledge uptake in TD projects. However, according to the interview data, knowledge brokers may have other important roles, such as creating a shared understanding.

With respect to institutional factors, I find the lowest reported influence on the effects. However, the observed influences are more often negative than positive. However, this result might be biased, as the authors of the articles may tend to report more on the negative aspects of institutions. The interviewees agreed that some institutional factors (“Political & Economic Priorities”; “Existing Conflicts”) complicate research processes. However, they did not directly mention influences on specific effects. This is different for the institutional factor “Academic Culture”. Here, all interviewees mentioned that the current “Academic Culture” negatively affects the effects of TD projects in one way or another. The role of academic publication pressure and its influence on the effects of research projects is also a topic in the current literature (Rocha et al., 2020; Waaijer et al., 2018). Regarding funding, I find a mixed picture in the results of both the review and interviews. Both reveal that there are funding mechanisms that are beneficial and others that are rather hindering for TD projects. Furthermore, funding mechanisms might influence not only the effects, but also input and process factors. This is in line with the findings of Jahn et al. (2022). They found that the funding system in place can influence the degree of collaboration in research projects. Whether or not funding instruments, such as the described inception period, are beneficial for TD projects in general, and for which effects in more detail remains an open question for future research.

Furthermore, as presented in the analytical framework, the different factors are interconnected (Katz & Kahn, 1978). Influential factors do not only influence the effects of TD projects, but also each other (see appendix, Table B 5, Table B 6, Table B 7, Figure B 2). These underlying interactions between input, process, and institutional factors could again explain why certain effects are achieved or not. Process factors, which I find to most often influence effects, are influenced by institutions and input factors. Around one third of the influences of input factors affect processes, rather than directly effects. Furthermore, the largest share of institutions influences of institutions affects input factors. This means that process factors cannot always be determined freely, but are also influenced by input and institutional factors. Although institutions are by definition factors external to the projects (Edelenbos et al., 2010; North, 1991) and thus more difficult to influence overall, input factors such as whether project participants share the same values are also factors that cannot directly be changed through the project design. This

study cannot provide more detailed insights regarding these interconnections. However, other authors provide more in-depth evidence based on impact pathways and ToCs (Deutsch et al., 2021; Oberlack et al., 2019; Schneider et al., 2019a).

This study has three significant shortcomings. First, the data scope of the collected is limited. I conducted all the interviews with researchers and practitioners working for Swiss organizations. However, people from different contexts (e.g. the global South) might have a different perspective. In the literature review, only scientific articles written in English and published before 2020 were considered. Findings from articles published afterward, or in different languages, as well as from grey literature, have therefore not been included in the analysis. Second, a large part of the analysis was based on the findings of 77 articles on TD projects. I only analyzed the effects and influential factors described by the authors of these articles. Therefore, I cannot be certain whether an influence that was not described was actually not present or just not reported in the article. Additionally, I was unable to control for potential biases within the studies. For example, these studies may report successes rather than failures. Furthermore, factors such as hurdles in communication or bureaucracy are often reported to hinder projects. However, the absence of these hurdles could be considered normal. I assume that the authors would not specifically report on how this influences the project. Furthermore, this holds true for the analysis of the interconnections between the different effects. As the authors of the studies may not have analyzed the interconnections specifically, there is a danger of bias in these results. Second, this analysis provides evidence of the strength and direction of the factors. However, based on these data, more detailed mechanisms of how a certain input, process, or institutional factor influences a certain effect cannot be explained. To address these shortcomings and questions, I propose three avenues for future research. First, researchers could conduct in-depth empirical case studies of TD projects, structured along the effects and input, process, and institutional factors presented in this study. Second, researchers could explore combining ToCs with the open system model to explore pathways, but also including input factors and institutions. Third, future research could look specifically at variances between different cases, for example, by comparing projects with different funding schemes.

6.6 Conclusion

This article studies how different input, process, and institutional factors influence the effects of TD projects. TD projects as integrative and collaborative approaches have been established to jointly address complex sustainability problems (Biermann et al., 2017; Bowen et al., 2017; Kozar et al., 2019; McAllister & Taylor, 2015; Patterson et al., 2017). I identified 115 cases of TD projects to systematically analyze which input, process, and institutional factors influence which effects. In addition, I conducted expert interviews with researchers and practitioners with extensive experience with TD projects.

Although a variety of factors influence the effects of TD projects, process factors have the most prominent influence. Furthermore, there are also interconnections between the different factors: institutions and input factors affect effects not only directly, but also indirectly because they influence process factors.

Based on the findings, I provide recommendations for researchers and stakeholders involved in TD projects, as well as for research funders. For people involved in TD projects, I recommend investing in careful project planning and adaptive management throughout the project. Pohl et al. (2017), for example, prepared a 10-step approach to make research societally relevant, which can be directly used as a guide for project planning and implementation. Furthermore, researchers should reflect on their motivation to actually work in a TD setting. As it may require time and resources, the question remains whether, for certain researchers, it makes more sense to conduct research without specific stakeholder involvement. Jahn et al. (2022) found that projects within sustainability sciences managed to have societal impact even without involving any stakeholders. I recommend that research funders experiment with different funding approaches. This could include funding inception periods, adaptive proposal-writing processes, or longer-term institutionalized funding. In addition, I recommend that funders keep track of the experiences they have with their funding approach and adapt it if necessary.

The results of this study make important contributions to several strands of literature and have relevant implications for practice and research. First, they provide a summary of the findings of TD projects, which contributes to a holistic understanding of the factors that influence these projects and the effects thereof. In addition, they show the interconnections of input, process, and institutional factors. This has important implications for scholarly discussions of the governance of these projects and trade-offs between different factors and effects. Second, TD projects implicitly or explicitly address two important dimensions of interaction that are key in relation, especially to sustainability governance, that is, between research and practice, and between different scientific disciplines (within research) and different policy sectors (within practice). The results of this analysis, beyond TD projects in a narrow sense, provide evidence about the management of these interactions. Third, from a practical point of view, the results, on the one hand, provide a scheme for a holistic analysis of TD projects, which might help identify positive and negative influences on effects. On the other hand, they also provide concrete recommendations to promote certain effects of TD projects, such as the use of adaptive management approaches to increase inclusion.

7 Article 3

“The reality in the DRC is just not the reality in Rwanda” – How context factors affect transdisciplinary research projects

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Abstract

Transdisciplinary research (TD) projects integrate different disciplines and non-academic stakeholders to jointly tackle complex societal challenges. Because of their focus on finding solutions for real-world problems in collaboration with stakeholders, the context in which TD projects are implemented, including social, political, or environmental conditions, influences their implementation. In this article, we examine how context factors influence the effects of TD projects. Effects include all intended and unintended outputs, outcomes, and impacts of projects. We built a working model, based on different established concepts from policy studies to operationalize context and effects, and applied it through a comparative case study of two regional subprojects of one large TD project on circular bio-economy for sustainable agriculture. The core concept and design were the same for both subprojects, but they achieved different effects. We used the differences in context factors to explain this variation. We find that a strongly developed public and private sector and access to a variety of action resources such as political support or laws, supported the uptake of knowledge by stakeholders and into policy. Nevertheless, a strong public sector can also hinder a project's success, if the interest of the government is not in line with the interests of the project. Further, we find that TD projects may achieve learning and social effects by tackling certain gaps in action resources. Our findings highlight that taking the context of a project into account is key to understanding the scope of action of a project. Thus, the context should be considered not only when planning but also - and especially - when evaluating a TD project.

Keywords

Transdisciplinary Research, Realist Evaluation, Context, Circular Economy

7.1 Introduction

Transdisciplinary research (TD) projects integrate diverse scientific disciplines and non-academic stakeholders to collaboratively address complex challenges (Lang et al., 2012). The potential of TD projects to address complex sustainability issues, such as waste management, sanitation, and depleted soils has been debated by scholars and practitioners (Chambers et al., 2021; Schneider et al., 2019a). It is crucial to consider that TD projects are influenced and shaped by their specific context (Lam et al., 2021). The role of context is discussed in two ways when it comes to TD research. First, TD research aims to be context-specific. Understanding the local context is key for generating knowledge and solutions that target existing needs (Lam et al., 2021; Lux et al., 2019). Lux et al. (2019) state that understanding the context in which a TD project takes place is important in order to fully comprehend the targeted problem as well as “*the scope of action in societal reality*” (p.186). Second, the high context-specificity of TD projects complicates the production of general knowledge beyond case knowledge. In that sense, Adler et al. (2018) emphasize the importance of knowing the context conditions in which given effects appear in order to formulate more general and transferable learnings. As a solution developed for a specific context might not work in another context, general solutions resulting from TD projects are often difficult to identify (Nagy et al., 2020).

The influence of context on effects has also been frequently discussed in evaluation studies. Williams (2020), for example, states that everyone in policy evaluation agrees that “*context matters*” (p.1), yet there is a lack of evidence on precisely how it matters for policy effectiveness. Bates and Glennerster (2017) elaborate on the challenge faced by policy makers to determine the applicability of tested programs to other settings. The authors highlight the crucial role of understanding the local context to ascertain whether a program's positive results in one setting can be replicated in another. This requires an understanding of whether the local context aligns with the program's theory, as well as whether the program's implementation can be realistically accomplished in the local setting. The concept of realist evaluation emphasizes the role of context. Rather than just asking whether an intervention worked or not, a realist evaluation asks what works, how, and under what circumstances (Pawson et al., 1997). They use the so-called context-mechanism-outcome configuration to identify the mechanisms and context conditions which lead to a certain outcome (Douthwaite et al., 2017; Jagosh, 2019). Realist evaluations are dynamic: an intervention might actually shape and transform a certain context, which then in turn influences the outcomes of subsequent interventions (De Souza, 2013; Pawson et al., 2004; Pawson et al., 1997).

Several authors propose integrating context factors into evaluation approaches for TD projects to better understand which solutions work in which context (Archibald et al., 2018; Knickel et al., 2019). Or, as Nagy et al. (2020) state, understanding the context is important to “*provide appropriate transfer and foster receptivity for TDR results*” (p.156). Against this background, we ask the following research question: how do context factors affect TD projects?

We address this question in line with the concept of realist evaluation. Thereby, we need an understanding and operationalization of what context means. While context is key in realist evaluations, there is little work on what context actually refers to, and attempts to conceptualize different context factors are still limited (Greenhalgh & Manzano, 2021; Nielsen et al., 2022). There

is also is little work which is exploring different context factors of TD projects. One exception is the recent publication from Schneider et al. (2022), where they present 15 different context dimensions which they developed inductively based on TD projects cases. For this study, we propose a theory-based approach to operationalize context. We build a working model to identify context factors based on established frameworks from natural resource governance (Cole et al., 2019; McGinnis, 2011), the concept of action resources (Knoepfel, 2018), as well as external shocks or events (Engwall, 2003; Weible & Sabatier, 2007).

We apply our working model to two regional sub-projects within the topic of sustainable agriculture and waste. These two sub-projects serve as comparative cases, as they have a similar design and set-up but take place in very different contexts. Furthermore, the two sub-projects also show differences in the effects they achieved. This setting allows us to study how differences in the context factors of the two cases influenced the differences in their effects. We use project documentation, interviews with involved researchers and stakeholders, and secondary data to identify and describe the different context factors and effects.

7.2 Operationalizing Context Factors and Effects

In its broadest sense, context refers to configurations of conditions in which something exists or occurs (Pfadenhauer et al., 2017). Relevant conditions for TD projects include those external to the project, but still influencing it. Conversely, we do not consider conditions such as team composition or the individual skills of the team members or stakeholders. In line with other scholars (Fritz et al., 2019; Schäfer et al., 2021), we define effects as all intended and unintended outputs, outcomes, and impacts of the project. Thus, our definition of effects does not align with the positivist perspective, which focuses solely on observable and replicable changes that can be caused by specific factors and tested through empirical methods (Creswell, 2014). We consider our approach as complementary to positivistic evaluations, since it is often not possible to have clear counterfactuals in the case of TD projects. We use a framework of six effect categories proposed by Pärli (2023) and grounded in existing literature: Knowledge production, uptake in practice, policy, and science, learning and social effects. Knowledge production, which encompasses the generation of knowledge about the current state of the system under study (system knowledge), the desired state (target knowledge), and the means to achieve that state (transformation knowledge) (ProClim, 1997). Uptake in practice involves the adoption of, or changes in, practices based on recommendations, while uptake in policy entails active dialogue with policy makers, the consideration of the project or results thereof in the political dialogue or the adoption of new policies or strategies (Fritz et al., 2019; Jacobi et al., 2020). Given that TD seeks to address real-world problems, it strives to produce knowledge that can be used by various stakeholders (Jacobi et al., 2020; Schneider et al., 2019a). Uptake in science refers to the integration of collected data in the scientific literature or the adaptation of methods and practices (ibid). Learning effects refer to the improvement of competencies of stakeholders or researchers, whereas social effects range from the formation of new contacts and networks to the development of higher levels of trust (Jacobi et al., 2020; Schneider et al., 2019a)

For the context factors, we base our operationalization on different established frameworks: The first two are Ostrom's Institutional Analysis Framework (IAD) as well as her Socio-Ecological Systems Framework (SES). Both frameworks are used to analyze the management of common

pool resources (Cole et al., 2019; McGinnis, 2011). As in the management of common pool resources, TD projects require coordination between and collective action by many different actors (Partelow, 2016). Both of Ostrom's frameworks take context factors into account. The IAD distinguishes three types of context factors: biophysical conditions, rules-in-use, and community attributes. The SES framework places an even stronger emphasis on context by dividing and specifying the various governance and socio-ecological factors influencing resource management (Cole et al., 2019; Ortiz-Riomalo et al., 2023). These include the resource or biophysical system and the respective resource units, the governance system, and the actors which interact with the resources (Ostrom, 2009). Ortiz-Riomalo et al. (2023) apply a combination of the IAD and the SES to study participatory interventions to increase collective action for the management of different watersheds. Indeed, they identified several context factors that influenced the success of the interventions. Context factors related to the governance system are also studied empirically by scholars in the aid effectiveness literature. Buntaine and Parks (2013), for example, found that environmental development projects score better in achieving their objectives in countries with higher levels of government effectiveness and regulatory quality. Wambaka and Mutenyo (2022) found that the level of institutional quality mediates the effect of foreign aid on economic growth.

Although the IAD and SES frameworks provide a good overview of fundamental context factors, they do not offer much insight into how the context influences processes on the ground. To fill this gap, we propose to draw on another concept of policy studies, the "public action resources" (Knoepfel, 2018). Knoepfel (2018) defines public action resources as: *"the means of action available to each of the public and private actors affected by the collective problem to be resolved."* (p.43). Compared to IAD or SES, the concept of "public action resources" puts more emphasis on the scope for action of involved stakeholders. Knoepfel (2018) discusses how certain actors are able to influence a policy process by using or mobilizing these different action resources. Therefore, the availability of different action resources as well as the actors' strategic use of resources is important. Knoepfel (2018) introduces ten action resources: Force, law, personnel, money, property, information, organization, consensus, time, and political support. Schweizer et al. (2016) apply the concept of action resources and show that the ability of NGOs to mobilize different action resources was a crucial condition in order to be able to influence a policy process.

External events and shocks can affect TD projects by changing system conditions and action resources (Engwall, 2003). To better understand the context of TD projects we thus propose to include external events in our working model. According to the advocacy coalition framework and other frameworks explaining policy change, external influences are crucial to understanding major policy changes (Weible & Sabatier, 2007). Indeed, external events can be opportunities to bring a topic to the political agenda (Odume et al., 2021). COVID-19 for example was an opportunity for the mobility sector to transition to a more sustainable path (Schmidt et al., 2021), while the Fukushima accident influenced collaboration patterns of actors in a policy process (Fischer, 2015).

Based on the concepts described above, we develop a working model to describe the different context factors that influence the effects of TD projects (Figure 7-1). From Ostrom's SES we

include the biophysical and the governance system, which together we name system conditions. We use the biophysical system to describe the status of the project setting. The governance system may include the public sector but depending on the project also the private sector, civil society, or academia. Additionally, we integrate the concept of action resources (Knoepfel, 2018) to describe how the context influences the actors and their actions. Lastly, we include different external events in our working model.

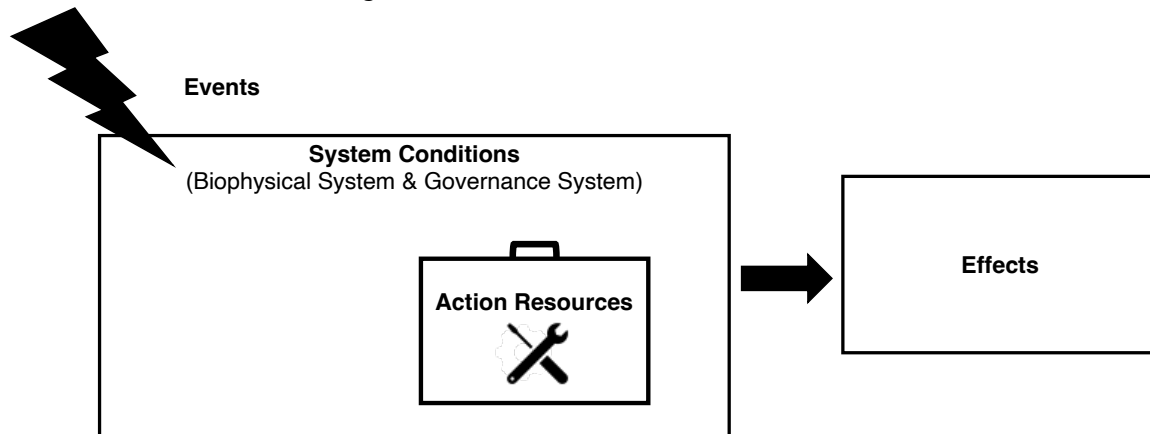


Figure 7-1 Working model to describe how the different context factors affect TD projects. source: own representation based on Engwall (2003); Knoepfel (2018); McGinnis (2011); Ostrom (2009)

The three context factor categories – system conditions, action resources, and events - are nested. The system conditions describe the fundamental context of a TD project. The action resources describe the project members’ and stakeholders’ resources, and how they use them during project implementation. They give more detailed insights in how the context influences the scope of action on the ground. Events describe sudden external changes that can, on the one hand, influence system conditions and action resources, and thus ultimately the effects of a project, but on the other hand might themselves depend on other context factors in place. Table 7-1 summarizes the different context factors of each category.

Table 7-1 Overview of the three context categories and the individual factors used in this study

System Conditions Based on Ostrom (2009)	Events Based on Engwall (2003)	Action resources based on Knoepfel (2018) ¹⁰
<p>Biophysical System Current status of the biophysical system (or sectors) targeted</p> <p>Governance System Systems involved in steering the project (e.g. public, private or research system)</p>	<p>Natural Extreme weather events, earthquakes etc.</p> <p>Economic Economic crisis, labour market development etc</p> <p>Political National or international conflicts, elections etc.</p>	<p>Financial Capital Availability and strategic use of financial means for the project implementation (savings, credits, funds etc.)</p> <p>Political Support Support from different governmental entities (regional to national) for the project. Degree of collaboration with different governmental entities.</p> <p>Law Availability and enforcement of legal resources (laws, policy) useful for the project implementation</p> <p>Organization Participating organizations experience in the field, quality of service, network of</p>

¹⁰ We did not include the action resource force because it did not fit our application.

		<p>organization, capability to access information or resources (e.g. funding)</p> <p>Time Availability and strategic use of time resources (windows of opportunities) for the project implementation. Time efficiency of processes relevant for project implementation.</p> <p>Consensus Agreement on the approach and aim of the project. Trust in the project implementation and its implementers.</p> <p>Infrastructure Material assets that can be used for the project implementation. This includes for example land, property, roads, equipment or other physical goods.</p> <p>Information Access to knowledge, information and data about the technical, economic, political and social aspects of the project to be implemented.</p> <p>Personnel Amount of personnel available for project implementation. Education levels and skills of involved personnel</p>
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7.3 Methods and Data

7.3.1 Case Description

The project, “RUNRES - Establishing a nutrient-based circular economy to improve city region food system resilience”¹¹, aims to implement technologies to circulate nutrients from organic and human waste from urban areas, back to agriculture in rural peripheral areas (Wilde et al., 2021). The project is financed by the Swiss Development Cooperation and coordinated by ETH. While it is implemented similarly in four different countries in Sub-Saharan Africa, we focus on two sub-projects: 1) RUNRES Rwanda, which takes place in Kamonyi, a municipality close to the capital Kigali and 2) RUNRES Democratic Republic of Congo (DRC), which takes place in the city region of Bukavu, in the South Kivu province. The project follows a transdisciplinary approach to co-develop and co-implement nutrient recycling and waste valorisation innovations with local, mostly private sector stakeholders from the agriculture and waste sectors. Each sub-project team consists of a project coordinator and senior scientist that are associated with the local partner the International Institute of Tropical Agriculture (IITA). Henceforth, the cases are referred to as Case Rwanda and Case DRC.

The project focuses on the implementation of different innovations for nutrient recycling on the ground. Table 7-2 provides an overview of the innovations implemented in the two countries. The development and selection of the innovation was part of a transdisciplinary process including a series of workshops with interested stakeholders to design innovations and plan their implementations. Thus, the specific selection of the innovation was strongly stakeholder driven. The implementation of the innovations is led by local organizations, with the support of the project

¹¹ <https://runres.ethz.ch/>

coordinators, and is accompanied by research activities. More information on the project implementation can be found in the appendix (C.1).

Table 7-2 Overview of the innovations that are implemented in Case Rwanda and Case DRC

Innovations	Case Rwanda	Case DRC
Amount and scope of innovations	In Rwanda the project supports three innovations (funding between 60'000 -100'000 \$) and two smaller pilot innovations (one 10'000 \$ and one 20'000 \$).	In DRC, the project supports three innovations (funding between 70'000 -100'000 \$)
Thematic focus of innovation	<p>Innovations</p> <ol style="list-style-type: none"> 1) Cassava Peels: Production of animal feed with cassava peels. Next to provision of feed, processing cassava peels reduces toxic waste 2) Black Soldier Fly: Production of black soldier fly larvae which are used as animal feed (protein) and feed on organic waste. This innovation also produces a substrate which can be used as soil amendment. 3) Compost production: Large scale composting plant, using organic waste from Kigali and Kamonyi district. <p>Pilot Innovations</p> <ol style="list-style-type: none"> 4) Tiger Worm Toilets: Urine separation toilets (dry) using tiger worms to process faeces. Gain urine as fertilizer and compost from co-composting. 5) Urine separation toilets (water-based) in commercial centre. Gain urine as fertilizer and compost from co-composting. 	<p>Innovations</p> <ol style="list-style-type: none"> 1) Compost production: Organic waste from households 2) Compost production: Organic waste from households and urban markets 3) Compost production: Organic waste from households and rural markets. Co-composting with human waste from toilets on markets (constructed by the project).

7.3.2 Methods

We answer our research question through a comparative case study analysis, an approach which involves studying similar cases that differ in certain respects to identify potential causal factors and gain insight into complex phenomena (Yin, 2003). Our comparative case study had an explanatory character, as we aimed to explain the relationship between differences in context factors and differences in the effects of projects. Our case study involved two regional sub-projects of one large TD project, with the same design, funding structure, and researchers involved. However, they take place in different contexts and achieved different effects (see Figure 7-2). Following a most similar system design (Mill, 1889), we selected two similar cases with different outcomes to identify factors that contribute to the observed differences. Based on our proposed working model, we described the context and effects of the two cases, identified the differences between them, and used the differences in context to explain differences in project effects.

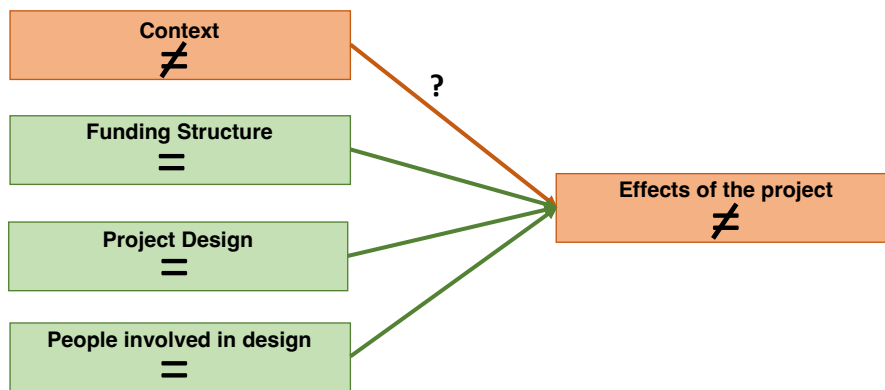


Figure 7-2 Visual representation of the most similar case study design. While the two cases are overall very similar, they take place in a different context and have different effects (own representation)

7.3.3 Data and Data Collection

Applying the principle of triangulation, we used several data sources for our comparative case study: interviews, project documentation, and secondary data on the economic and political situation in the case study countries. The same set of 20 interviews has been conducted between September 2021 and March 2022 to identify the effects and the context factors. We provide a table with an overview of the interview partners in the appendix (Table C 1). The interviewees were either stakeholders (private sector organizations which implement the innovations) or project members (researchers and project coordinators). Additionally, we used minutes from a one-day stakeholder workshop which took place in both sub-projects in October 2021. For the secondary data we relied on various development indicators and published case studies in the field. The selection of indicators used is provided in the appendix (Table C 2). Some of these indicators may vary across regions of a country. However, we are using the indicators primarily to triangulate our qualitative data, which is context specific.

Several authors of this article are directly involved in the RUNRES project. The first author, who conducted the interviews, joined the project during the implementation phase as an observer, and was never involved in strategic decisions. Several of the authors of this article are part of the RUNRES project team, and were interviewed for this study. In the overview of interview partners, we mark the respective interviewees accordingly.

7.4 Results

First, we provide an overview of the effects the two cases achieved and identify the main differences between them. Second, we give an overview of the context factors which are different between the two cases, and show whether our data gives us insights in how the differences in a specific context factor relate to a difference in a specific effect. Finally, we go through the context factors in detail and describe how they influenced the projects, and hence the differences in the effects. Whenever we refer to a statement of an interviewee, we add the identification of the interviewee in brackets.

7.4.1 Differences in Effects

The two cases show similarities but mostly differences in the effects they achieve, which we present in Table 7-3. For the categories knowledge generation and the uptake in science, we found that both cases had issues with data quality and data collection. However, research

activities are coordinated across the cases, so we did not see any differences between the cases. As we are conducting a most similar system case study, our focus lies on the effect categories where we found differences between the cases, namely uptake practice, uptake policy, learning and social. Table 7-3 gives more details about the effect categories and illustrates the differences between the two cases.

Table 7-3 Aggregation of the effects the two cases scrutinized in this study. The structure is based on the effect categories from Pärli et al. (2022)

Effect Categories	Case Rwanda	Case DRC
Knowledge Generation	Knowledge generation is in general on-going, however, both cases face issues with data availability and quality. Research activities are coordinated across the countries. Thus, there are no differences between the two subprojects as results and data are shared.	
Uptake Practice	<ul style="list-style-type: none"> Expanding existing businesses in terms of scale and scope (e.g. cassava processing plant now also produces animal feed from cassava peels, additional site for black soldier fly production) (AS5-5, WS7-8) Animal feed innovations profitable (AS5-6) From compost piloting to mechanised composting and source sorting of the waste at household level. Compost production not yet profitable (WS7-8) Human waste pilots (AS8-9) Quality management of products and improvement through research support (AS5, Minutes Rwanda) 	<ul style="list-style-type: none"> Three waste valorisation innovations set-up and running (composting sites), but currently not profitable (WS1-6, AS1-2, Minutes DRC) Quality of waste sorting at source not yet satisfactory (WS1-6, WS9, Minutes DRC) Human waste pilots (WS1, WS6, AS2) Quality management of products and improvement through research support (WS9, AS1, Minutes DRC)
Uptake Policy	<ul style="list-style-type: none"> Active interest from local and national government (R3, AS5-9, Minutes Rwanda) Support for certification and permits (AS7-9) Government picked up cassava peel innovation and organized training for farmers and interested stakeholders (RAB, 2022) (AS6, R3) 	<ul style="list-style-type: none"> non observed (R1-2, WS3-4, Minutes DRC)
Uptake Science	First scientific publications (Sekabira et al., 2022; Wilde et al., 2021) are published. Research activities are coordinated across countries. Thus, we consider no differences between the two subprojects as results and data are shared.	
Learning	<ul style="list-style-type: none"> Technical capacity building (e.g. processing cassava peels) (AS6-9) 	<ul style="list-style-type: none"> Technical capacity building (composting) (WS1, WS9) Capacity building in business development (R1-2, WS1-3, WS5-6) Working in consortia as a learning experience (WS5-6, WS9) Idea of circular economy and waste valorisation (AS1-4, WS5, WS9) Working with international funders (WS5-6, WS9)
Social	<ul style="list-style-type: none"> Connection with new partners (AS5) 	<ul style="list-style-type: none"> Gained credibility by working with an international donor (WS5-6, WS9) Connections between agriculture and waste sector (R1-2, AS1-5, WS3-5)

With regard to the “Uptake in Practice” category, we find three major differences between the two cases: First, the type of innovations implemented is different. In Case Rwanda the project resulted in a broad portfolio of innovations including animal feed and compost as well as some piloting of human waste innovations. Case DRC focused mostly on the implementation of compost innovations, with one additional pilot of human waste. This difference is key, as the animal feed innovations show to be financially viable. Second, for Case Rwanda we observed that existing businesses were expanding in scope or scale. Examples are an existing cassava processing plant which now uses residues to produce profitable animal feed or the waste collection company which, based on some pilot trials with compost, introduced mechanized composting. For Case DRC the achievements were the set-up of three compost innovations led by one newly formed consortium consisting of different stakeholders each. Third, we find difference in the compost production. While for both cases, compost production is not financially viable at the time of data collection, in Case Rwanda compost production became partially mechanised during the project, while compost production in Case DRC is handled manually (WS7-9, WS1-6). Further, stakeholders from Case Rwanda stated that the source sorting was successfully adopted by households (WS7-8, R3), while the stakeholders from Case DRC reported that the quality of source sorting by households was insufficient (WS1-6, WS9, Minutes DRC).

Regarding “Uptake in Policy” we detected several effects related to uptake in policy for Case Rwanda. Stakeholders described the local municipality as very interested in and supportive of the innovations. Throughout the project implementation there was dialogue between the local municipality and the project (R3, AS8-9). The cassava peel innovation was even picked up by the national government. When learning about the interest in the product, they organised a training session for farmers to raise awareness (RAB, 2022). In contrast, at the time of data collection, stakeholders from Case DRC did not report about any effects related to uptake in policy.

For “Learning” we find that in Case DRC more learning effects were achieved including working together in a consortium and the idea of waste valorisation and circular economy. Many stakeholders involved in Case DRC stated that RUNRES was the first project they worked with who actually supported them in developing business ideas and actually implementing them (WS1-3, WS5-6). In Case Rwanda the stakeholders mostly emphasized “Learning” in terms of technical capacity building (AS6-9), business development was not specifically mentioned. For “Social” we find that while for Case Rwanda the project created some new relationships, for Case DRC the project facilitated the connection between the agriculture and the waste sector, which were almost not connected before (Späth et al., in preparation). Again, this is different for Case Rwanda, where already before the beginning of the project, there were connections between the two sectors (ibid). Additionally, only stakeholders from Case DRC described gaining experience with an international funder as a major achievement by many stakeholders (WS5-6, WS9).

7.4.2 Context factors

We identified the context factors for our cases based on our working model as shown in Figure 7-1 and Table 7-1. For the system conditions we included the waste and agriculture sector to explain the biophysical system in place and the public and private sector to explain the governance system in place. Regarding events, we found that Covid-19 was the only disruptive

event during the study period. For certain context factors we could not find any major difference between the cases. First, we did not find any difference regarding the research system in place, as both cases were implemented by regional offices of the International Institute of Tropical Agriculture (IITA). Further, we could not identify any differences in the action resources time, consensus, information, and personnel. Both cases had the same implementation timeline, faced similar delays due to fund disbursement (AS5, WS3, WS7, R2-3), and had high consensus for using treated waste for nutrient recycling (Sekabira et al., 2022). Access to appropriate labs posed a challenge for both cases. The team members and stakeholders in both cases had similar degrees of experience and know-how (R1-2). As our comparative case study approach focuses on differences in context factors, we did not consider these context factors further.

7.4.3 Relations between differing context factors and differing effects

In Table 7-4, we list the context factors and the effects that display differences between the cases. The columns of the table represent the effect categories with differences, while the rows correspond to the context factors that differ. Based on our most similar system design study, we have not included the contextual factors or effects that were the same across cases. Further, we indicate for which links between differing context factors and differing effects we found explanations in our data. In 7.4.4 - 7.4.13 we will go through all the context factors from Table 7-4 and show how they might explain differences in effects.

Table 7-4: Results for context factors and effects. The columns of this table represent the effect categories for which we found differences between the two cases. The rows represent the context factors with differences. A symbol "✓" in a cell indicates that our data gives explanations on how the difference in the context factor relates to the difference in effects.

	Differing Context Factors	Differing Effects				Comment
		Uptake Practice	Uptake Policy	Social	Learning	
System Conditions	Agriculture Sector	✓				
	Waste Sector	✓				
	Public Sector	✓	✓			
	Private Sector	✓			✓	
Events	Covid-19					No direct influence on effects, but influence on the project implementation in general
Action Resources	Financial Capital	✓				
	Political Support	✓	✓			
	Law	✓				
	Infrastructure	✓				
	Organization	✓		✓	✓	

7.4.4 System Conditions – Agriculture Sector

As indicated in the summary of our results in Table 7-4 we find differences in the agriculture sector of the two cases, which explain differences in the uptake in practice. These differences concern mostly livestock husbandry. Livestock husbandry in Rwanda commonly involves the use of animal feed, necessitating the importation of significant quantities of such feed. Unfortunately, Rwanda currently experiences a shortage of high-quality animal feed, resulting in elevated prices (Nkurunziza, 2022a, 2022b). Participants involved in animal feed innovation in Rwanda pointed out that the high prices of animal feed presented a business opportunity and inspired their interest in developing innovative solutions to address the shortage (AS5-6, Minutes Rwanda). Conversely, in the DRC, livestock are typically fed with grass and household waste (Munyahali et al., 2020). According to two interviewees the less widespread use of animal feed in the DRC, also influenced that no innovation in this field was developed through the transdisciplinary process (AS1). They stated, that the use of animal feed was just not really a topic (AS1-2). Overall, this difference in the agriculture sector explains the differences in the uptake in practice: namely, the high demand for animal feed drove the implementation of animal feed innovations in Rwanda, and concomitantly enhanced their financial viability.

7.4.5 System Conditions – Waste Sector

The current waste systems in the two case study regions show major differences, which can partially explain the differences in the uptake in practice (Table 7-4). Rwanda is considered as one of the cleanest countries in Sub-Saharan Africa (Kabera & Mutavu, 2022; Kabera et al., 2019). Waste collection is organized in public-private partnerships, and each company needs at least three collection trucks to qualify as a collector (RURA, 2021). Having a waste collector is mandatory in Rwanda, and all residents participate in monthly mandatory community service to keep the cities clean (Kabera et al., 2019; Rajashekar et al., 2019; Squire & Nkurunziza, 2022). In contrast, in Bukavu, the geographic focus of the case the DRC, an overarching waste management system is lacking (Cléophaçe et al., 2021; Solhjell, 2019). Private waste collection companies serve some areas of the city. In the interviews, the waste collectors stated that there was a low motivation to pay for the waste collection and there was limited awareness of the environmental and health problems related to the lack of waste management (WS2-5, AS1). Solhjell (2019) describes a similar pattern in her case study on the waste system in Bukavu. She states that in Bukavu waste was considered a “*public bad*” (p. 172) for which no one takes responsibility. Residents who are not using waste collection services are mostly depositing their waste in public places, in the lake, or in drainage channels (Solhjell, 2019). We assume that on the one hand, the absence of an overall waste management system makes it difficult for the waste collectors of the Case DRC to find enough customers to pay for their service. The more established waste evacuation-system in Rwanda on the other hand, might support the good waste sorting of the households, which in turn supports the compost innovation in Rwanda.

7.4.6 System Conditions – Public Sector

The public sector is more strongly developed for Case Rwanda than Case DRC, which we found to influence the uptake in policy. A well working public sector is also supporting general project implementation, through institutional structure, which is why we also link it to uptake in practice (Table 7-4). According to the World Bank's Worldwide Governance Indicators, the Government Effectiveness Indicator, which assesses the quality of public services, reveals a substantial disparity between the two countries. While DRC is on rank 3.85 out of 100 in 2021, Rwanda ranks 61.54

(Figure C 1, appendix). This was confirmed in the interviews. Several stakeholders of Case Rwanda stated, that processes, such as obtaining certifications for the products produced in their innovations were handled transparently and efficiently (R3, AS5-9, WS7-). Further, they stated that the local municipality was in general really interested in solutions which target existing needs of their inhabitants (AS5-9). Several respondents for Case DRC, on the other hand, opined that the government was ineffective, and has no authority, especially in the field of waste management (WS2-3, WS5, AS1, R1-2, Minutes DRC). Another respondent from Case DRC explicitly stated that the government was completely neglecting its responsibilities (R1).

7.4.7 System Conditions – Private Sector

We found a stronger development of the private sector in Case Rwanda than in Case DRC, which offers explanation for the differences in uptake of practice and learning effects (Table 7-4). In Rwanda, established businesses along the value chain already existed at the beginning of the project (R3, WS7-8, AS6). This is different for Case DRC, where private companies were active in waste collection and dumping, but not in recycling (WS4-6). A good indicator for the development of the private sector is the domestic credit to private sector indicator. This world bank indicator measures the share of credit to the private sector in % of the GDP. In 2020, this share was more than 5 times higher in Rwanda than in DRC, and a similar pattern can be observed since 2015 (Figure C 2, appendix). We suggest that this difference in the private sector development explains why Case Rwanda was able to build on existing businesses, while Case DRC had to start from scratch. Furthermore, interviewees stated that private sector stakeholders in DRC are used to receive funding in the form of donations from NGOs, but there are no projects which are trying to foster business spirit (R1-2). Another interviewee explained that in the DRC bad business climate, including high taxes, and bureaucratic hurdles, discouraged entrepreneurs (R2). Based on our data, we assume that due to the lower levels of private sector development Case DRC profited significantly from capacity building in the field of business development through the project, and consequently achieved more learning effects.

7.4.8 Events – Covid-19

The most notable shock during the study period was the Covid-19 pandemic, which we classify as a political and economic event. Based on our data, Case Rwanda was influenced much more by the pandemic, however, we could not relate that difference with differing effects (Table 7-4). Rwanda implemented several lockdowns, including curfews. Some stakeholders mentioned that they struggled to access the innovation sites (AS5-6, WS7-8, Minutes Rwanda). The waste collectors from Case Rwanda reported a decrease in organic waste during the Covid-19 pandemic, due to closed restaurants and hotels and the absence of tourists (WS7-8, Minutes Rwanda). The interviewees from Case DRC did not directly mention the influences of Covid-19, probably because there were less strict regulations but also because there are overall much fewer tourists in the region of Case DRC. Therefore, we assume that Case DRC did not face a substantial reduction in organic waste. In line with other scholars (Weible et al., 2020) we thus observe that the same event led to very different reactions of the government. While our evidence shows that the project implementation was clearly more affected in Case Rwanda, we cannot say whether without Covid-19 the differences in effects would be different between the two cases.

7.4.9 Action Resources – Financial Capital

We found that the stakeholders of the Case Rwanda have better access to the action resource financial capital than the stakeholders of Case DRC. Based on our data, we suggest that this mostly influenced the general project implementation and the uptake in practice. In general, both cases have received the same amount of funding to develop the project. The project funding was distributed equally between the sub-projects. However, the interviews showed that the same amount of financial capital has a different value in the two contexts. Interviewees from Case DRC (R1-2) stated that there are differences in the price levels between the two countries, and that project activities and the implementation innovations were costlier in DRC than Case Rwanda. Indeed, the Purchasing Power Parity conversion factor is higher in the DRC (0.5 in 2021) than in Rwanda (0.3 in 2021) (Figure C 3, appendix), although the price levels often differ according to regions. The fact that implementing the innovations is costlier in Case DRC might have caused hurdles for innovations there. Another point mentioned in the interviews is the overall access to funding. The amount of overall development assistance per person is approximately five times lower in the DRC compared to Rwanda (Figure C 4, appendix). The same holds for funding from philanthropic organizations (Figure C 4, appendix). This might have affected whether the stakeholders were able to find additional funding. The stakeholders of Case DRC stated that when sorting organic and non-organic waste, they should also be able to recycle the inorganic waste, but they have no additional funding or viable business model for that (WS3, WS6, Minutes DRC). Finding additional funding from other organizations might be more difficult for Case DRC stakeholders. One interviewee from Case DRC even stated that the idea to find other funders to support the innovations was naïve, as there are relatively few funders active in the region (AS1). We suggest that access to other financial capital, facilitates running the innovations and offers more flexibility and less dependability on the project funding. Further, we suggest that access to financial capital is also interlinked with other action resources, specifically with the availability of infrastructure. As shown in Table 7-3 in Case Rwanda compost making was partially mechanized, while this was not the case for Case DRC. This difference resulted from different initial conditions. The composting sites were newly established for Case DRC, while the stakeholder working on compost in Rwanda is an established business in waste collection and recycling. Thus, with the funding from the project, the compost innovation of Case Rwanda managed to install a partially mechanized procedure, which was not possible for the innovations in Case DRC.

7.4.10 Action Resource - Political Support

We found clearer political support for Case Rwanda than for Case DRC, and we suggest that this influenced the uptake in practice and policy (Table 7-4). All the interviewees involved in the innovations in Rwanda mentioned that the national government, but especially the municipality of the case study region, were supportive of the implementation of the innovations. As an example: the municipality provided the land for the composting site (WS7-8), and supported one animal feed innovation in finding appropriate land (AS5). Political support played an important role in that. According to an interviewee, high prices for animal feed were on the national government's agenda for a while (AS5-6, Minutes Rwanda). Getting to know the cassava peel project, the government supported a technical training to support the technique further. A stakeholder from Rwanda mentioned that it was easy for them to obtain construction permits for the toilets they are building because the municipality was involved in the project and already well-informed and interested in the project (AS7). Another interviewee (WS7) mentioned that the interest of the national government was crucial. If the government decided to invest more in waste-to-energy instead of nutrient

recycling innovations, that could change the level of support, and thus the prospect of the innovation. This interviewee emphasized in the Case Rwanda, being in line with the governmental interests was crucial (WS7). For Case DRC, the level of political support is much less clear. At the beginning of the project, the municipality connected the project team with the waste sector stakeholder (WS2-6, R2). As the RUNRES project team has a background in agriculture rather than waste, this connection with waste collectors through the municipality was important (R2). However, since the implementation of the innovations started, the level of support became unstable (R1-2) and fluctuations in the municipality's staff have made cooperation difficult (WS3, minutes DRC). An interviewee explained that the municipal authority at the time of research expected RUNRES to build a dumpsite, and lost interest after realizing that the project wanted to implement recycling innovations (R1-2). In general, the political support for waste collection in Bukavu is rather low (Solhjell, 2019): the municipality charges waste collectors 10% of the collection fee in return for a concession to collect waste from a certain area of town. One interviewee stated that the municipality does not see waste as a public sector task, but rather as an opportunity to gain money from the work of the private waste collectors (WS9). We thus observed that in Rwanda the interest of the government was aligned with the project, which in turn led to political support, and finally facilitated the implementation of innovations and the uptake in policy. In the DRC the project was not in line with interests of the municipal authority at the time of research. We assume that this misalignment also led to the fact that there has not yet been uptake in policy in the DRC.

7.4.11 Action Resource - Law

We found that Case Rwanda has more access to the action resource law, and that this access supported the effects related to uptake in practice (Table 7-4). In the World Bank's Worldwide Governance Indicators, Rwanda reaches higher ranks for the indicators "Rule of Law" (57.21 vs 3.85 in 2021) and "Regulatory Quality" (54.33 vs 6.73 in 2021) than the DRC (Figure C 1, appendix). The two indexes capture the degree to which the government formulates policies and regulations (Regulatory Quality) and the degree to which they are enforced (Rule of Law). This difference is clearly observable in the waste sector: in Rwanda, it is mandatory for households to have a subscription with a waste collector, and there are penalties in case of non-compliance (Kabera et al., 2019; Rajashekar et al., 2019; Squire & Nkurunziza, 2022). This is, of course, helpful for ensuring sufficient customers for the waste collection services for Case Rwanda. According to a respondent from Case Rwanda working in the waste sector, this mandatory waste service was also helpful for ensuring the high levels of commitment to waste separation, as the customers were already used to the collection services (WS8). Furthermore, we propose that other waste policies implemented in Rwanda supported the uptake of waste separation. One example is the nationwide ban on plastic bags, which has increased the general awareness for waste issues in Rwanda (Kabera et al., 2019). Conversely, there is a lack policy enforcement in the DRC: one stakeholder from Case DRC emphasized that there were indeed environmental laws, some even targeting waste management, but they are not enforced at all (WS3). Several waste stakeholders from Case DRC (WS1-4, WS9) stated that the lack of an enforced legal basis, makes it very hard for waste collectors to find clients who would pay for their services and are willing to sort the waste.

7.4.12 Action Resource - Infrastructure

We observed more developed infrastructure for Case Rwanda, and suggest that it influenced the uptake in practice (Table 7-4). First, we observed differences regarding the availability of land for

processing sites. For Case DRC, it was very difficult to find sites for compost production, as large part of the lands, especially close to the city, is owned by concessionaries (R1-2). The stakeholders had to install their composting sites far away from the city, which led to high fuel consumption and high costs for compost production (R1-2, Minutes DRC). In Case Rwanda, land availability was not a problem because the businesses either already had land or, in the case of composting, land was provided by the municipality. Second, we observed differences in the road quality. While the main roads are in good shape around Kamonyi, the roads between Bukavu and the composting sites are in poor shape. Especially during the rainy seasons, the sites are difficult to reach (WS6, Minutes DRC). Third, we found that waste collectors of Case Rwanda have their own trucks, while the waste collectors of Case DRC are renting them. Waste collectors report that renting the trucks leads to many uncertainties. They have to deal with changing prices and poor-quality trucks (WS2, WS5, WS9). Thus, overall, we find that more developed infrastructure facilitates running the innovations for case Rwanda and enabled them to expand their businesses.

7.4.13 Action Resource - Organization

We found that Case Rwanda is exhibiting stronger organizations than Case DRC, which influenced the uptake in practice, as well as the social and learning effects (Table 7-4). First, the organizations participating in Case Rwanda appear to have stronger external connections, as evidenced by their higher level of international engagement and familiarity with collaborating with international donors (WS7-8, AS5-8). Second, there is a difference in how well the organizations are connected with organizations from another sector. At the start of the project, the RUNRES researchers analyzed the relationships, and the information flow between stakeholders in the waste and agriculture sector (Späth et al., in preparation). For Case DRC, they discovered a strong divide between the two sectors, with little exchange between them. For Case Rwanda, they also found that the organizations are more often connected within their sector, but they also found established connections between them. We observe that stronger organizations supported the expanding of businesses in Case Rwanda. However, for Case DRC the less developed organizations offered room for learning and social effects, such as gaining experience with international funders or building a network between the agriculture and waste sectors. These effects were not considered new achievements for Case Rwanda. Conversely, many stakeholders from Case Rwanda (AS5-7, WS7-8) mentioned during the interviews that they already had experience with other international funders.

7.5 Discussion

Through this study, we found that the differences in the context factors can – at least partially – explain differences in “Uptake in Practice”, “Uptake in Policy”, “Social”, and “Learning”. Conversely, we did not find any substantial differences for effects related to knowledge production or uptake of knowledge in science. While both cases succeeded in the production of knowledge, they struggled with some data quality issues. We assume that for our cases, these effect categories were not affected by the differences in context. This might be due to the fact that the research activities in the larger project are strongly coordinated, or because relevant context factors such as the research system in place are similar for both cases. In this section, we bundle our results and first discuss how differences in context factors relate to differences in “Uptake in Practice” and “Uptake in Policy” and then to “Social” and “Learning”. Furthermore, we discuss the limitations of this study and suggest areas for further research.

7.5.1 Influence of Context Factors on “Uptake in Practice” and “Uptake in Policy”

The Case of Rwanda succeeded in scaling up existing businesses due to high demand for cheaper animal feed, well-connected businesses, and political support. With implementing animal feed innovations, Case Rwanda managed to have financially viable innovations. In contrast, Case DRC faced difficulties in creating new waste-valorization businesses due to a lack of established organizations, infrastructure, and financial capital, as well as insufficient government support and legal resources. This finding is in line with the literature on aid effectiveness, which shows that strong institutions and an efficient government are highly beneficial for the development and implementation of projects (Buntaine & Parks, 2013; Wambaka & Mutenyo, 2022). Our study suggests that context factors are important both when planning and evaluating a project. We found that, despite having similar effects related to research activities, the two cases showed considerable differences in the more practice-oriented effects due to context variations. Specifically, in our cases, we suggest that the set-up and implementation of innovations in Case DRC should be considered a notable achievement given the context factors, rather than seeing it as underperforming compared to Case Rwanda.

For Case Rwanda, we observed dialogue with and interest by policy makers and even some uptake in terms of supporting the dissemination of an innovation outside of the project. At the time of data collection, we could not find such evidence for Case DRC. The difference can be attributed to the varying levels of development in the public sector and political support. For Case Rwanda the project was in line with the national government’s agenda, while for Case DRC, political support became unstable when the project’s objectives no longer aligned with the government’s waste disposal vision. More generally and again in line with existing literature (Buntaine & Parks, 2013; Wambaka & Mutenyo, 2022), our findings indicate that higher levels of governmental efficiency supported the uptake in policy for Case Rwanda. However, we also find that more efficient governments can also lead to hurdles if their vision is not aligned with the aim of the project. Stakeholders from Case Rwanda fear that if the government decided to take another angle in waste policy (e.g., waste-to-energy), this change could compromise the project’s success. Thus, staying in contact with governmental actors and ensuring that the projects aims are in line with governmental interests seems a crucial component for fostering uptake in policy. Further, we find that there can be a re-enforcement between the effects of the project and political support. For Case Rwanda, the first results of the project (e.g., demand for animal feed ingredients, see section 7.4.10) strengthened the political support. This reinforcement between the context and the effects of projects is also often described by realist evaluation-scholars (De Souza, 2013; Pawson et al., 2004; Pawson et al., 1997). We propose that presenting tangible results and effectively communicating them early in a project can help garner political support. This highlights the importance of achieving some early successes that can be showcased.

7.5.2 Influence of context factors on “Learning” and “Social”

For Case DRC, a set of social and learning effects were achieved during project implementation, which are not new for Case Rwanda. We found that these differences are influenced by the fact that Case DRC has a less developed private sector and less established and connected organizations. In line with the idea of a reinforcement of effects and context in realist evaluation (De Souza, 2013; Pawson et al., 2004; Pawson et al., 1997), we found that these learning and social effects actually resulted in changes in context conditions. More specifically, we suggest that the project strengthened the action resource organization and the private sector development, which,

as we know from other parts of our analysis (see sections 7.4.7, 7.4.13), are crucial context factors when it comes to “Uptake in Practice”. Thus, even in cases where the context factors may not be directly favorable for effects related to uptake in practice (e.g. profitable innovations), progress can still be achieved by changing the context factors.

7.5.3 Limitations and Future Research

This study faces several limitations. First, context factors can change rapidly. By the time we are writing this article for example, upcoming elections in the DRC have opened certain windows of opportunities to gain political support for the innovations we observed in this study. As we conducted the interviews for this study before this new development, it remains an empirical question whether these changes in the context factors have an influence on the effects of Case DRC in the future. Second, we cannot fully exclude that the positionality of the authors of this article has influenced the results. Therefore, the evidence for causal influences of context factors on effects remains limited. However, two of the co-authors who contributed to data analysis were not involved in the project, which serves as a measure of validation. Third, based on our study design, our analysis focused on differences in context factors and effects. Thus, we cannot determine how context factors may have influenced the effects related to knowledge production and uptake in science, which were similar for both cases. This is particularly unfortunate because for example Schneider et al. (2022) have found that factors such as research institutions or “*Science–policy–society relations*” (p.2338) can influence the process of knowledge production. Finally, this was the first application of our working model of context factor. The working model was useful to identify the specific context factors which were different between the cases. However, we struggled sometimes to clearly distinguish between the context factors, especially as they are often also connected. Organizations with more experience in the field (action resource organization) might often come with more financial capital for example. The literature on action resources also emphasizes these interconnections and suggests that the effectiveness of action resources has to do with the strategic management of a portfolio of resources, rather than the sole reliance on one resource (Knoepfel, 2018).

We propose four areas for further research. First, we propose to further deepen our research and address the limitation that we did not consider the influence of the context factors which are similar between the cases. We propose to use realist evaluation to also assess how the similar context factors influenced the effects of the project. Second, future research could improve our working model of context factor by studying how it could best integrate interconnections between the different context factors. Third, we suggest to follow-up research from Schneider et al. (2022) by using realist evaluation to study how context factors influence the research process of TD projects such as the methods that are used or the form of collaboration. Thereby, we would adapt our working model by considering not only how the context influences the effects but also the process to achieve these effects. Forth, future research could focus on the variance of different context factors by conducting a large-N study across many different TD projects.

7.6 Conclusion

In this study, we investigated how different contextual factors influence the effects of TD projects. Our data suggest that having a strongly developed public and private sector, as well as access to a variety of action resources, supported the implementation of innovations and uptake in both practice and policy. During the TD project, the context factors changed, as the project addressed

gaps in action resources and weaknesses in private sector development, which created more favorable conditions, and thus contributed to learning and social effects.

Our proposed working model can be used to identify essential context factors for assessing whether an intervention or project can be successful in a certain context (Williams, 2020). For future TD projects focused on establishing financially viable waste valorization innovations with local businesses, we recommend choosing areas with a developed private sector and experienced stakeholders with access to other financial resources. However, even without these context factors, projects can tackle gaps to change context factors during project implementation and thus still achieve important effects such as connecting sectors, sparking business spirit, and disseminating ideas. Hence, an important insight arising from our analysis is that it is not always possible to create favorable context conditions at the outset of a project. Therefore, it seems important to take the roles of the context factors into consideration during project evaluation and thus identify potential context-specific factors that may influence project effects. Our results thus support the need for evaluators and funders of TD projects to have different expectations depending on the context in which the project takes place (Douthwaite et al., 2017; Jagosh, 2019; Pawson et al., 1997).

Identifying the context factors that affect a TD project is important (Lam et al., 2021). First, TD research aims to be context-specific, as the local context is crucial for generating knowledge and applicable solutions that address existing needs (Lam et al., 2021; Lux et al., 2019). Second, the high context-specificity of TD projects complicates the production of general knowledge beyond case knowledge (Adler et al., 2018; Nagy et al., 2020). Therefore, knowing the context conditions in which given effects appear is critical to formulating more needs-based and applicable solutions, as well as more general and transferable learnings. The working model and findings of this studies thus contribute to the growing body of literature on TD projects and provide important practical recommendations for future research and interventions.

8 Synthesis

The following synthesis is structured in three sections. First, I outline the contributions of this PhD thesis and present some recommendations for research and practice. Second, I describe the limitations of this thesis and suggest how future research could address these shortcomings.

8.1 Contributions and Recommendations

With the three scientific publications which resulted in this thesis, I answered the following overarching research question: *How do the design, implementation and context influence the effects of TD projects?* With this research question, I tackle two research gaps: the of effects TD projects can have, and how they are influenced by project characteristics (design, implementation and context). I describe how I answered this research question and address the two research gaps by outlining three overarching contributions of this thesis. Furthermore, I present a set of recommendations for each contribution.

8.1.1 Contribution 1: Describing General Patterns

With the first two publications I addressed all the elements of the research question by providing an overarching overview of the different effects of TD projects as well as the input, process, and context factors which affect them, based on empirical data drawn from over 100 cases. With this first contribution I thus also address both research gaps of this thesis. Providing this empiric overview and systematization is in line with the concept of quantitative description (Gerring, 2012) and the call for more descriptive empirical research (Besbris & Khan, 2017) as it enriches the stock of knowledge in a growing field of research. Regarding the variety of effects (Article 1), I contributed a structured overview of different effects that have been described already. Existing studies either focus mostly on social effects (Lux et al., 2019) or stay rather broad by distinguishing between societal and academic effects (Jahn et al., 2022; Newig et al., 2019). Based on Article 2, I summarized and categorized different factors regarding the design of the project (input), the implementation (process) and the context (institutions).¹²

Furthermore, I contribute to the body of literature that looks at interrelations or trade-offs and synergies between effects. This analysis is important, as the pathways to effects are rarely linear in TD projects (Muhonen et al., 2019; Schneider et al., 2019a). One finding was consistent across the different context analyzed in Article 1: the effects uptake of knowledge in practice, learning, and societal effects such as building relationships are often co-occurring. Thus, building trust, establishing networks, and providing learning opportunities seem key for the uptake of knowledge in practice. Furthermore, the patterns of co-occurrence of effects are also in line with the trade-off issues described by several other scholars (Chambers et al., 2021; Jahn et al., 2022): There is a disconnect between the production and the uptake of knowledge.

Also, the findings of Article 2 indicate that there are interactions between the design, the implementation, and the context factors. While overall the findings from Article 2 show that the implementation (process factors) are more often linked with effects than the other two dimensions, the implementation cannot always be chosen freely, as it is itself influenced by the design and

¹² As already described in section 3 I used a slightly different terminology in Article 2. However, the terms can be used synonymously.

context of the project. In the box below I present a set of recommendations based on this contribution.



Recommendations – Contribution 1

- ⇒ For strengthening the diverse effects of TD projects (Article 1), projects would benefit from an adaptive management approach or specific methodologies such as participatory tools or co-creation (Article 2).
- ⇒ Regarding implementation, the most influential factor is the quality of management (Article 2). I recommend investing in careful planning and project management by following, for example, the 10 reflective steps for making research societally relevant by Pohl et al. (2017).
- ⇒ Another guide helpful guide is the guide for transboundary research partnerships by the Swiss Commission for Research Partnerships with Developing Countries (KFPE). It offers 11 principles and 7 questions which are helpful to plan or reflect on TD projects. While their guide aims at transboundary research partnerships, I suggest that it can strengthen management in TD projects in general.
- ⇒ As there are interconnections between different effects (Article 1) as well as between the design, implementation and context dimension, I recommend being aware of the complexity of these interconnections early on.
- ⇒ A further important factor related to the design of TD projects is the motivation of researchers and stakeholders (Article 2). I recommend reflecting on the motivation for TD work individually, as well as within the TD project.

8.1.2 Contribution 2: The Role of the Context


Within this thesis, I analyzed the role of the context in TD projects in all the three publications. This second contribution is thus in line with the second research gap. First, I considered it in the large-N comparison in Article 1, where I compared TD projects in taking place in the global North with “North-South” TD projects. In Article 2, again a large-N study, I inductively developed different context categories which were influencing the effects of TD projects. Article 3 analysis the role of context factors with a most similar system design case study. It includes a comparative case study of two TD projects with many similarities in design and implementation, but with a very different context. Tackling the role of context on multiple levels is a crucial contribution to the current literature on TD research. Currently, many scholars agree that “context matters”, but there is very limited evidence on exactly how context can influence TD projects (Lam et al., 2021; Schneider et al., 2022)

With Article 1 I contribute to the literature on analysis of context by demonstrating that in projects with a different background and thus a different context in which the research is conducted, that difference can indeed lead to differences in effects, across more than 100 cases. The biggest contribution lies in an actual discussion of differences between cases with different contexts. Most existing studies to date tend to focus solely on cases implemented in the “Global North” (Newig et al., 2019) or only on cases in the “Global South” (Belcher et al., 2019). While there are some cases that integrate both types of cases (e.g. Chambers et al., 2021; Schneider et al., 2019a), they do not use a comparative approach. The findings from Article 1 indicate that there are differences between N-S and within North TD projects. N-S projects tend to focus more on societal effects, while North projects are better at producing tangible outputs such as academic publications. Further, N-S projects perform better at knowledge uptake in practice and policy, indicating that North projects can improve in this regard. Especially when addressing trade-off issues between societal and academic effects of TD projects (see contribution 1), this difference between North-South and “within North” projects becomes very interesting. TD projects with different contexts could profit from the different experiences in strengthening the effects that are not yet as prominent.

In-depth analysis of the influence of context factors (Article 3) shows that TD projects with virtually identical design and implementation but taking place in very different context can have very different effects. These findings clearly show that there is no one-size fits it all solution when it comes to TD projects, at least not when they are taking place in different contexts. This insight is in line with the core idea of realist evaluation, and a frequently discussed topic in international development (Williams, 2020). Also research focusing on TD projects shows similar results: Lux et al. (2019) for example find that identifying relevant context factors is key in order to make the transdisciplinary context-specific and thus relevant but also in order to assess whether a certain solution also works in other context. Further, Schneider et al. (2022) state that TD research needs to be very adaptive in its design in order to adapt to different local contexts. Nevertheless, I am not aware of similar comparative studies that zoom in on the isolated influences of different context factors with the same level of detail as mine does. The findings of Article 3 also show that context conditions can become more favorable through the work of TD projects, which emphasizes an important point to remember, namely, that throughout a project, context factors can change. This finding is important when it comes to realistic planning of TD projects, which should include an analysis of the relevant context factors, especially when it comes to evaluation.

The findings from Article 2 highlight the importance of two further context factors, which were not yet covered in Article 1 and 3: the funding circumstances and the academic system. The influence of the academic system is described as rather hindering for the effects of TD projects. Related to the discussions about changing roles and responsibilities of researchers, there seems to be a need for the academic system to adapt to the development in the way research is conducted (Guimarães et al., 2019; Sellberg et al., 2021). However, the academic system in place might again be dependent on other context factors. For instance, Schneider et al. (2022) found that research institutions involved in different TD projects vary strongly in the way they are structured and their “*dominant epistemological values*” (p.2338). This, in turn, influenced the manner in which co-production is carried out in TD projects.

The findings regarding funding circumstances indicate that funding can support but also hinder the achievement of effects, and furthermore, *a priori* influences the design and the implementation of the project. This insight is in line with the findings from other scholars, who also find that research funders often shape TD projects (Jahn et al., 2022; Lux et al., 2019). Overall, I suggest that it is important that research funders become aware of their influence on projects. It is promising that a shift towards this type of awareness is already happening to some degree. As mentioned in the introduction, the Swiss National Science Foundation (SNSF) just commissioned a report about their role in achieving social innovations. The report also includes a set of recommendations from researchers to SNFS (Schuch, 2023). For this contribution, too, I have formulated a number of recommendations in the box below.

 Recommendations – Contribution 2
<ul style="list-style-type: none">• TD projects in the global North and TD projects within North-South research projects have a different context and take place in different contexts (Article 1). I suggest that the two research fields and communities could increase coordination and exchange to enable mutual learning.• For researchers, I recommend taking the context into account when planning, as well as when reflecting about projects they are involved in (Article 3). I suggest to 1) not only consider broad context categories such as “socio-economic” or “political factors” but to also be more specific and 2) to think through how the context condition could influence their projects.• For research funders, I recommend supporting and or even requesting context studies as part of proposals. Furthermore, the influence of context on a project should be taken into account in an eventual project evaluation (Article 3).• For research funders, I also recommend that they continue working on alternative success measures for research projects, ones that go beyond publications (Article 2 and 3).

8.1.3 Contribution 3: Heuristics to Analyze TD Projects

In addition to their contribution to current research, Article 2 and 3 also each propose a heuristic to analyze or plan a TD project. In Article 2, I identified broad sets of different factors related to the design, the implementation and the context of TD projects, and analyzed how they influence their effects. This set of factors and how they relate to different effects can be helpful tools for reflecting on ongoing or past TD projects, and especially for collecting different perspectives on a project (junior vs. senior researcher, researcher vs. stakeholder, etcetera). Based on the findings of Article 2 I summarized and categorized different factors regarding the design of the project (input), the implementation (process) and the context in Table 8-1. I used the structure presented in Table 8-1, including as an interview framework for further research which is not part of this thesis. More concretely I used it to collect different perspectives the factors that influence different effects of TD projects. While I did not do a systematic assessment of the framework, many interviewees found the framework a helpful tool to reflect upon the project process. In general, frameworks or heuristics which can be used to include diverse perspectives in planning or evaluating TD projects are described as very helpful (Deutsch et al., 2021). Furthermore, the different factors and categories presented in Table 8-1 can serve as a basis for future research, for example, to assess the influence of one specific factor in detail.

Table 8-1 Overview Characteristics of TD projects that can influence their effects, based on Article 2

Design	Content & Composition	Individual Attributes	Social Network Structure & Community Attributes
	Structure of Team	Motivation for TD	Knowledge Brokerage & Reputation
	Interdisciplinarity	Qualifications & Skills	Shared Values & Understanding
	Transnational Cooperation	Resources of Stakeholders	Power Distribution
	Diversity of Team		Defined Responsibilities
	Involvement of Students		Previous Contact & Experience
Implementation	Strategies	Methods	Quality
	Safe Space & Privacy	Co-creation	Degree of Collaboration
	Informal Exchange	Participatory Tools	Quality of Communication
	Contracts & Incentives	Training	Quality of Management & Planning
	Emphasizing	Stakeholder-Led Activities & Monitoring	Available Time & Efficiency
	Adaptive Management		Translation
	Visualization of Information		Transparency
Context	Formal	Informal	
	Administration	Existing conflicts	
	Funding	Academic Culture	
	Political & Economic Priorities	Cultural Norms & Differences	

In Article 3, I present a working model for context factors, which is based on different existing and established frameworks. Figure 8-1 shows the corresponding model again. This working model for context factors could be used to identify which context factors could affect a TD project. With the exception of Schneider et al. (2022) there is limited work on contextualizing context in TD projects. I have not tested this framework on projects other than the ones in this publication, nor have I tried to use the model in a more participatory process. However, I assume that the framework could be helpful as early as in a planning phase of a project. It could be used to identify the available action resources, the favorable system conditions but also the conditions which are less favorable, and which should be specifically targeted within a project. It is important to note, that there are some overlaps between the framework presented in Table 8-1 and the working model on context factors in Figure 8-1 (e.g., both include context factors). However, both have a different background and scope and I do consider them as two separate heuristics.

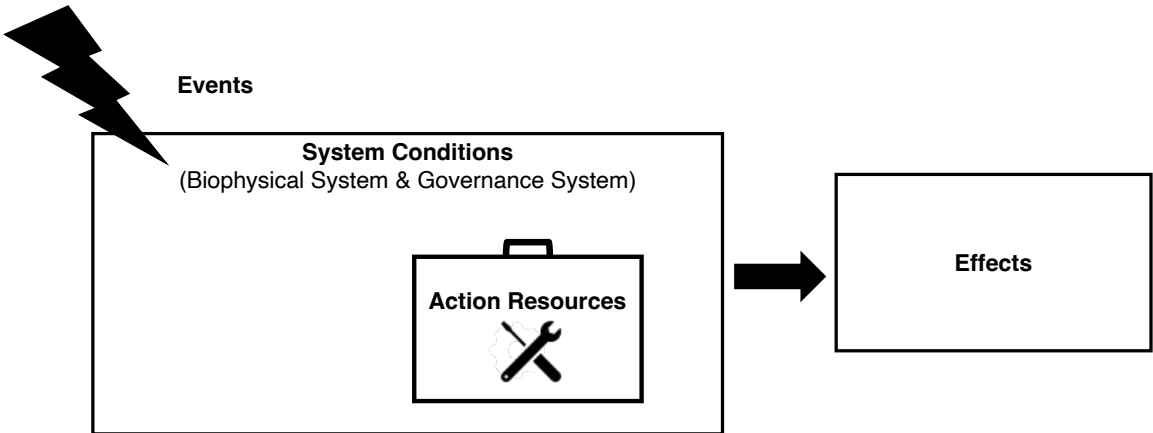


Figure 8-1 Context working model, based on Article 3

Of course, there are already frameworks from other fields which help to characterize the context. One example is the PESTLE framework which was designed to identify the political, economic, social, technical, legal and environmental components of a business or a project (Rastogi & Trivedi, 2016; Sobhani et al., 2020) . Nevertheless, the PESTLE analysis and similar tools often stay very broad, whereas the working model I propose, while by no means perfect, offers a more granular tool for identifying important context factors.

8.2 Limitations and Future Research

8.2.1 No Comparison with non-TD Research

A first limitation of this thesis is that I did not conduct any comparison between TD and non-TD research. The purpose of my research was to explore the potential benefits and challenges of transdisciplinary research and to understand how it works in practice. The strength of qualitative research, which is the research direction I adhere to here, lies in its ability to generate insights and understanding of complex and messy phenomena, rather than isolating the effects of certain variables through control groups (Robson, 2002). However, while, I did not intend to compare TD with non-TD research in this thesis, I do think that assessing their differences in terms of knowledge production but especially also regarding their potential in knowledge uptake is highly relevant. There are scholars who have already conducted excellent research on comparing TD and non-TD projects with a more variance-based approach, for instance Newig et al. (2019) or Jahn et al. (2022).

For future research, I suggest exploring the mechanisms behind the trade-off issue, namely, that TD research has more societal impact and non-TD research has more academic impact. Such a study could, for example, apply a most similar system case study approach to compare a TD with a non-TD project (e.g., interdisciplinary project but without stakeholder integration). However, I assume that finding fitting cases could be difficult.

8.2.2 No Specific Analysis of Methods and Tools

A second limitation concerns the depth of the conducted research. During the work on this thesis, I needed to determine the appropriate level at which to approach my research question. In Articles 1 and 2, my focus was on synthesizing and categorizing existing evidence, which resulted in a rather general approach. Consequently, I found it challenging to give specific recommendations on how TD projects could be conducted more effectively in the future. Although I discovered some general patterns, such as the importance of adaptive management, I did not explore the efficacy of different methods, tools, and strategies. Based on the theoretical framework of my thesis and the findings from Article 2, I suggest that the methods employed in a TD project are just one aspect of what makes such a project successful. Nevertheless, I propose that there is significant potential for future research in this area, including testing the effectiveness of various workshop formats and engagement strategies. To accomplish this, drawing from existing research in organizational behavior or team sciences could be useful. For instance, a study by Hoever et al. (2012) found that perspective taking was key to unlocking the potential of a diverse team. In an experimental setting, simple perspective-taking exercises could boost the creative performance of highly diverse teams. As TD projects frequently involve diverse stakeholders working together to develop innovative solutions, similar research could be valuable.

8.2.3 Time Frame and Scope of Analysis

A third limitation of this thesis is the relatively short timeframe during which TD projects were examined, and the fact that I did not specifically observe processes over time. The analysis of Articles 1 and 2 are based on publications about TD projects. This means that the data set consisted of projects with varying durations, but also that the length of observation was varying. For Article 3, where I directly observed a TD project, I was only involved in the project during one part of the implementation process (for around 18 months). This is certainly not ideal, as for example for accompanying research, as introduced in section 1.2, Defila and Di Giulio (2018)

propose that the accompanying research should start as early as the project and last potentially longer than the actual project. While I used the interviews and project documentation to get insights about what happened before my involvement with the project, I cannot claim to cover a temporal dimension. I specifically discuss this limitation in the discussion section of Article 3, where I describe how quickly context conditions can change, and that I could not include all the changes in context factor in the analysis. Overall, TD projects involve nonlinear processes with manifold and interconnected effects that may be contingent on different contexts, and thus the short timeframe may not fully capture the long-term effects of these projects. There is some research on TD programs which were running for ten years and longer. Examples include an analysis of knowledge utilization within a 10-year research for development program by Jacobi et al. (2020) or the synthesis report of a transdisciplinary research and education program in plant science (Dahinden et al., 2021). However, even these longer-term evaluations do not cover the degree to which effects of TD projects sustain once the project is over. To my knowledge, this issue remains an open and understudied question. For future research, I suggest focusing on projects which have been completed for some time, and to explore long-term effects and the durability of TD projects.

8.3 Concluding Remarks

TD integrates different disciplines but also non-academic stakeholders in the research process (Lang et al., 2012). It is described as an important research approach in order to tackle complex and multifaceted sustainability challenges. TD is still a rather new approach and there are many open questions regarding the effects as well as the project characteristics which influence them (Belcher et al., 2016). There is a growing body of literature, including this thesis, which focuses on these questions by considering TD projects and programs as field of inquiry (Lawrence et al., 2022).

This thesis contributes to the understanding of the plurality of effects that TD projects can have and how these effects are interconnected. Moreover, this thesis offers an empirical overview of the different characteristics - more specifically different factors related to the design, implementation, and context of TD projects - that can influence the effects of TD projects. By providing an empirical collection of different effects and characteristics of TD projects, this thesis provides heuristics for reflecting on and planning future TD projects, as well as structures for future research. Additionally, this thesis emphasizes the role of context in TD projects. It demonstrates that two TD projects with very similar designs and implementation can have very different effects when taking place in different contexts. Therefore, there is a need for more in-depth analysis of relevant context factors that go beyond merely stating that "context matters" (Williams, 2020), but instead examines which specific context factors matter and how they affect a project. This is essential not only for researchers but also for research funders, particularly when evaluating projects.

Moreover, I also provide ideas for future research and suggest the following three steps: First, comparing TD research approaches with other, less participatory approaches especially in terms of their potential regarding knowledge production and uptake thereof; second, assessing the effectiveness of different methods and formats used in implementing projects; and third, accompanying TD projects over a longer period in order to study changes over time.

Appendix

A Appendix Article 1

Table A 1 Overview cases

Case	North-South vs. North	Topic	Reference
1-4	North	Agriculture/Fisheries	Wiek A, Harlow J, Melnick R, van der Leeuw S, Fukushi K, Takeuchi K, Farioli F, Yamba F, Blake A, Geiger C, et al.: Sustainability science in action: a review of the state of the field through case studies on disaster recovery, bioenergy, and precautionary purchasing. <i>Sustainability Science</i> 2015, 10:17-31.
5	North	Sustainable Land Management	Weiss G, Steiner R, Eckmüllner O: Assessing institutional frameworks of inter-and transdisciplinary research and education. <i>Higher Education Policy</i> 2011, 24:499-516.
6	North	Urban Planning/Sustainable Cities	Wang B-C, Chou F-Y, Lee Y-J: Awareness of Residents Regarding the Construction of a Sustainable Urban Community: A Case Study of Action Research in Taiwan. <i>Systemic Practice and Action Research</i> 2010, 23:157-172.
7	North	Agriculture/Fisheries	Stephenson RL, Wiber M, Paul S, Angel E, Benson A, Charles A, Chouinard O, Edwards D, Foley P, Lane D: Integrating diverse objectives for sustainable fisheries in Canada. <i>Canadian Journal of Fisheries and Aquatic Sciences</i> 2019, 76:480-496.
8	North	Climate Change	Siebenhüner B: Conflicts in transdisciplinary research: reviewing literature and analysing a case of climate adaptation in Northwestern Germany. <i>Ecological Economics</i> 2018, 154:117-127.
9	North	Urban Planning/Sustainable Cities	Sharp D, Salter R: Direct Impacts of an Urban Living Lab from the Participants' Perspective: Livewell Yarra. <i>Sustainability</i> 2017, 9:1699.
10	North	Agriculture/Fisheries	Schodl K, Leeb C, Winckler C: Developing science–industry collaborations into a transdisciplinary process: a case study on improving sustainability of pork production. <i>Sustainability Science</i> 2015, 10:639-651.
11	North	Water & Sanitation	Schneider F, Bonriposi M, Graefe O, Herweg K, Homewood C, Huss M, Kauzlaric M, Liniger H, Rey E, Reynard E: MontanAqua: tackling water stress in the Alps: water management options in the Crans-Montana-Sierre Region (Valais). <i>GAIA-Ecological Perspectives for Science and Society</i> 2016, 25:191-193.
12	North	Climate Change	Schikowitz A: Creating relevant knowledge in transdisciplinary research projects - Coping with inherent tensions. <i>Journal of Responsible Innovation</i> 2020, 7:217-237.

13 - 14	North	Urban Planning/Sustainable Cities	Schäpke N, Omann I, Wittmayer JM, Van Steenbergen F, Mock M: Linking Transitions to Sustainability: A Study of the Societal Effects of Transition Management. <i>Sustainability</i> 2017, 9:737.
15	North	Diverse/other	Ruppert-Winkel C, Arlinghaus R, Deppisch S, Eisenack K, Gottschlich D, Hirschl B, Matzdorf B, Mölders T, Padmanabhan M, Selbmann K, et al.: Characteristics, emerging needs, and challenges of transdisciplinary sustainability science
16 - 20	North	Urban Planning/Sustainable Cities	Polk M: Achieving the promise of transdisciplinarity: a critical exploration of the relationship between transdisciplinary research and societal problem solving. <i>Sustainability Science</i> 2014, 9:439-451.
21	North	Urban Planning/Sustainable Cities	Perrotti D: Evaluating urban metabolism assessment methods and knowledge transfer between scientists and practitioners: A combined framework for supporting practice-relevant research. <i>Environment and Planning B: Urban Analytics and City Science</i> 2019, 46:1458-1479.
22	North	Agriculture/Fisheries	Nguyen TPL, Seddaiu G, Roggero PP: Hybrid knowledge for understanding complex agri-environmental issues: nitrate pollution in Italy. <i>InterNorth Journal of Agricultural Sustainability</i> 2014, 12:164-182.
23	North	Diverse/other	Newig J, Jahn S, Lang DJ, Kahle J, Bergmann M: Linking modes of research to their scientific and societal outcomes. Evidence from 81 sustainability-oriented research projects. <i>Environmental Science & Policy</i> 2019, 101:147-155.
24	North-South	Water & Sanitation	Leimona B, Lusiana B, van Noordwijk M, Mulyoutami E, Ekadinata A, Amaruzaman S: Boundary work: Knowledge co-production for negotiating payment for watershed services in Indonesia. <i>Ecosystem Services</i> 2015, 15:45-62.
25	North	Agriculture/Fisheries	Kawabe M, Kohno H, Ikeda R, Ishimaru T, Baba O, Horimoto N, Kanda J, Matsuyam M, Moteki M, Oshima Y: Developing partnerships with the community for coastal ESD. <i>InterNorth Journal of Sustainability in Higher Education</i> 2013.
26	North	Diverse/other	Kassab O, Schwarzenbach RP, Gotsch N: Assessing ten years of inter-and transdisciplinary research, education, and outreach: The Competence Center Environment and Sustainability (CCES) of the ETH Domain. <i>GAIA-Ecological Perspectives for Science and Society</i> 2018, 27:226-234.
27	North	Energy	Jansujwicz JS, Johnson TR: The Maine Tidal Power Initiative: transdisciplinary sustainability science research for the responsible development of tidal power. <i>Sustainability Science</i> 2015, 10:75-86.
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60	North-South	Agriculture/Fisheries	Trimble M, Plummer R: Participatory evaluation for adaptive co-management of social-ecological systems: a transdisciplinary research approach. Sustainability Science 2019, 14:1091-1103.
61	North-South	Energy; Urban Planning/Sustainable Cities	Thomas S, Richter M, Lestari W, Prabawaningtyas S, Anggoro Y, Kuntoadji I: Transdisciplinary research methods in community energy development and governance in Indonesia: Insights for sustainability science. Energy Research & Social Science 2018, 45:184-194.
62-66	North-South	Energy	Tejada G, Cracco M, Bouleau CR, Bolay J-C, Hostettler S: Testing Analytical Frameworks in Transdisciplinary

			Research for Sustainable Development. Sustainability 2019, 11:4343.
67	North-South	Sustainable Resources	Taylor PL, Cronkleton P, Barry D: Learning in the Field: Using Community Self Studies to Strengthen Forest-Based Social Movements. Sustainable Development 2013, 21:209-223.
68-71	North-South	Sustainable Land Management;Water/Sanitation	Siew TF, Aenis T, Spangenberg JH, Nauditt A, Döll P, Frank SK, Ribbe L, Rodriguez-Labajos B, Rumbaer C, Settele J, et al.: Transdisciplinary research in support of land and water management in China and Southeast Asia: evaluation of four research projects. Sustainability Science 2016, 11:813-829.
72-73	North-South	Urban Planning/Sustainable Cities	Seymoar N-K, Ballantyne E, Pearson CJ: Empowering residents and improving governance in low income communities through urban greening. InterNorth Journal of Agricultural Sustainability 2010, 8:26-39.
74	North-South	Diverse/other	Schneider F, Giger M, Harari N, Moser S, Oberlack C, Providoli I, Schmid L, Tribaldos T, Zimmermann A: Transdisciplinary co-production of knowledge and sustainability transformations: Three generic mechanisms of impact generation. Environmental Science & Policy 2019, 102:26-35.
75	North-South	ICT	Sarrica M, Denison T, Stillman L, Chakraborty T, Auvi P: "What do others think?" An emic approach to participatory action research in Bangladesh. AI & SOCIETY 2019, 34:495-508.
76	North-South	Sustainable Resources	Ruankaew N, Le Page C, Dumrongrojwattana P, Barnaud C, Gajasen N, van Paassen A, Trébuil G: Companion modelling for integrated renewable resource management: a new collaborative approach to create common values for sustainable development. InterNorth Journal of Sustainable Development & World Ecology 2010, 17:15-23.
77-78	North-South	Sustainable Land Management	Roux DJ, Nel JL, Cundill G, O'Farrell P, Fabricius C: Transdisciplinary research for systemic change: who to learn with, what to learn about and how to learn. Sustainability Science 2017, 12:711-726.
79	North-South	Sustainable Land Management	Rodriguez Lopez JM, Tielbörger K, Claus C, Fröhlich C, Gramberger M, Scheffran J: A Transdisciplinary Approach to Identifying Transboundary Tipping Points in a Contentious Area: Experiences from across the Jordan River Region. Sustainability 2019, 11:1184.
80	North-South	Agriculture/Fisheries	Restrepo MJ, Lelea MA, Kaufmann BA: Assessing the quality of collaboration in transdisciplinary sustainability research: Farmers' enthusiasm to work together for the reduction of post-harvest dairy losses in Kenya. Environmental Science & Policy 2020, 105:1-10.
81	North-South	Diverse/other	Oyinlola M, Whitehead T, Abuzeinab A, Adefila A, Akinola Y, Anafi F, Farukh F, Jegede O, Kandam K, Kim B, et al.: Bottle house: A case study of transdisciplinary research for

			tackling global challenges. <i>Habitat InterNorth</i> 2018, 79:18-29.
82	North-South	Agriculture/Fisheries	Neef A: Fostering Incentive-Based Policies and Partnerships for Integrated Watershed Management in the Southeast Asian Uplands. <i>Southeast Asian Studies</i> 2012, 1:247-271.
83	North-South	Water & Sanitation	Maheshwari B, Varua M, Ward J, Packham R, Chinnasamy P, Dashora Y, Dave S, Soni P, Dillon P, Purohit R, et al.: The Role of Transdisciplinary Approach and Community Participation in Village Scale Groundwater Management: Insights from Gujarat and Rajasthan, India. <i>Water</i> 2014, 6:3386-3408.
84-85	North-South	Urban Planning/Sustainable Cities	Marshall F, Dolley J, Priya R: Transdisciplinary research as transformative space making for sustainability. <i>Ecology and Society</i> 2018, 23.
86	North-South	Sustainable Land Management	Lund S, Banta GT, Bunting SW: Applying stakeholder Delphi techniques for planning sustainable use of aquatic resources: experiences from upland China, India and Vietnam. <i>Sustainability of Water Quality and Ecology</i> 2014, 3:14-24.
87	North-South	Agriculture/Fisheries	Jagustović R, Zougmore RB, Kessler A, Ritsema CJ, Keesstra S, Reynolds M: Contribution of systems thinking and complex adaptive system attributes to sustainable food production: Example from a climate-smart village. <i>Agricultural systems</i> 2019, 171:65-75.
88	North-South	Diverse/other	Jacobi J, Llanque A, Bieri S, Birachi E, Cochard R, Chauvin ND, Diebold C, Eschen R, Frossard E, Guillaume T: Utilization of research knowledge in sustainable development pathways: insights from a transdisciplinary research-for-development programme. <i>Environmental science & policy</i> 2020, 103:21-29.
89	North-South	Diverse/other	Eitzel M, Hove EM, Solera J, Madzoro S, Changarara A, Ndlovu D, Chirindira A, Ndlovu A, Gwatipedza S, Mhizha M: Sustainable development as successful technology transfer: Empowerment through teaching, learning, and using digital participatory mapping techniques in Mazvihwa, Zimbabwe. <i>Development Engineering</i> 2018, 3:196-208.
90-91	North-South	Agriculture/Fisheries	Douthwaite B, Hoffecker E: Towards a complexity-aware theory of change for participatory research programs working within agricultural innovation systems. <i>Agricultural systems</i> 2017, 155:88-102.
92	North-South	Agriculture/Fisheries	Davies J, Maru Y, Hall A, Abdourhamane IK, Adegbidi A, Carberry P, Dorai K, Ennin SA, Etwire PM, McMillan L: Understanding innovation platform effectiveness through experiences from west and central Africa. <i>Agricultural Systems</i> 2018, 165:321-334.
93	North-South	Agriculture/Fisheries	Dangles O, Carpio F, Villares M, Yumisaca F, Liger B, Rebaudo F, Silvain J-F: Community-based participatory research helps farmers and scientists to manage invasive pests in the Ecuadorian Andes. <i>Ambio</i> 2010, 39:325-335.

94	North-South	Agriculture/Fisheries	Brent L: Participation and Compliance in Tension: Developing Women-led Yarn Spinning Businesses in Tajikistan. <i>The Journal of Development Studies</i> 2020, 56:1295-1308.
95	North-South	Water & Sanitation	Brennan M, Rondón-Sulbarán J: Transdisciplinary research: Exploring impact, knowledge and quality in the early stages of a sustainable development project. <i>World Development</i> 2019, 122:481-491.
96-100	North-South	Agriculture/Fisheries	Belcher BM, Claus R, Davel R, Ramirez LF: Linking transdisciplinary research characteristics and quality to effectiveness: A comparative analysis of five research-for-development projects. <i>Environmental Science & Policy</i> 2019, 101:192-203.
101	North-South	Energy	Ambole A, Musango JK, Buyana K, Ogot M, Anditi C, Mwau B, Kovacic Z, Smit S, Lwasa S, Nsangi G: Mediating household energy transitions through co-design in urban Kenya, Uganda and South Africa. <i>Energy Research & Social Science</i> 2019, 55:208-217.

Table A 2 This table gives an example of a text excerpt for each effect.

	Effect (Abbreviation)	Example text excerpt	Reference
Knowledge Production	System knowledge (K_System)	The application of the Mode 2 research approach through the integration of a participatory process into biophysical studies provided added value for a more comprehensive understanding of the nitrate issue, by taking into account a wider range of factors that influence management decisions and practices in inter-dependent farms. We argue that such an understanding couldnot emerge from just the experimental results and the transfer of information from scientists to others.	(Nguyen et al., 2014)
	Target knowledge (K_Target)	When modelling the future, the research team considered regional climatescenarios as well as four scenarios – derivedfrom collaboration with regional stakeholders of possible societal and economic development.	(Schneider & Rist, 2014)
	Transformation knowledge (K_Transform)	Due to the participatory approach, research findings were translated into management practice. Community foresters now call every resident after tree delivery, and automated emails send seasonal tree care tips; such follow-up communication was previously resident-driven and infrequent.	(Campbell et al., 2016)
Uptake of Knowledge	Uptake in Practice (Uptake_Pr)	Both communities developed and implemented their Green Plans to create productive green spaces, including community gardens, shade trees and the planting of 20 new local species.	(Seymoar et al., 2010)
	Uptake in Policy (Uptake_Po)	the initiation of a process by which tribal governments in Maine and the U.S. Department of Agriculture Animal and Plant Health Inspection Service (USDA-APHIS) can develop a memorandum of understanding to ensure quick and collaborative responses to infestations.	(Hart et al., 2015)

	Uptake in Science (Uptake_S)	Stakeholder engagement advances scientific discovery by incorporating stakeholder knowledge and questions into scientific studies in a way that research teams would not have done alone. Stakeholders provided feedback on questions, model parameter assumptions, output metrics, modelling scenarios and interpretations in WW2100.	(Ferguson et al., 2018)
	Change in practices (Change)	After learning new cause–effect relations from their experiments, farmers changed their practices. As such, monitoring activities served to sustain enthusiasm as farmers noticed positive progress.	(Restrepo et al., 2020)
	Sustainability of project (Sust)	In all three projects, there have been benefits to the community that have been sustained over time. As noted, the Bangkok communities are still working on environment issues together eight years later due to the combination of a growing grassroots culture of environmental concern, support from the national environmental NGO and municipal funding.	(Seymoar et al., 2010)
	Transfer of results (Transfer)	This knowledge was also used to establish water governance systems at different levels (i.e. village level, communities surrounding the lake, and the nagari forum in Singkarak; a community forestry scheme at the watershed level and conditional corporate social responsibility by the HEP company in the riparian zone in Sumberjaya)	(Leimona et al., 2015)
Products	Academic Outputs (O_Academic)	In terms of output the project has produced a set of desk-studies to increase theoretical grounding and integrate previous research around social sustainability. Project participants have disseminated and discussed project results at several workshops and external conferences.	(Hansson & Polk, 2018)
	Outreach Outputs (O_Outreach)	This work also helped create revised ordinances that account for a changing climate, as well as education materials to improve citizen-level stewardship.	(Hart et al., 2015)
Learning	Problem awareness (Prob_Awar)	Dairy farmers could relate to the risk that toxic cyanobacteria pose to their cows and hence the dangers associated with nutrient enrichment of farm dams. It was also rewarding to learn that, following one of the dialogues, a farmer had sourced further reading on the tragedy of the commons and that the concept has helped him to better understand social–ecological challenges in the area.	(Roux et al., 2017)
	Capacity Building (Capacity_A;Capacity_S)	Other positive effects were the opportunity for young researchers to gain confidence and experience through repeated meetings with the project group, including opportunities to collaborate with practitioners and gain support from senior researcher.	(Brink et al., 2018)
Societal Effects	Building trust (Trust)	A general characteristic of both case studies was that scientists respectfully and empathetically listened to their transdisciplinary learning partners. Such listening helped to remove social distance and build trust among participants.	(Roux et al., 2017)
	Networks & Relationships (Network)	At NGLinfra, the interactions with practitioners have helped to improve the relevance of the research capacity and to develop a cross-sectoral network. This network has continued to exist after the programme ended. Six practitioners have initiated a follow-up programme and	(Hessels et al., 2018)

		there are still follow-up projects outside the programme with funding from other schemes.	
Inclusion (Inclusion)		Farmers developed their own trials to test practices to improve milk quality and to buffer seasonality based on different feeding strategies. Fig. 1a shows a high percentage of participation, whereby farmers had the freedom to decide what they wanted to test. On average, 75 % of the farmers participated in the farmer-led experimentations, and 90 % in the monitoring activities. This created a sense of ownership of the process of experimenting that also contributed toward sustaining their autonomy.	(Restrepo et al., 2020)

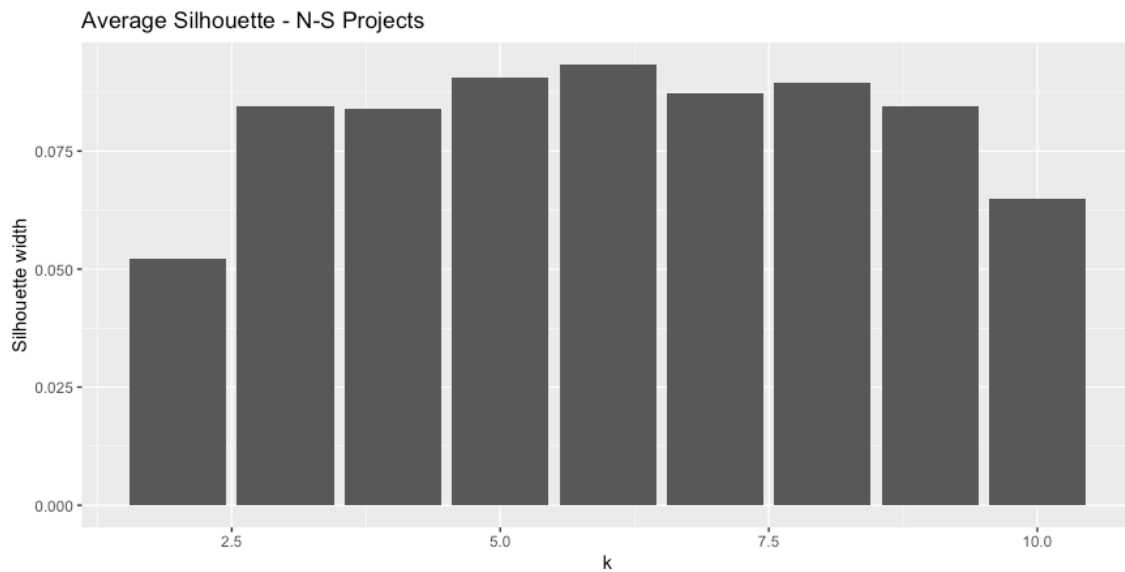


Figure A 1 Average Silhouette plot for N-S Projects. According to the plot, the ideal number of clusters is 6.

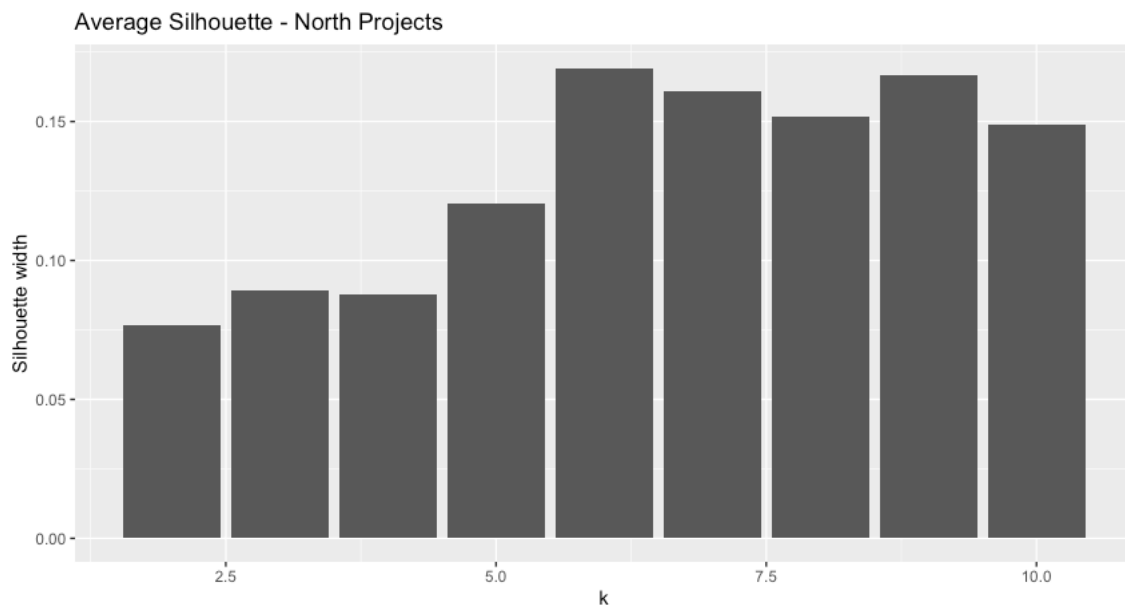


Figure A 2 Average Silhouette plot for N projects. According to the plot, the ideal number of clusters is 6.

B Appendix Article 2

Table B 1 Overview first deductively developed categories of effects, input, process and institutional factors

Effects	Input	Process	Institutions
Knowledge Generation	Stakeholders Involved	Quality	Formal
Uptake of Knowledge	Disciplines Involved	Methods	Informal
Learning	Networks & Social Structure	Strategies	
Social	Individual Attributes		
	Community Attributes		

Table B 2 Overview of the cases used for the analysis

Case	Topic	Reference
1-5	diverse	Wiek A, Ness B, Schweizer-Ries P, Brand FS, Farioli F: From complex systems analysis to transformational change: a comparative appraisal of sustainability science projects. <i>Sustainability science</i> 2012, 7:5-24.
6	Sustainable Land Management	Weiss G, Steiner R, Eckmüllner O: Assessing institutional frameworks of inter-and transdisciplinary research and education. <i>Higher Education Policy</i> 2011, 24:499-516.
7	Urban planning/sustainable cities	Wang B-C, Chou F-Y, Lee Y-J: Awareness of Residents Regarding the Construction of a Sustainable Urban Community: A Study of Action Research in Taiwan. <i>Systemic Practice and Action Research</i> 2010, 23:157-172.
8	Agriculture/Fisheries	Stephenson RL, Wiber M, Paul S, Angel E, Benson A, Charles A, Chouinard O, Edwards D, Foley P, Lane D: Integrating diverse objectives for sustainable fisheries in Canada. <i>Canadian Journal of Fisheries and Aquatic Sciences</i> 2019, 76:480-496.
9	Climate Change	Siebenhüner B: Conflicts in transdisciplinary research: reviewing literature and analysing a of climate adaptation in Northwestern Germany. <i>Ecological Economics</i> 2018, 154:117-127.
10	Urban planning/sustainable cities	Sharp D, Salter R: Direct Impacts of an Urban Living Lab from the Participants' Perspective: Livewell Yarra. <i>Sustainability</i> 2017, 9:1699.
11	Agriculture/Fisheries	Schodl K, Leeb C, Winckler C: Developing science–industry collaborations into a transdisciplinary process: a study on improving sustainability of pork production. <i>Sustainability Science</i> 2015, 10:639-651.
12	Water & Sanitation	Schneider F, Bonriposi M, Graefe O, Herweg K, Homewood C, Huss M, Kauzlaric M, Liniger H, Rey E, Reynard E: MontanAqua: tackling water stress in the Alps: water management options in the Crans-Montana-Sierre Region (Valais). <i>GAIA-Ecological Perspectives for Science and Society</i> 2016, 25:191-193.
13	Climate Change	Schikowitz A: Creating relevant knowledge in transdisciplinary research projects - Coping with inherent tensions. <i>Journal of Responsible Innovation</i> 2020, 7:217-237.
14-15	Urban planning/sustainable cities	Schäpke N, Omann I, Wittmayer JM, Van Steenberghe F, Mock M: Linking Transitions to Sustainability: A Study of the Societal Effects of Transition Management. <i>Sustainability</i> 2017, 9:737.
16	diverse	Ruppert-Winkel C, Arlinghaus R, Deppisch S, Eisenack K, Gottschlich D, Hirschl B, Matzdorf B, Mölders T, Padmanabhan M, Selbmann K, et al.: Characteristics, emerging needs, and challenges of transdisciplinary sustainability science

17 - 21	Urban planning/sustainable cities	Polk M: Achieving the promise of transdisciplinarity: a critical exploration of the relationship between transdisciplinary research and societal problem solving. <i>Sustainability Science</i> 2014, 9:439-451.
22	Urban planning/sustainable cities	Perrotti D: Evaluating urban metabolism assessment methods and knowledge transfer between scientists and practitioners: A combined framework for supporting practice-relevant research. <i>Environment and Planning B: Urban Analytics and City Science</i> 2019, 46:1458-1479.
23	Agriculture/Fisheries	Nguyen TPL, Seddaiu G, Roggero PP: Hybrid knowledge for understanding complex agri-environmental issues: nitrate pollution in Italy. <i>International Journal of Agricultural Sustainability</i> 2014, 12:164-182.
24	diverse	Newig J, Jahn S, Lang DJ, Kahle J, Bergmann M: Linking modes of research to their scientific and societal outcomes. Evidence from 81 sustainability-oriented research projects. <i>Environmental Science & Policy</i> 2019, 101:147-155.
25	Water & Sanitation	Leimona B, Lusiana B, van Noordwijk M, Mulyoutami E, Ekadinata A, Amaruzaman S: Boundary work: Knowledge co-production for negotiating payment for watershed services in Indonesia. <i>Ecosystem Services</i> 2015, 15:45-62.
26	Agriculture/Fisheries	Kawabe M, Kohno H, Ikeda R, Ishimaru T, Baba O, Horimoto N, Kanda J, Matsuyam M, Moteki M, Oshima Y: Developing partnerships with the community for coastal ESD. <i>International Journal of Sustainability in Higher Education</i> 2013.
27	diverse	Kassab O, Schwarzenbach RP, Gotsch N: Assessing ten years of inter- and transdisciplinary research, education, and outreach: The Competence Center Environment and Sustainability (CCES) of the ETH Domain. <i>GAIA-Ecological Perspectives for Science and Society</i> 2018, 27:226-234.
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44	Sustainable Ressources	Ferguson L, Chan S, Santelmann MV, Tilt B: Transdisciplinary research in water sustainability: What's in it for an engaged researcher-stakeholder community? <i>Water Alternatives</i> 2018, 11:1.
45	diverse	Ernst A, Fischer-Hotzel A, Schumann D: Transforming knowledge for sustainability: Insights from an inclusive science-practice dialogue on low-carbon society in Germany. <i>Energy research & social science</i> 2017, 29:23-35.
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54	Agriculture/Fisheries	von Munchhausen S, Haring AM: Lifelong learning for farmers: enhancing competitiveness, knowledge transfer and innovation in the eastern German state of Brandenburg. <i>Studies in Agricultural Economics</i> 2012, 114:86-92.
55-58	Water & Sanitation; Sustainable Land Management	Wolff MG, Cockburn JJ, De Wet C, Carlos Bezerra J, Weaver MJT, Finca A, De Vos A, Ralekhetla MM, Libala N, Mkabile QB, et al.: Exploring and expanding transdisciplinary research for sustainable and just natural resource management. <i>Ecology and Society</i> 2019, 24.

59-61	Energy	Wiek A, Harlow J, Melnick R, van der Leeuw S, Fukushi K, Takeuchi K, Farioli F, Yamba F, Blake A, Geiger C, et al.: Sustainability science in action: a review of the state of the field through studies on disaster recovery, bioenergy, and precautionary purchasing. <i>Sustainability Science</i> 2015, 10:17-31.
62	Agriculture/Fisheries	Trimble M, Plummer R: Participatory evaluation for adaptive co-management of social–ecological systems: a transdisciplinary research approach. <i>Sustainability Science</i> 2019, 14:1091-1103.
63	Energy; Urban planning/sustainable cities	Thomas S, Richter M, Lestari W, Prabawaningtyas S, Anggoro Y, Kuntoadji I: Transdisciplinary research methods in community energy development and governance in Indonesia: Insights for sustainability science. <i>Energy Research & Social Science</i> 2018, 45:184-194.
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69	Sustainable Ressources	Taylor PL, Cronkleton P, Barry D: Learning in the Field: Using Community Self Studies to Strengthen Forest-Based Social Movements. <i>Sustainable Development</i> 2013, 21:209-223.
70-74	Sustainable Land Management; Water & Sanitation	Siew TF, Aenis T, Spangenberg JH, Nauditt A, Döll P, Frank SK, Ribbe L, Rodriguez-Labajos B, Rumbaer C, Settele J, et al.: Transdisciplinary research in support of land and water management in China and Southeast Asia: evaluation of four research projects. <i>Sustainability Science</i> 2016, 11:813-829.
75-76	Urban planning/sustainable cities	Seymoar N-K, Ballantyne E, Pearson CJ: Empowering residents and improving governance in low income communities through urban greening. <i>International Journal of Agricultural Sustainability</i> 2010, 8:26-39.
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78	ICT	Sarrica M, Denison T, Stillman L, Chakraborty T, Auvi P: “What do others think?” An emic approach to participatory action research in Bangladesh. <i>AI & SOCIETY</i> 2019, 34:495-508.
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82	Sustainable Land Management	Rodriguez Lopez JM, Tielbörger K, Claus C, Fröhlich C, Gramberger M, Scheffran J: A Transdisciplinary Approach to Identifying Transboundary Tipping Points in a Contentious Area: Experiences from across the Jordan River Region. <i>Sustainability</i> 2019, 11:1184.
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84	diverse	Oyinlola M, Whitehead T, Abuzeinab A, Adefila A, Akinola Y, Anafi F, Farukh F, Jegede O, Kandan K, Kim B, et al.: Bottle house: A study of transdisciplinary research for tackling global challenges. <i>Habitat International</i> 2018, 79:18-29.
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95	Agriculture/Fisheries	Davies J, Maru Y, Hall A, Abdourhamane IK, Adegbidi A, Carberry P, Dorai K, Ennin SA, Etwire PM, McMillan L: Understanding innovation platform effectiveness through experiences from west and central Africa. <i>Agricultural Systems</i> 2018, 165:321-334.
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97	Agriculture/Fisheries	Brent L: Participation and Compliance in Tension: Developing Women-led Yarn Spinning Businesses in Tajikistan. <i>The Journal of Development Studies</i> 2020, 56:1295-1308.
98	Water & Sanitation	Brennan M, Rondón-Sulbarán J: Transdisciplinary research: Exploring impact, knowledge and quality in the early stages of a sustainable development project. <i>World Development</i> 2019, 122:481-491.
99-103	Agriculture/Fisheries	Belcher BM, Claus R, Davel R, Ramirez LF: Linking transdisciplinary research characteristics and quality to effectiveness: A comparative analysis of five research-for-development projects. <i>Environmental Science & Policy</i> 2019, 101:192-203.

104	Energy	Ambale A, Musango JK, Buyana K, Ogot M, Anditi C, Mwau B, Kovacic Z, Smit S, Lwasa S, Nsangi G: Mediating household energy transitions through co-design in urban Kenya, Uganda and South Africa. <i>Energy Research & Social Science</i> 2019, 55:208-217.
105	Sustainable Land Management	Balvanera P, Daw TM, Gardner TA, Martín-López B, Norström AV, Speranza CI, Spierenburg M, Bennett EM, Farfan M, Hamann M: Key features for more successful place-based sustainability research on social-ecological systems: a Programme on Ecosystem Change and Society (PECS) perspective. <i>Ecology and Society</i> 2017, 22.
106	Urban planning/sustainable cities	Polk M: Transdisciplinary co-production: Designing and testing a transdisciplinary research framework for societal problem solving. <i>Futures</i> 2015, 65:110-122.
107	Sustainable Land Management	Robinson CJ, Maclean K, Hill R, Bock E, Rist P: Participatory mapping to negotiate indigenous knowledge used to assess environmental risk. <i>Sustainability Science</i> 2016, 11:115-126.
108	diverse	Lux A, Schäfer M, Bergmann M, Jahn T, Marg O, Nagy E, Ransiek A-C, Theiler L: Societal effects of transdisciplinary sustainability research—How can they be strengthened during the research process? <i>Environmental Science & Policy</i> 2019, 101:183-191.
109	diverse	Klenk NL, Meehan K: Transdisciplinary sustainability research beyond engagement models: Toward adventures in relevance. <i>Environmental Science & Policy</i> 2017, 78:27-35.
110	Agriculture/Fisheries	Kudo S, Mursaleen H, Ness B, Nagao M: Exercise on transdisciplinarity: lessons from a field-based course on rural sustainability in an aging society. <i>Sustainability</i> 2018, 10:1155.
111	diverse	Angelstam P, Andersson K, Annerstedt M, Axelsson R, Elbakidze M, Garrido P, Grahn P, Jönsson KI, Pedersen S, Schlyter P: Solving problems in social-ecological systems: Definition, practice and barriers of transdisciplinary research. <i>Ambio</i> 2013, 42:254-265.
112	Sustainable Land Management	Wang J, Aenis T, Siew TF: Communication processes in intercultural transdisciplinary research. 2019.
113	Sustainable Land Management	Allen E, Kruger C, Leung F-Y, Stephens JC: Diverse perceptions of stakeholder engagement within an environmental modeling research team. <i>Journal of Environmental Studies and Sciences</i> 2013, 3:343-356.
114	Sustainable Ressources, Sustainable Land Management	Holzer JM, Adamescu CM, Cazacu C, Díaz-Delgado R, Dick J, Méndez PF, Santamaría L, Orenstein DE: Evaluating transdisciplinary science to open research-implementation spaces in European social-ecological systems. <i>Biological Conservation</i> 2019, 238:108228.
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B.1 Information on Case Selection

Table B 3 Search strategy for identification of relevant studies

Transdisciplinary Research Project	Effects	Topic
Title-Abs (OR)	Title-Abs (OR)	Title-Abs (OR)
transdisciplinary*	Output	Sustainability
"research-practice integration"	Impact	Sustainable Development
"collaborative research"	Evaluation	
"community-based research"	Assessment	
"community-led research"	Effic*	
"participatory action research"	Effect*	
"community-based action research"	"achiev* of objective"	
"co-production of knowledge"	"achiev* of goal"	
"knowledge co-production"	"goal achiev*"	
"transdisciplinary co-production"	"achiev* of objective"	
"co-producing knowledge"		
"co-creation of knowledge"		
"knowledge co-creation"		
"co-creating knowledge"		
"mode 2 research"		
"mode 2 science"		
"mode-2 research"		
"mode-2 science"		
"postnormal science"		
"post-normal science"		
"transformative research"		
"transformative science"		
"living lab*"		
"Real-world lab*"		

Table B 3 shows the final selection of search terms. Based on my definition of TD research, this includes search terms that describe research approaches including several disciplines and non-academic stakeholders. I checked the robustness of the search by asking three highly experienced TD researchers about the completeness of the list. Additionally, I tested the approach by using rather unspecific terms related to TD research projects such as "participation" or "engagement". However, the articles gained by adding these terms were not sufficiently related to the research question, mostly because they did not cover collaborations with researchers, but more generally among several types of actors. To identify publications that deal with effectiveness, I include a variety of search terms that relate to the effects of a project. Next to terms directly related to effectiveness, I use terms related to evaluation, goal achievement, and the three levels on which effectiveness of projects is often evaluated (output, outcome, impact). I combine the search term for each concept with the Boolean operator OR and three concepts with AND operators. A title-abstract search of articles and reviews written in English and published in 2010 or later from Web of Science and Scopus resulted in overall 745 articles¹³.

¹³ The final search was conducted on March 4th 2020

During the case selection, I followed the PRISMA guidelines on reporting for systematic reviews (Moher et al., 2009). The process is shown in Figure B 1 below.

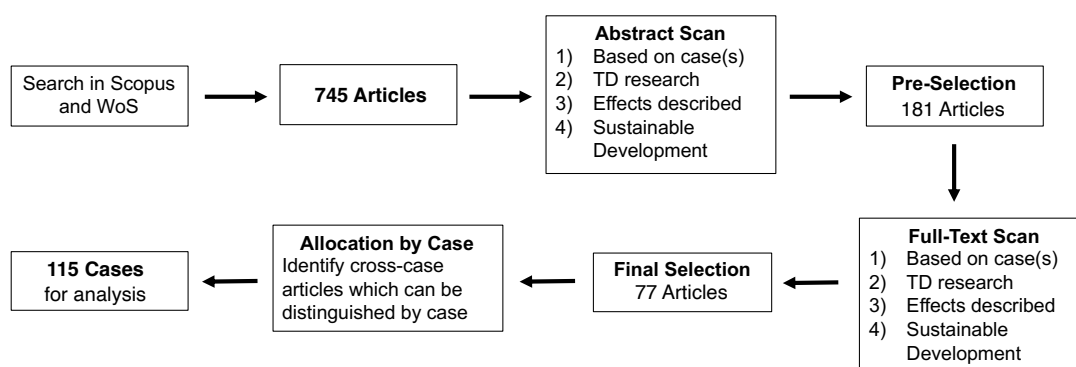


Figure B 1 Process of case selection

I conducted an abstract scan to assess whether the article is relevant, based on the following conditions: 1) The article is based on at least one case, i.e., one or more described TD projects, meaning a research project that includes several disciplines as well as non-academic stakeholders, which has happened or is currently being conducted. 2) The article presents some information on the effectiveness of the projects. 3) The project studied is related to sustainable development. Examples of studies that I did not consider in the sample are theory papers with no description of any empirical results from one or several cases, or papers based on general expert opinions but not on the experience from one or several cases (violating condition 1). Furthermore, some articles describe collaborative processes without the involvement of researchers (violating condition 1). I also excluded articles where the authors applied a TD approach but focused on presenting the results of the project rather than reflecting on the effects of the TD approach (violating condition 2). In line with Newig et al. (2019) I excluded studies that used the term “sustainability” only to describe long-term effects (e.g., long-term effects of a medical treatment) (violating condition 3). The abstract scan along these four conditions led to the exclusion of 564 articles, resulting in a set of 181 articles. Then I then used the same four conditions again for a full text screen, leading to a final selection of 77 articles. Of the selected articles, 20 are cross-case studies, meaning that they deliver information from more than one case of a TD research project. Some cross-case studies provide synthesized information over several cases (5), others present specific information on each case (15). I decided to split up the articles that contain several separate cases into single cases. This resulted in overall 115 cases that I analyse in this article.

B.2 Appendix – Interview Guideline

Material: Framework printed in A3, sticky notes, pens

Introduce myself and project. Present our definition of TD.

1. Area of research

“Could you tell me a little bit more about your experience with TD projects (research projects involved etc.) and your current work?”

2. Effects

Show analytical framework. Explain that I am trying to understand how processes work with this model.

We will start with the effects and then look at the different influential factors. But you do not have to think about that, I will guide you through the process.

a) From your perspective, “If you think about the TD projects you were involved in, what type effects did you achieve/or not?”

⇒ Start open, ask about specific categories of effects once interviewee does not name any new effects.

Effects

Knowledge Generation

Uptake of Knowledge

Learning

Societal

b) “If you look at the effects identified, where do you think TD projects are most successful? Which effects are in general harder to achieve?”

3. Influences

After identifying the effects achieved/not achieved we will now try to find out what influences them (explain according to framework)

a) Input Factors: “Can you think about input factors which positively or negatively affected the effects of a project?”

Example: One study found that involving different non-academic stakeholders in the project triggered the establishment of a cross-sectoral stakeholder network (Input – Effects)

⇒ Start open, ask about specific categories of input factors once interviewee does not name any new factors.

Input

Stakeholders Involved

Disciplines Involved

Networks & Social Structure

Individual Attributes

Community Attributes

b) Process Factors: “Can you think about any factors related to the process of a project that positively or negatively affected effects of a project.”

Example: Use of participatory methods, where farmers were trained in using GIS increased their motivation in the project and their trust in the research results (Process – Effects).

⇒ Start open, ask about specific categories of process factors once interviewee does not name any new factors.

Process

Quality

Methods

Strategies

4. Context (Institutions)

a) After looking at factors that are directly related to the project, we also want to look at the context.

“Are there factors external to the project such as requirements from the funding scheme, cultural issues etc. that influenced either the effects, input or process factors of a project?”

5. Overall

a) “Are there other factors that we have not discussed yet, that were either supporting or hindering for the effects of a project”

b) “Of all those input, process and context factors could you name 1-3 factors that you think were the most influential (positively/negatively)?”

c) “What advice would you give to someone who plans to conduct a transdisciplinary research project?”

Table B 4 Overview of the different input, process and institutional factors and their influences on the different effects

	General Success	Knowledge Generation	Quality of Data	Uptake Practice	Uptake Science	Uptake Policy	Learning Stakeholder	Problem Awareness	Network & Relationships	Inclusion & Relevance	Overall
Overall Input	53	22	9	30	19	12	2	11	45	44	247
Capacity of Stakeholders	6		1		1	1			1		10
Defined Responsibility	4	3	1	2					3	6	19
Diversity of Team	2	4		1				1	3	3	14
Interdisciplinarity		4		1	7				3		15
Involvement of Students		1		1	3			1	1	2	9
Knowledge Brokers & Reputation	4	1	1	7		6		2	7	3	31
Motivation for TD	10	2	2	1	5	2	1	3	5	5	36
Power Distribution	3		2	2					2	3	12
Previous Contact & Experience	9								2	3	14
Qualifications & Skills	8	1		4		1	1	1	7	5	28
Shared Values & Understandings	5	3	1	4	1	1		1	7	2	25
Structure of Team		2		5	1				2	8	18
Transnational Cooperation	2	1	1	2	1	1		2	2	4	16
Overall Process	76	36	12	59	28	16	32	53	99	65	476
Adaptive Management	6	1		1	2		2		2	9	23
Available Time/Efficiency	14	3	1	3	6	2	1	2	8	3	43
Co-creation	1	5		6		1	2	5	9	5	34
Contracts & Incentives	3							1	4	2	10
Degree of Collaboration	6	4	1	8	5	2	1	3	7	13	50
Emphasizing	4	4		3	2	1		2	7	3	26
Informal Exchange	2	1	2	2		1		4	12	1	25
Participatory Tools	1	4	1	1	2	1	8	9	13	2	42
Quality of Communication	4	1		1				1	4	6	17
Quality of Management & Planning	18	4	2	7	7	5	3	1	14	7	68
Safe Space & Privacy	1		1	2			2	5	4	3	18
Stakeholder-led Activities & Monitoring	2	3		5		1	4	11	4	3	33
Trainings	1	1		5	2		6	3	3	1	22
Translation	3		2	3			1	1	2	5	17
Transparency	7	3	2	5	2		1	1	4	2	27
Visualization of Information	3	2		7		2	1	4	2		21
Overall Institutions	20	2	5	9	3	13	3	3	3	14	72
Academic Culture	3								1	3	7
Administration	3		1	1	2	5				1	13
Cultural Norms and Differences	1		2				1			2	6
Existing Conflicts	6			2		1	1		1	3	14
Funding	3	2	1	3	1				1	4	15
Political & Economical Priorities	4		1	3		7	1			1	17
Overall	149	60	26	98	50	41	37	64	147	123	795

Table B 5 Overview of the different institutional factors and their influence on the different process factors

Institution	Capacity of Stakeholders	Defined Responsibility	Diversity of Team	Interdisciplinarity	Involvement of Students	Knowledge Brokers & Reputation	Motivation for TD	Power Distribution	Previous Contact & Experience	Qualifications & Skills	Shared Values & Understandings	Structure of Team	Transnational Cooperation	Overall
Academic Culture					1		2	1			1	1	1	7
Administration	3						1	1		1		1		8
Cultural Norms & Differences						1		3				4	2	10
Existing Conflicts								1				5	2	8
Funding	1	4	2	1			2	5	2			9	2	29
Political & Economical Priorities	3							1			1	2		7
Overall	7	4	2	1	1	2	5	12	2	1	3	22	7	69

Table B 6 Overview of the different institutional factors and their influence on the different input factors

Institutions	Adaptive Management	Available Time/Efficiency	Degree of Collaboration	Informal Exchange	Quality of Communication	Quality of Management & Planning	Safe Space & Privacy	Stakeholder-led Activities & Monitoring	Transparency	Overall
Academic Culture	2	2	3			1	1			9
Administration	1	2	1						2	6
Cultural Norms & Differences			1			3	1		3	8
Existing Conflicts			1	1	1		1 1		3	8
Funding	1	2	7				1	1		12
Political & Economical Priorities		1	3	1						5
Overall	4	8	15	2	5	3	2	1	8	48

Table B 7 Overview of the different input factors and their influence on the different process factors

Input	Adaptive Management	Available Time/Efficiency	Co-creation	Contracts & Incentives	Degree of Collaboration	Emphasizing	Informal Exchange	Participatory Tools	Quality of Communication	Quality of Management & Planning	Safe Space & Privacy	Trainings	Transparency	Visualization of Information	Overall
Capacity of Stakeholders		4			2					2					8
Defined Responsibility		3			3					6			1		13
Diversity of Team					1				1		1				3
Interdisciplinarity		2		1					4	2	1				10
Involvement of Students									2			1			3
Reputation			2				1		5	3			1	2	14
Motivation for TD	1	1	1		2		1	2	1	3		2	1		15
Power Distribution					2				4	1					7
Previous Contact & Experience					3				1	1			1		6
Qualifications & Skills	2		1			2				1		1		1	8
Shared Values & Understandings		3	1		2		1		5	2			2		17
Structure of Team	1				3				1						4
Transnational Cooperation					1	1			5				2		9
Overall	4	13	5	1	19	3	3	2	29	21	2	4	8	3	117

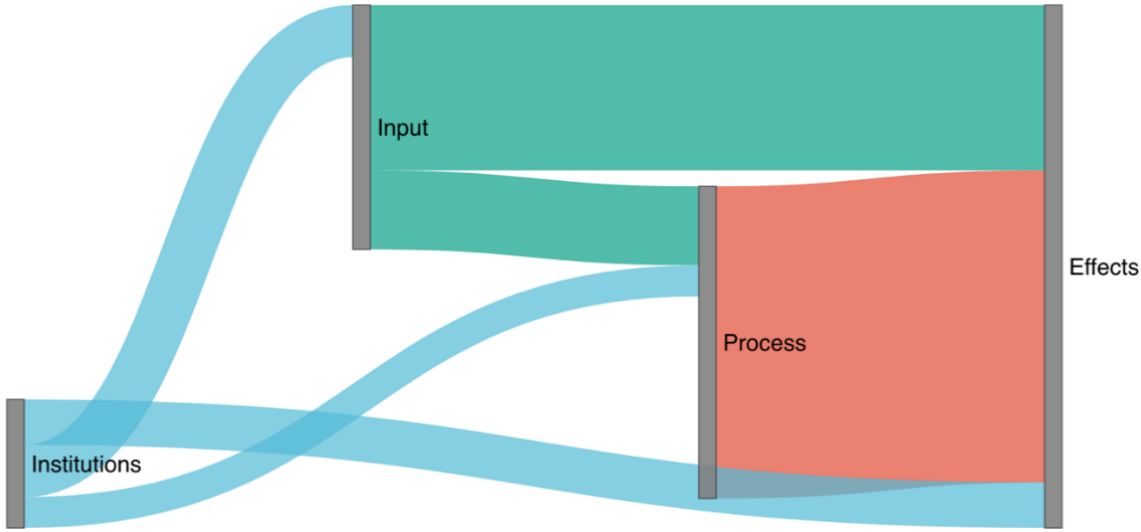


Figure B 2 Interlinkages between institutional, input and process factors

C Appendix Article 3

Table C 1 Overview interviewees. The interviewees marked with * co-authors of this article

Interview	Code
Waste Stakeholder, DRC	WS1
Waste Stakeholder, DRC	WS2
Waste Stakeholder, DRC	WS3
Waste Stakeholder, DRC	WS4
Waste Stakeholder, DRC	WS6
Agriculture Stakeholder, DRC	AS1
Waste Stakeholder, DRC	WS5
Coffee cooperative, DRC	AS2
Coffee cooperative, DRC	AS3
Coffee cooperative, DRC	AS4
Research, DRC*	R1
Research, DRC*	R2
Waste Stakeholder, DRC	WS9
Agriculture Stakeholder, Rwanda	AS5
Waste Collector, Rwanda	WS7
Agriculture Stakeholder, Rwanda	AS6
Research, Rwanda*	R3
Waste Stakeholder, Rwanda	WS8
Agriculture Stakeholder, Rwanda	AS7
Agriculture Stakeholder, Rwanda	AS8
Agriculture Stakeholder, Rwanda	AS9

Table C 2 Overview of the secondary data we use to describe certain context factors for the cases

Secondary Data	Explanation	Related context factor
Official Development Assistance per Capita (ODA)	ODA is the amount of development money that flows into a country from OECD countries and multilateral countries.	Financial capital
Worldwide Governance Indicators	A set of six indicators to assess the quality of governance based on expert opinions. We use the indicators "Government Effectiveness", "Rule of Law" and, "Regulatory Quality". The indicators are using percentile ranks between 0 (lowest) and 100 (highest) for all the countries.	Governance System, Law
Private Funding per capita	The amount of money that private donors (philanthropies) give to a country.	Financial capital
Fertilizer use per hectare	The average fertilizer use per hectare	Biophysical system
Credit to private sector	Domestic credit to private sector refers to financial resources provided to the private sector by the government (e.g. loans). Measured in share of credits in % of GDP	Governance System

PPP conversion factor	The price level ratio is the ratio of a purchasing power parity (PPP) conversion factor to an exchange rate. This provides an indicator of the differences in the general price levels of countries. Values < 1 indicate below average price levels.	Financial capital
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C.1 Design of the Project

The project is highly transdisciplinary in design and contains three major phases:

- 1) **Project Development:** In this initiation phase the project team co-defined the research questions of the project together with local stakeholders and developed an overall project planning. This phase also included context studies based on primary data (surveys, interviews) and secondary data (existing studies). The context studies covered the following areas: Socio-economic background, policy and regulatory environment, agricultural production system, food value chains of the city regions and waste flows. The same data were collected for case DRC and case Rwanda.
- 2) **Co-Design of Innovations:** This phase included a series of workshops with interested stakeholders to design innovations and plan their implementations. Both subprojects used the same methods, but sometimes proposed solutions were adapted to the context of the country. The stakeholders then prepared innovation plans, which were evaluated by several members of the RUNRES teams. After several feedback loops, a set of innovations was approved for each sub-project. The selected innovations received funding from the project but also had to contribute own co-funding (at least 30%) For each approved innovation, a memorandum of understanding was signed before the distribution of funds.
- 3) **Innovation Phase:** This phase includes the implementation of the innovation on the ground. The stakeholders are responsible for the implementation. Research activities are carried out to support innovations and collect data on the feasibility and effects of innovations. This includes the quality control of the produced products (e.g. compost, animal feed ingredients) but also data on the economic feasibility of the innovations.



Figure C 1 Three indicators of the Worldwide Governance Indicators (2012-2021), all measured in percentile ranks from 0 (lowest) to 100 (highest). The Government Effectiveness Index stands for the quality of public services, the Regulatory Quality Index stands for the ability of the government to implement sound policies, the Rule of Law Index stands for the level of enforcement of policies and laws, source: own representation, data by The World Bank (2020b)

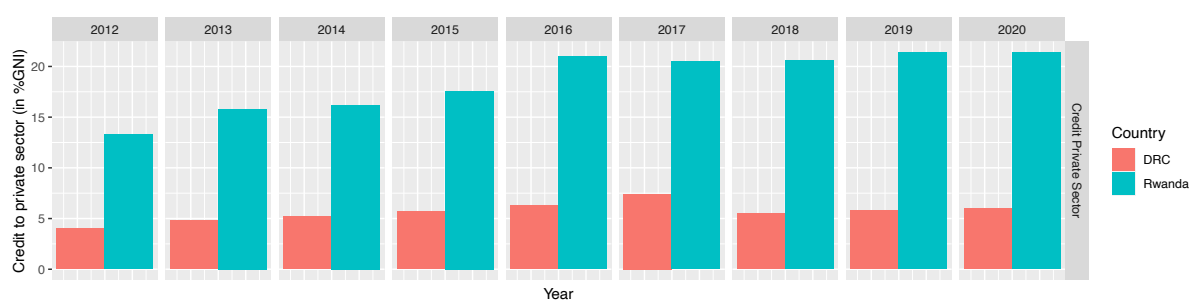


Figure C 2 Share of credit from the government to the private sector in % of the GDP (2012 – 2020), source: own representation, data by The World Bank (2021)



Figure C 3 The Purchasing Power Parity (PPP) conversion factor provides an indicator of the differences in the general price levels of countries. Values < 1 indicate below average price levels, source: own representation, data by The World Bank (2020a)

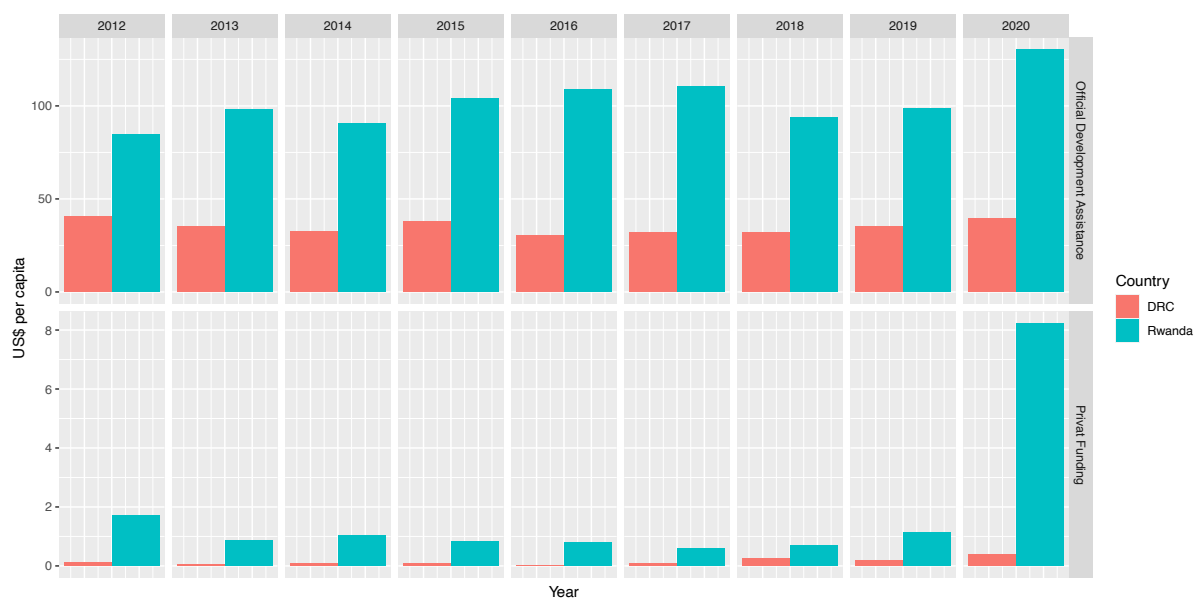


Figure C 4 Amount of Official Development Assistance and Private Funding in US\$ per capita (2012 – 2020), source: own representation, data by OECD (2023a, 2023b)

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