Key Considerations to Carry Out Collaborative Research: The Project Team's Perspective of Three Climate Adaptation Projects

Janne Groot

TU Delft

1-9-2023

TU Delft

Key Considerations to Carry Out Collaborative Research: The Project Team's Perspective of Three Climate Adaptation Projects

Master thesis submitted to Delft University of Technology

in partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE

in **Complex Systems Engineering and Management**

Faculty of Technology, Policy and Management

by

Janne Groot

Student number: 4547764

To be defended in public on 01-09-2023

Graduation committee

Chairperson	: Dr. G. de Vries, Organisation and Management
First Supervisor	: Dr. ir. V.J. Cortes Arevalo, Policy Analysis
Second Supervisor	: Dr. G. de Vries, Organisation and Management
External Supervisor	: Ellen Minkman, Organisation and Management

PREFACE

I am honoured to present this study, which marks the finalisation of my Master's study at the Complex Systems Engineering and Management program at TU Delft. The completion of this research would not have been possible without the guidance, support, and encouragement of several individuals who have played a crucial role in shaping this endeavour.

First and foremost, I express gratitude to my supervisors, Juliette Cortes Arevalo, Gerdien de Vries, and Ellen Minkman. Your support, insightful guidance, and thoughtful feedback have been instrumental in shaping the direction of this study. Your expertise, encouragement, and patience have been invaluable as I navigated through the complexities of the thesis. I especially want to express appreciation to Juliette, who guided me through the thesis process by meeting and supporting me on many occasions. Your commitment to my academic growth and the quality of this study have been truly inspiring, and I am thankful for the opportunity to work under your guidance.

I also want to thank to my family and friends for their support, encouragement, and belief in my abilities. Your constant presence and encouragement have been my driving force, and I am grateful beyond words for your love and support.

With the support of my supervisors, the academic community at TU Delft, and my loved ones, I am proud to present the insights gained from this research. It is my hope that this study contributes to the ongoing discourse in the realm of transdisciplinary projects for climate adaptation and serves as a stepping stone for further exploration and understanding.

Janne Groot

August, 2023

ABSTRACT

Transdisciplinary (TD) research plays a crucial role in addressing the complex challenges of climate adaptation. Despite popularisation of TD research, ambiguity remains in the specific implementation of this approach. As more projects aim to adopt TD approaches, more clarity is needed to structure the organisation and implementation of TD projects. This study aims to provide insight from practice on how challenges and successes can be addressed in TD projects. Through an in-depth investigation of three TD projects, this research explores the key components of TD projects, identifies main challenges and successes, and elicits stakeholders' suggested improvements. The study consists of a comprehensive analysis of literature, expert interviews, interview data, and focus group discussions. A theoretical framework is developed to define TD concepts and relationships, addressing the issue of diffuse definitions. The research highlights the importance of shared understanding among stakeholders, particularly in addressing cultural challenges and achieving inclusiveness. Stakeholders' differing perspectives on successes and challenges are observed, leading to the identification of common themes across projects. The results underscore the significance of existing relationships and collaboration in TD projects, contributing to successful outcomes. However, certain challenges, such as inflexible institutional regulations, are also shared across cases. The analysis highlights the need for more explicit reflection on successes and structured approaches for envisioning improvements. The study also reveals a divide between participants based on their backgrounds, suggesting the importance of promoting knowledge integration among diverse stakeholders. Overall, this study contributes to the advancement of TD research in climate adaptation, empowering stakeholders to navigate complex challenges and foster sustainable solutions.

Key words: transdisciplinary collaboration, climate adaptation, challenges, successes, perceptions.

CONTENTS

1. INTRODUCTION

Around the world, the social and environmental challenges caused by climate change are increasing. As the global temperature rises closer to the 2ºC limit, demand for more rapid climate change adaptation strategies intensifies (IPCC, 2023). Challenges caused by this include issues such as floods causing damages, salination of coastal areas leading to fresh water shortages and unequal access to sufficient and safe energy. However, these issues are multi-dimensional problems including cultural, ecological, economic, social, psychological institutional, and technological dimensions (McGreavy et al., 2022; Mitchell et al., 2017). Finding and implementing solutions to these complex challenges requires an approach that is able to integrate these dimensions. The traditional approach to knowledge creation through academic research focusses on a siloed approach limited to one discipline (Djenontin & Meadow, 2018). This type of knowledge creation is often focussed on theoretical knowledge relevant for high-level analysis. However, finding solutions to climate change and the multi-dimensional challenges it produces requires research into real-world problems, beyond the theoretical inclination of science.

Solutions to these real-world problems include practical implementations and knowledge applications for research users to adapt to and mitigate the effects of climate change (Hoffmann et al., 2017). For example, the implementation of conservation initiatives and co-creation with citizens in urban planning initiatives implement collaboration between research providers and research users to create practically relevant knowledge (Luetkemeier et al., 2021; Polk, 2015; Siew & Döll, 2012) However, as academic research is often focussed on producing theoretical knowledge, the scientific research results are often not directly relevant to research users; a so-called "usability gap" (DeLorme et al., 2016). To address this gap, there is a need for integrating practical, solution-oriented perspectives into the problem definition of scientific research to create a "link between scientific progress and societal needs" (Knickel et al., 2019, p. 2).

To develop knowledge that is useful for practitioners and decision-makers, the application of collaborative research beyond the academic domains which encompass a variety of disciplines and cross sectoral delineations is required (DeLorme et al., 2016; Hessels et al., 2018; Siebenhüner, 2018). The transition to these research approaches is in full development and can be demarcated by the rise of transdisciplinary (TD) research projects to address climate change challenges (Jakobsen et al., 2004; Polk, 2015). TD projects aim to create scientific knowledge that involves societal actors in the entire knowledge creation process, from problem definition to implementation and dissemination of results, to develop knowledge that is relevant to real-world problems (Hakkarainen et al., 2022; Lawrence et al., 2022). These projects aim to foster collaboration between research providers and research users (Luetkemeier et al., 2021).

1.1. PROBLEM DEFINITION

Despite popularisation of TD research, difficulties with the specific implementation of this approach remain. At the foundation of these difficulties lies the ambiguity that surrounds TD research (Brundiers et al., 2021; Lawrence et al., 2022). Nuances exist in a focus on collaboration across disciplines and industries, an emphasis on knowledge integration or the level of stakeholder involvement in problem definition or even the project (Mann & Schäfer, 2018). Besides that, a comprehensive list of specific definitions as to which activities or project components make a project TD are missing. To define a working definition, TD research can be described as "a reflexive, integrative, method-driven scientific principle aiming at the solution or transition of societal problems by differentiating and integrating knowledge from various scientific and societal bodies of knowledge" (Lang et al., 2012, pp. 2–3) in which "the problem definition starts from the sustainability deficit expressed by local actors" (Hakkarainen et al., 2022, p. 2). As projects aim to implement TD research to create more solution-oriented knowledge, the inconclusive definitions of the approach and the impact that can be generated result in problems. These problems vary across projects but can take the form of wasted resources, dissatisfaction among involved stakeholders or results that are not contributing to solving the problem (Hakkarainen et al., 2022; Lawrence et al., 2022).

As more projects aim to adopt TD approaches, these problems need to be addressed to ensure the implementation of TD research generates useful results for climate adaptation. To do this, a deeper

understanding of TD research from project experience is needed to increase the ability of projects to overcome challenges in their projects and increase their success (DeLorme et al., 2016). However, TD projects have great variety, which can increase the challenge of finding which lessons from other projects can aid in improving the project (Zhuang et al., 2021). Subsequently, considering the involvement of different stakeholders in TD project teams, variety exists in which aspects of the project are considered challenging (Hessels et al., 2018; Jakobsen et al., 2004). Therefore, this paper aims to provide an overview of considerations and perspectives of TD projects organisation that can and need to be taken into account by stakeholders involved in TD projects. This research compares the similarities and differences between TD projects from the perspective of the stakeholders involved in the project by reviewing the existing literature, conducting interviews and comparing three case studies. By structuring and comparing TD projects and creating an understanding of the aspects of effective collaboration, stakeholders involved in TD research will be better equipped to address the challenges they face and grow the success of their projects.

The paper is structured as follows: First, a literature search is performed to define the knowledge gaps in literature. This is necessary as TD research deals with a broad spectrum of disciplines, and a delineation of the problem is required. The review concludes with a research question aimed at filling the identified knowledge gaps. Second, an overview of the research design and method is provided. Then, a description of the results is provided. This section describes the results from the data collection process. The discussion synthesizes an answer to the research questions based on the results. Lastly, the conclusion provides an overview of the most important findings and provides recommendation for TD projects and further research.

2. LITERATURE SEARCH

To place the concept of TD research in the context of existing literature, a literature search is conducted on the evaluation of TD projects. This section first describes the literature collection process that forms the basis of this review. Then, the inferences from the search are discussed, and the knowledge gaps in literature are identified.

2.1. LITERATURE REVIEW PROCESS

Before determining a body of literature for reviewing, a set of inclusion criteria were determined to direct the search of literature. As a vast body of academic literature exist, it is crucial to determine how and why certain articles are included in the review (Wee & Banister, 2016). The inclusion criteria are based on the problem definition as described in the introduction. The inclusion criteria included for the review are that the article:

- Discusses climate change or climate adaptation
- Focusses on evaluation of TD collaboration
- Mentions improvements or lessons learned of TD projects
- Is based on a (comparative) case study
- Mentions relationships between transdisciplinary concepts

To find a suitable body of literature that describes the existing knowledge on research projects focussed on problem definition, knowledge creation and integration involving collaboration between academic and non-academic stakeholders, a set of three search strings was used to collect articles from Scopus[*]. The key words used in this search are based on the inclusion criteria to collect a body of literature that matches these criteria. Figure 1 presents the search strings that were used and provides and overview of the inclusion process. Additional to forward snowballing[†] of the eligible papers, articles recommended by the thesis supervisor were

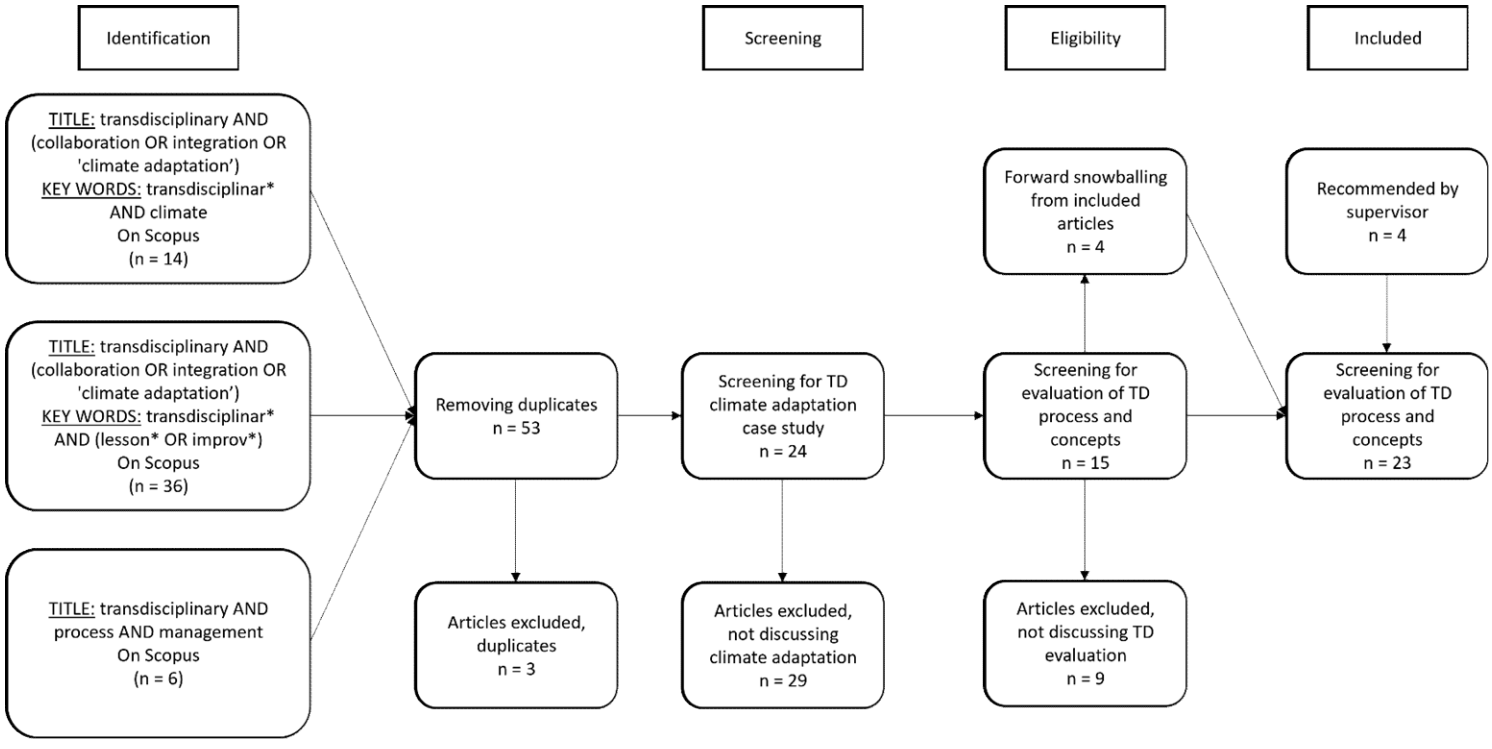


Figure 1. Literature review exclusion process.

[*] During a review of the search terms it was noticed that the string is not necessarily exhaustive. During a review of the newly found documents, no significantly diverging information to the literature included in the review was found.

[†] Forward snowballing implies finding citations to a paper (Wee & Banister, 2016, p. 7).

included. After review, a total of 23 papers are included in the literature review. An overview of the articles that are included in the review is provided in Appendix C - Table 1.

2.2. KNOWLEDGE CREATION FOR CLIMATE ADAPTATION

To address the complexity of climate adaptation and deal with the multiple dimensions that span climate change and sustainability transformations, knowledge creation activities should focus on integrating and creating knowledge beyond single disciplines and include non-academic stakeholders in the process (Hakkarainen et al., 2022; McGreavy et al., 2022; Mitchell et al., 2017). This means that an integration between knowledge from cultural, ecological, economic, social, psychological, institutional and technological dimensions is crucial to developing solutions to issues driven by climate change. Research projects that implement multi-dimensional knowledge creation have become more prevalent in academic research (Jakobsen et al., 2004; Polk, 2015). In these projects, multiple dimensions that are relevant to a problem are brought together in activities aimed at integrating and creating knowledge across and relevant to more than one discipline or industry (Klenk & Meehan, 2015; Lang et al., 2012; Mitchell et al., 2017). Different approaches to multi-dimensional knowledge creation activities can be defined. These approaches vary in who are involved in the research project and the way in which they collaborate and participate in knowledge creation.

2.2.1. KNOWLEDGE CREATION APPROACHES

At the basis of multi-dimensional knowledge creation lies an multidisciplinary approach to research activities. This approach is characterized by a loose collaboration between disciplines focussed on exchanging knowledge (Mitchell et al., 2017). When an intentional and close collaboration between researchers from different disciplines forms the goal of the knowledge creation approach, the activities can be defined as interdisciplinary (Karcher et al., 2021; Mitchell et al., 2017). These approaches are specifically distinguished by the closeness of the collaboration between disciplines. Multidisciplinary approaches include a more informal, loose collaboration and lack a focus on integration of knowledge across disciplines. Interdisciplinary approaches focusses on knowledge integration through close collaboration between academic disciplines (Lawrence et al., 2022). Nevertheless, in these approaches the task of knowledge creation remains the responsibility of academic scholars.

Transdisciplinary (TD) knowledge creation approaches aim to include non-academic stakeholders in the entire knowledge creation process and focus on collaboration among and between academic researchers and non-academic stakeholders (Lang et al., 2012; Mitchell et al., 2017). In these activities, academic and non-academic stakeholders are intended to have equal involvement in the project (Bréthaut et al., 2019; McGregor, 2017). This diffuses the divide between academic- and non-academic stakeholders and their roles within the project. Therefore, the people and organizations involved in the research project can be grouped based on their relation to the research rather than their professional background. Specifically, the groups of research providers and research users can be distinguished (Luetkemeier et al., 2021; Mitchell et al., 2017). Research users can be defined as stakeholders on the receiving end of the interaction between the two groups. They are the ones using the created knowledge and applying it into practice. Research providers are on the knowledge creation end of the interaction. They collaborate to produce usable knowledge for research users. With this grouping, stakeholders could also be part of both categories depending on the role they are fulfilling throughout the project. By focussing on a collaboration between research providers and research users, TD knowledge creation approaches aim to address the differences between what “scientists and decision-makers consider useful knowledge” (DeLorme et al., 2016, p. 1).

2.2.2. TYPES OF KNOWLEDGE

By implementing knowledge creation approaches, different types of knowledge can be created. Literature distinguishes three types of knowledge that can be created: system, target and transformation knowledge. Knowledge that describes and explains problem situations is categorized as *systems knowledge*. This type of knowledge addresses what the current problem situation is. This type of knowledge includes, for example, knowledge collected and developed during a project’s problem definition phase. *Target knowledge* includes norms and values that are related to a (desired) future. This includes, for example, the objectives and desired

scenarios that are developed in a project. Lastly, *transformation knowledge* describes the development from the present situation (described by system knowledge) to the (desired) future situation (target knowledge) (Lawrence et al., 2022; Siew & Döll, 2012). This includes, for example, the knowledge related to methods implemented in a project. Different knowledge creation approaches can produce different types of knowledge about the present, future or development in between. For TD knowledge creation approaches, it is argued that all three types of knowledge are produced by and required for this approach (Brandt et al., 2013).

2.3. IMPLEMENTATION OF KNOWLEDGE CREATION APPROACHES

It should be noted that knowledge creation approaches are not hierarchical or mutually exclusive. Rather, certain approaches are more suitable for certain research activities and produce different types of knowledge (Heilmann & Pundt, 2021; Siew & Döll, 2012). Besides that, one knowledge creation approach can be used in an activity that provides the input for another activity that uses a different approach to knowledge creation (e.g. knowledge created in an interdisciplinary setting can be used as input for a transdisciplinary discussion for knowledge creation). Though the activities related to specific knowledge creation approaches are not mutually exclusive, researchers often tend to or are required to label their projects with a specific type of knowledge creation (Klenk & Meehan, 2015). This tendency has various reasons, one of which is that funding organisations try to emphasise the importance of TD research. They enforce this by requiring research projects to incorporate TD knowledge creation approaches in their methodologies (DeLorme et al., 2016). This amplifies the stigma of TD knowledge creation approaches being 'better' and inevitably mutually exclusive in research approaches.

Due to this broad application of TD approaches, similar concepts are used to describe different project activities, levels of stakeholder participation and projects in general. To structure the concepts used in this paper, the term *TD projects* is used to indicate research projects implementing TD knowledge creation approaches. *TD knowledge creation approaches* refer to the research methods aiming to include non-academic stakeholders in the entire knowledge creation process and focus on collaboration among and between academic researchers and non-academic stakeholders (as defined in Section 2.2.1). These methods include *TD collaboration* which refers to the activities involving close collaboration between academic and non-academic stakeholders. The collection of TD collaboration activities and other activities related to knowledge creation through TD knowledge creation approaches is referred to as *TD research*. Nevertheless, this does not mean that a TD projects solely include TD research. Interdisciplinary, multidisciplinary and even disciplinary approaches can also be part of the research process (Lawrence et al., 2022). However, as TD projects set the goal of implementing TD research, the research process is labelled as being TD.

2.4. DEFINING TRANSDISCIPLINARY RESEARCH

Despite the general description of TD research involving a collaboration between both research providers and research users, differences in definitions of the concept exists (Heilmann & Pundt, 2021). TD research is specifically defined in this thesis by the definition of Lang et al. (2012) which is referenced by several papers included in the literature review. Additionally, the definition of Hakkarainen (2022) is used to incorporate the involvement of societal actors in the problem definition in the description. The working definition of TD research then reads: TD research is "a reflexive, integrative, method-driven scientific principle aiming at the solution or transition of societal problems by differentiating and integrating knowledge from various scientific and societal bodies of knowledge" (Lang et al., 2012, pp. 2–3) in which "the problem definition starts from the sustainability deficit expressed by local actors" (Hakkarainen et al., 2022, p. 2).. Besides this principle definition of TD research, five characteristics that are often present in TD projects can be identified from the literature.

First, TD projects characteristically address real-world problems that are relevant to research users. These real-world problems often relate to multiple dimensions (e.g. cultural, ecological, economic, social, institutional, and technological dimensions) and include complexities that cannot be addressed by one discipline or industry (Knickel et al., 2019; Polk, 2015). Specifically, these problems require solution-oriented knowledge creation in which the produced knowledge is transferable within and beyond the stakeholders involved in the project (Lang et al., 2012). In the context of this thesis, TD projects have the goal to initiate sustainability transformations to address the complex challenge of climate adaptation (Basta et al., 2021).

Second, TD projects employ a combination of multi-disciplinary scientific perspectives and relevant, practical knowledge (Polk, 2015). This means that TD projects include a variety of stakeholders that are relevant to the issue that is being addressed. These stakeholders have either an academic background and operate from different disciplinary perspectives, or they have a background rooted in professional practice and operate under the assumption that they will use and implement the knowledge that is created in the project (Basche et al., 2014). This characteristic is often a result of the multi-dimensional problems that are addressed in TD projects. By including stakeholders with a variety of perspectives, the relevance of different dimensions can be included in the decision-making and knowledge creation process.

Also, TD projects often involve a close and long-term collaboration between research providers and research users (Heilmann & Pundt, 2021; Hessels et al., 2018). This close, long-lasting collaboration is focussed on the creation and integration of knowledge among stakeholders. Increasing the duration of the project to multiple years provides an opportunity to implement the created knowledge within the timeline of the project and facilitates deep knowledge integration between stakeholders (Luetkemeier et al., 2021).

Besides that, collaboration and co-production are present in the entire knowledge production process of TD projects. This means that stakeholders collaborate in the "entire knowledge production process including joint problem formulation, knowledge generation and application in both scientific and real world contexts" (Polk, 2015, p. 2). Through this process, solution-oriented, practically relevant, scientific knowledge can be created to address the real-world problems that are researched by TD projects.

Lastly, TD projects focus on continuous reflection and evaluation of the process and its results. Throughout the knowledge creation process, stakeholders reflect on their activities and results and assess whether their collaborative efforts are producing knowledge that is relevant to the stakeholders involved (Knickel et al., 2019; Lawrence et al., 2022). This also means that the evaluation of the project is a continuous process instead of limited to the final phase of the project (Basta et al., 2021). The long duration of the project also requires the intermediate and continuous reflection by stakeholders to ensure the goals of the project remain aligned.

2.5. CHALLENGES AND SUCCESSES

TD projects address issues that are multi-dimensional and often strongly context-specific. This could result in the project being organised differently depending on the context of the issue. Besides that, the knowledge that is created in this project would only be relevant for that specific issue in that particular context which can complicate knowledge transfer across projects (Zhuang et al., 2021). However, despite the complications in transferring created knowledge across projects, insights and lessons learned from projects implementing TD research can be used in other projects to improve the process (DeLorme et al., 2016). Lessons learned in case study literature are often described as challenges and successes that were encountered in the project (Harrison et al., 2017).

2.5.1. CHALLENGES

In TD projects challenges can be described as the aspects of the project's process that experienced practical or institutional difficulties (Brandt et al., 2013). This thesis extends this definition to the aspects of the project's process that were practically or institutionally difficult or experienced as such by the involved stakeholders. Lawrence et al. (2022) and Brandt et al. (2013) argue that there are five common challenges that are encountered in TD projects.

The first challenge they describe relate to the differences in definitions TD research and the lack of a framework structuring the concepts that are relevant to TD research. As described in Section 2.4, differences exist in the way TD research is defined. These differences can pose a challenge when they hamper the coherent framing of the problems addressed in the project.

Second, they describe that there are unclear relationships between methods, process phases and knowledge types. As different disciplines collaborate in TD projects, it is a challenge to integrate methods and ways of working

across disciplines. This can inhibit the ability of TD projects and its involved stakeholders to collaborate efficiently and effectively with each other.

Also, Lawrence et al. (2022) and Brandt et al. (2013) describe differences between the theoretical 'best practice' of how TD research should be implemented and how the practical application of a TD research is executed which poses a challenge for TD projects. Specifically, the description of project phases involved in TD projects or the knowledge types required and produced through TD collaboration are not necessarily included in the practical implementation of TD research. However, consensus is lacking on which elements of the 'best practice' of TD research should be emphasized in it practical application. This lack of structure makes the design and set-up of a TD project more challenging.

Besides that, even though TD research is aimed at engaging with non-academic stakeholders and involving them in the research project, many case studies reveal that there is still a limited involvement of non-academic stakeholders in project decision-making. The involvement is often limited to the knowledge creation of the project and executive decisions on planning and organisation remain the responsibility of academic stakeholders of the project. This means that involving non-academic stakeholders in the entire knowledge creation process remains a challenge for many TD projects.

Lastly, Lawrence et al. (2022) and Brandt et al. (2013) describe the challenge of evaluating the societal and scientific impact of TD projects. Specifically, there is a lack of cohesive methods for measuring and evaluating the societal effects and impacts generated by TD projects. This lack of cohesive methods inhibits the demonstration of the success and long-term, positive effects TD projects have on the problems they address (Mann & Schäfer, 2018). Without this justification, TD projects often struggle with creating legitimacy and validation for the importance of their efforts.

Many case studies included in this review describe one or more of the challenges as described by Lawrence et al. (2022) and Brandt et al. (2013). For example, Siebenhüner (2018), Mitchell et al. (2017), and Jakobsen et al. (2004) describe the challenge of diffuse definitions. Reports of different interpretations of (discipline specific) applications of methodologies being a challenge are described by Jakobsen et al. (2004) and Zhuang et al. (2021). The specific presentation of each challenge varies across each case study but can be summarized in one of the five challenges. Nevertheless, context and project specific challenges that do not fit the categories proposed also remain and should not be disregarded.

2.5.2. SUCCESSES

Similarly for challenges, literature describes successes that were observed in TD project evaluations. However, there is a less defined definition for what success entails within a project. This often relates to the lack of structures for systematically evidencing success beyond achieving the project's goals (Karcher et al., 2021). In this thesis, a success is defined as the aspects of the project's process that went well or were experienced as such by involved stakeholders. Karcher et al. (2021) have summarized three successes identified in the evaluation of TD projects as usability, social outcomes and process components.

They describe that the usability of the created knowledge in TD research is often referenced as a measure of success for TD projects. This usability is mostly described in terms of the credibility, legitimacy and salience of the created knowledge. These concepts are mostly related to academic usability of knowledge that can be produced in projects. Besides that, usability is also related to the relevance, comprehensiveness, accessibility and solution orientation of the knowledge that is created. These concepts relate more to the practical usability of the knowledge that is created. Social outcomes and process components describe the successes that are experienced in TD projects that are non-linear, less visible and related to relationships and mindsets (Karcher et al., 2021).

Though these descriptions provide some direction on what successes are in TD projects, the definition of success enjoys great diversity in project evaluations (Karcher et al., 2021). Besides that, assessment of TD projects in practice often focus on the outcomes, results of a project or the ability to achieve its goals. However, as described by Karcher et al. (2021) process components are also relevant in defining the success of a project. Jakobsen et al. (2004) describe these process components as facilitators in their case studies' process. Yet, their

description of the facilitators in their case studies only focus on how the project's challenges were or can be overcome. This type of successes is observed in several articles included in the literature review. Though it is relevant to TD projects how challenges can be overcome, the specific description of successful TD research remains limited.

2.5.3. PRECEPTIONS OF CHALLENGES AND SUCCESSES

As highlighted by Karcher et al. (2021), success in TD projects encompasses great diversity. This diversity also exists in the challenges that can be identified in TD projects as described in Section 2.5.1. One of the sources of this divergence of challenges and successes in TD projects is the specificity of the context in which the projects operate. However, another contributor to the great variety of challenges and successes experienced in TD projects are the people involved in the project that have different perspectives and perceptions of these challenges and successes (Hoffmann et al., 2017). The personal experience a stakeholder has in the project's processes or activities is grounded in subjectivity and the uniqueness of the person representing the stakeholder. As TD projects focus on collaboration between people, the experiences of what went well and what was difficult in the project's process are inevitably diverse.

The assessment of the success of a project is also related to these subjective perspectives on the project's process. Whether stakeholders are satisfied and content with the way in which collaboration is organized and the results it produces is an assessment based on the perceptions of the challenges and successes of these stakeholders. The perception of challenges and successes also relates to the difficulties assessing the impact of TD projects (Karcher et al., 2021). Often, vagueness of results and project impacts are preferred over specific, detailed ones as different stakeholders need to agree with them. By leaving overall project results ambiguous, more stakeholders are able to reach consensus and find themselves in the presented outcomes (Lang et al., 2012). Even though the measurement of impact is complex and often difficult, the consensus that is required in the project's outcomes contributes to the challenge.

2.6. KNOWLEDGE GAP

During the literature review, three knowledge gaps have been identified. The first knowledge gap that has been identified is the lack of specific definitions describing TD research. As described in Section 2.4, general descriptions of what TD research entails are provided in literature. However, what TD research entails, which activities can be identified as inherently TD in nature or which characteristics are imperative for calling a knowledge creation approach TD lack specification. The absence of defined concepts in TD research contributes to a more challenging implementation of TD research in climate adaptation projects. Specifically, the difficulties in implementing TD research are highlighted by the gap between the theoretical 'best practice' of TD research and the actual implementation in projects as described by Lawrence et. al (2022) and Brandt et. al (2013). This lack of structure stems from a diffuse set of concepts that are used to describe TD research hampering the practical implementation of theoretical concepts.

This leads to the second knowledge gap that has been identified, which is described as a limited understanding of the benefits and risks of TD research and the approach being implemented solely to fulfil funding requirements or because knowledge integration inherently creates 'better' knowledge (DeLorme et al., 2016; Klenk & Meehan, 2015). Even though TD research is a process focussed on the collaboration between people, concepts such as satisfaction, personal challenges and perceptions lack specification. As a result, stakeholders that participate in TD projects are unaware of the competencies and lessons that can be learned and developed through TD research. This is exaggerated by the lack of defined competencies and learning objectives that are relevant to TD research. Competencies for conducting, facilitating and participating in TD research are developed by stakeholders of TD projects but lack sufficient structure and definition. This results in stakeholders not understanding what they could gain from TD projects. Also, undefined learning objectives contribute to a lack of coherence in competencies across projects, a difficulty with determining which skills are required to further improve TD projects and a limited ability to develop competencies to their full potential during projects.

Lastly, the third knowledge gap that has been identified relates to the lack of assessment criteria that are able to assess the subjective experiences, progress and results of TD projects. As described in Sections 2.5, measuring

the success of TD projects remains a challenge. The success criteria that are currently used to assess the progress of TD projects are, in practice, often focussed on objective, end-of-project results and the impacts projects generate by achieving their goals. Even though TD projects are characterised by continuous evaluation and reflection, the assessment of successful processes beyond the achievement of specific goals of the project lack definition. Specifically, the internal review and assessment of the processes and collaboration activities remain scarcely defined in literature.

To fill these knowledge gaps, this study aims to organize the definitions and characteristics of TD research and structure the opportunities for learning and reflection throughout TD projects. By addressing these knowledge gaps, stakeholders involved in TD research will be better equipped to address the challenges they face and grow the success of their projects. Section 3 provides an overview of the research questions that are used to support this study and describe how the answers to these questions fill the identified knowledge gaps.

2.6.1. SCIENTIFIC AND SOCIETAL RELEVANCE

By addressing the knowledge gaps identified in the literature review, conclusions relevant to both science and society will be synthesized. First of all, the structural organisation of TD concepts and defining the learning objectives that are relevant to TD research improves the scientific understanding of collaborative knowledge creation efforts. With this increased understanding, scientific research can better implement their efforts to create practically relevant knowledge. These efforts further the understanding of climate change and how humans impact and adapt to the changing climate.

Besides that, in societal aspects, the knowledge that is created through TD collaboration initiatives is of great importance to develop climate adaptation strategies. TD projects create practically relevant and practically implemented knowledge. As society struggles to adapt to the changes brought about in the climate, development of technologies and strategies that help in the process of creating a more resilient and sustainable society is of utmost importance. By aiding academic and non-academic stakeholders in developing more effective collaboration initiatives and help them address challenges and successes in their project using practical project experiences, more meaningful knowledge can be created to further both scientific and societal development.

2.6.2. RELEVANCE OF THE MASTER PROGRAM

Climate adaptation is a complex, multi-dimensional problem that requires a comprehensive understanding of its various aspects. In order to develop effective technological solutions in this domain, it is essential to organize and contextualize these complexities. TD projects play an essential role in generating relevant knowledge for climate adaptation by bringing together diverse stakeholders who collaborate to address climate challenges. By integrating knowledge from various disciplines, such as natural sciences, engineering, social sciences, and policy, TD projects can effectively address the complex and interconnected issues related to climate adaptation. This is an integral part of the Master program Complex Systems Engineering and Management. Specifically, experience in stakeholder analysis and being able to identify different perspectives in projects and addressing them during analysis is a significant part of the program. Besides that, systems thinking plays a crucial role in grasping the complex interactions and addressing the challenges and successes of TD projects.

The stakeholders involved in TD projects for climate adaptation encompass a wide range of backgrounds, goals, and interests. This diversity is intentional and contributes to the practical relevance of the knowledge created. When analysing the challenges and successes encountered in TD projects, it is important to appreciate and consider the diverse perspectives and expertise of these stakeholders. Their contributions play a vital role in shaping the outcomes and effectiveness of the projects.

Lastly, the technological aspects of the development of solutions to climate adaptation are crucial to the TD projects included in this study. The bridging function between technological and societal aspects of these projects is a major part of the Master's program. As a systems engineer, the Master's program provides education on how the languages of engineers, policy-makers and practitioners differ and can be translated across the disciplines. Being able to understand and translate perspectives of both technical oriented stakeholders and more practically oriented stakeholders is relevant to integrating the different dimensions relevant to TD projects.

3. RESEARCH QUESTIONS

To fill the knowledge gap identified in Section 2.6, a research question that guides this research has been formulated. By providing an answer to the following research question, the identified knowledge gaps will be filled. The question is formulated as follows:

How can transdisciplinary, climate adaptation projects better address their perceived challenges and successes?

The goal of this research question is to provide recommendations to the stakeholders involved in TD projects on how they can better address the challenges and successes in their projects, while taking the different perceptions of these aspects into account. This goal is specifically aimed at highlighting the project team's perspective in addressing challenges and amplifying the successes to achieve the goals of the project.

This thesis is focussed on three projects that implement TD knowledge creation approaches to develop solutions for different climate adaptation themes. The projects have been analysed in previous studies (Koopal, 2023; Limburg, 2023; Zegveld, 2023). This study uses the results from these studies as input and follows up on the results by discussing them with the stakeholders involved in the projects. Further elaboration on the projects, their research design and the results used as input is provided in Sections 5, 6, and 7.2 respectively. By collecting and analysing the perceptions and experiences on challenges and successes from stakeholders, this research aims to gain insight in how perceived challenges and successes can better be addressed in TD projects. The conclusions and recommendations from these three projects are generalized to suggest implications for future TD projects focussing on climate adaptation and how they can take perceptions into account.

3.1. SUB-RESEARCH QUESTIONS

As described in Section 2.4, different definitions and explanations of TD research exist in literature. Also, Section 2.5 describes the importance of context in TD projects. These factors lead to great variety between TD projects. To compare perceived challenges and successes across cases, a fundamental structure describing the aspects that are at the core of TD projects needs to be established. These aspects are described as key components of TD projects and structure the processes in TD projects. To accomplish this, the following sub-research question is included in the thesis:

RQ1: What are the key components of transdisciplinary projects for climate adaptation?

This research question provides structure to the analysis and comparison of the three projects included in this thesis. Specifically, the goal of this research question is to develop a framework in which the key components of TD projects are defined and their relationships are highlighted. By developing this framework, the perceived challenges and successes can be placed into the context of the project while also being comparable with other projects. To develop the framework, literature and TD experts are consulted (Sections 7.1 and 7.4.1).

Challenges and successes of a TD project are perceived by the stakeholders that are involved in the project. The previous studies on the three TD projects focussed on uncovering these perceived challenges and successes present in the projects in relation to the key components of TD projects. The stakeholders involved in the projects perceive the challenges and successes, form an opinion on them, and influence how they are addressed. In answering the question of how projects can better address the perceived challenges and successes, it is important to identify which challenges and successes are most important in the projects and where in the project they occur. The most important, or 'main', challenges and successes are identified by how often the challenges and successes are repeated by stakeholders. Besides that, where in the project the challenges and successes are perceived is identified through their relationship with the key components of TD projects (Koopal, 2023; Limburg, 2023; Zegveld, 2023). To uncover the main challenges and successes perceived in the three TD projects related to the key components, the following research question is included:

RQ2: What are the main challenges and successes perceived in the three transdisciplinary projects related to these key components?

The data from the previous studies is used to identify the main challenges and successes perceived in the three TD projects. How this data was collected is described in Section 6. The data is analysed and the challenges and successes that are repeated by stakeholders are related to the key components of TD projects. The method for this analysis is described in Section 7.2. By identifying the main challenges and successes, suggestions for how they can be better addressed can be synthesized.

Finally, stakeholders perceive the challenges and successes in their projects and develop an idea on how they can be improved. Which improvements stakeholders suggest to address the perceived challenges an successes provides insight into which key components of their projects stakeholders think should be improved. These suggested improvements and the related key components of the project provide a better understanding of how the perceived challenges and successes can be better addressed. Therefore, the following research question is included:

RQ3: Which improvements do stakeholders envision to address the perceived challenges and successes in their projects?

The improvements suggested by stakeholders can be identified in the data collected during the previous studies. However, this data is focussed on identifying the main challenges and successes in the three TD projects and not on reflecting on the improvements that could be implemented. Therefore, this study collects additional data on which improvements stakeholders envision to improve their projects. This data is collected in a follow-up discussion with stakeholders involved in the three projects focussed on reflecting on the main challenges and successes identified in RQ2 and the improvements to address these. How this data is collected in described in Sections 7.4 and 7.5. By discussing the improvements stakeholders envision for their projects, ways in which perceived challenges and successes can be better addressed can be uncovered.

By developing a framework defining the key components of TD research and their relationships (RQ1), the first knowledge gap of insufficiently defined concepts in TD projects. Then, identifying the main challenges and successes that are perceived in the three TD projects (RQ2) and how stakeholders envision to address these challenges and successes through improvements (RQ3) addresses the second knowledge gap of a lack of understanding of what the benefits and risks are of TD collaboration. Specifically, this knowledge gap is addressed by the reflection on the perceived challenges and successes by stakeholders as they reflect on their perception of the project and what the challenging and successful aspects are they perceive. Lastly, the third knowledge gap is addressed through the reflection of the TD projects (RQ3) using the key components of TD projects (RQ1). By answering these sub-research questions, suggestions for how to better address perceived challenges and successes in TD projects for climate adaptation can by synthesized.

4. RESEARCH DESIGN

To answer the research questions, an analysis of TD knowledge creation for climate adaptation has to be conducted. The goal of this research is to explore the perceptions of stakeholders involved in TD projects on challenges and successes encountered in the project. This section describes the research design that is used to analyse these perceptions.

The research focusses on three TD projects addressing climate adaptation topics. Section 5 provides an elaborate description of the projects that are used in this study. To gain an in-depth understanding of the projects and explore the perceptions of the involved stakeholders, this study will follow a qualitative research approach implementing case-study research design (Creswell, 2009). Specifically, this research design will include a comparison of the three case studies and analyse the different perceptions on challenges and successes.

4.1. CASE STUDY RESEARCH DESIGN

Case studies are used to gain an in-depth understanding of a particular case taking into account the context in which the case occurs. It can specifically be defined as "the study of the particularity and complexity of a single case, coming to understand its activity within important circumstances" (Harrison et al., 2017, p. 6). As mentioned in the previous sections, knowledge creation for climate adaptation involves multiple dimensions and requires integration across various disciplines and stakeholder groups. With this research design, the complexities and variety of dimensions of can be explored and investigated in its real-life setting (Crowe et al., 2011; Harrison et al., 2017).

By implementing a case study research design, the circumstances that are relevant to the case can be included in the analysis. This is especially important when analysing the context dependent perceptions of stakeholders involved in TD projects. The case study research design enables the analysis of contextual factors that shape knowledge creation activities in climate adaptation projects (Brandt et al., 2013; Harrison et al., 2017). The perceptions of stakeholders and their interactions with the context of the cases can be examined and inform the recommendations for addressing challenges and successes.

Besides that, including multiple cases in the research design allows for a comparative analysis of the cases. This enables the examination of similarities and differences between the perception of challenges and successes of the cases. The comparison of cases can enable general implications of findings beyond the delineation of the projects (Crowe et al., 2011). This can be done by determining which the challenges and successes that are perceived by stakeholders are similar across cases. Though the generalizability of implications synthesized from case studies is limited, the findings can be relevant to not only the projects under study but also to other projects aiming to implement TD knowledge creation approaches. Further description of the limitations of the research design are addressed in Section 4.1.1.

As described in Section 2.5, a great variety of TD projects exist spanning many topics, dimensions and contexts. Therefore, it is infeasible to analyse all variations of TD projects within the time limit of this thesis. Instead, a selection of three cases has been made to collect data from and include in the analysis. The selection has been made based on the issue the project aims to address, the subsequent objectives the project focusses on, the variety of stakeholders that are involved and the accessibility to the project's coordinators and participants.

The cases included in the study have varying organisation structures and goals, though, they are all considered TD according to the working definition of this thesis (Section 2.4). Besides that, the five criteria described in Section 2.4 can also be identified in all three projects. Section 5 provides a description of the cases included in the study including the different issues and objectives of the projects and the involved stakeholders. Section 4.1.1 elaborates on the limitations of this research design and the selection of limited case studies.

4.1.1. LIMITATIONS OF THE RESEARCH DESIGN

While a case-study approach offers several advantages for studying knowledge creation for climate adaptation, its limitations should be considered and measures to ensure that the selected cases are representative and provide valuable insights into the broader research topic are taken.

This comparative case study involves a small number of cases, which limits the generalizability of the findings (Crowe et al., 2011). The specific characteristics and contextual factors of the selected cases may not be representative of other TD projects. However, the findings can still be relevant to not only the projects under study but also to other projects aiming to implement TD knowledge creation approaches for climate adaptation.

Besides that, selection bias should be addressed as a limitation of the research design (Harrison et al., 2017). All cases have been selected through the network of the supervisors, one supervisor is also involved in the cases themselves. To limit the bias in the collected results, this supervisor does not participate in the focus group discussions and is not involved in the active analysis of the data collected during the study. Also, the existing case data that was available on these case studies are reason for them to be included in this comparative case study. Lastly, it should be noted that the selection of the cases is not exhaustive and a comparison between other cases could generate different results.

Bias from the researcher themselves should also be taken into account. As the research design involves interpretation and subjective judgement, the researcher's biases and interpretations can influence the selection and interpretation of the data. To increase the objectivity of the study, the researcher employs reflexivity and discusses the findings with a supervisor of the study (not the supervisor involved in the three case studies). Despite these limitations, a comparative case study remains a suitable approach for this study and provides in-depth insights into the complex natures of TD projects for climate adaptation.

4.2. METHOD

As described, the research design of this study follows a comparative case study approach. This thesis undertakes a comprehensive re-analysis of data extracted from three distinct case studies, each rooted in the domain of climate adaptation. Additionally, the study follows-up on the results in a focus group discussion with the stakeholders of each case study. The previous studies, constituting Bachelor's theses conducted at the TPM faculty of the TU Delft, individually examined challenges and successes of TD projects for climate adaptation within different domains (Koopal, 2023; Limburg, 2023; Zegveld, 2023)[*]. The three cases span the climate adaptation related topics of floods, agriculture and energy and are described in detail in Section 5. This section provides an overview of the methods that were used to collect the existing case data that is used as input for this study.

To visualise the methodological steps and ways in which the collected data relates to the research questions, a research flow diagram of this study was constructed. Figure 2 depicts this research flow diagram and highlights which methodological steps include existing case data and which steps collect new data. As can be seen, the methodological steps of this study are interrelated and one step provides input for other steps. To structure the description of the methodological steps in a clear way, a detailed description of the methods used is provided in the respective result sections describing the results collected through these methods. This section provides a general overview of the method that is used to collect the data for this study.

To answer the research questions described in Section 3, qualitative data to explore the perceptions of stakeholders is required. The primary method of collecting this qualitative, empirical and rich data are focus group discussions held with the stakeholders of the case studies. To structure the definitions related to TD projects and provide a foundation for analysis and interpretation, a theoretical framework based on the framework used in the previous studies is defined. By using a theoretical framework, the knowledge gap of

[*] These theses are not publicly available but are referenced to properly acknowledge the work from the researchers involved in the theses.

insufficiently defined concepts identified in Section 2.6 can be structured and an overview of concepts can be created. Specifically, conceptual clarity is imperative for this study as definitions vary throughout the literature and various conceptual frameworks identify different components related to TD research (Djenontin & Meadow, 2018).

The use of a theoretical framework aids in the collection and comparison of data across cases. As the framework arranges the concepts used in the study, the data collected in the three case studies can be aligned and comparable. Lastly, a theoretical framework can support the interpretation of results by placing the research in the context of existing literature and theory. This contextual understanding enhances the interpretation of research findings and enables researchers to make connections between their study and the wider body of knowledge (Harrison et al., 2017). Overall, a theoretical framework serves as a guiding framework that shapes the entire research process, from conceptualization to interpretation. It provides a structured and systematic approach to research, enhancing its rigor, coherence, and relevance. How the framework from the previous studies is adapted to the framework used in this study is described in Section 6.1.1.

The data collected in the previous studies was analysed through thematic coding of the interviews. This means that the codes extracted from the interview transcripts were categorized based on the theoretical framework used across the studies and new categories were created if codes did not fit the predetermined framework. The codes were also labelled as challenging, successful or suggesting an improvement. A more detailed description of the data collection in the previous studies is provided in Section 6.1.2.

The theoretical framework used in the case studies has a similar structure to the theoretical framework used in this study. However, the framework used in this study includes adaptations leading to some concept definitions having a different nuance. Also, several components that were not included in the previous studies have been added to the framework[*]. This means that the previous analysis of the interview transcripts will not entirely fit the framework and definitions used in this study. Therefore, the codes extracted from the interview transcripts of the previous studies are re-coded using the framework and definitions from this study. This way, the categorization of data matches the definitions presented in the focus group discussions. The description of how the data is re-coded is provided in Section 7.2.

The primary method of data collection in this study are focus group discussions. Focus groups provide an interactive and dynamic environment that encourages the pre-selected participants to share their perspectives, experiences, and insights (Hennink, 2013). This data collection method is used as it is capable of facilitating interaction between participants and encourages discussion of the topics of the focus group. It is imperative to capture this interaction is the data collection as the differences between perceptions of challenges and successes affect the considerations that are taken into account in decision making. Therefore, solely relying on individual interviews with stakeholders is insufficient as reactions, interactions and feedback among stakeholders are not captured.

It should be noted that during a focus group discussion, the goal is not to reach a consensus among participants but rather to define the range of perspectives and issues that are experienced by participants (Hennink, 2013). By defining this range of perspectives on the challenges and successes that are experienced in the projects, the differences between these perceptions can be identified.

The focus group discussions are structured by the questions that participants discuss. These questions are based on the theoretical framework used to organise the key components of TD projects and elicit reflection on the improvements necessary to address the perceived challenges and successes. To ensure participants to the focus group discussion properly understand the questions it is necessary to adapt the framework to be able to facilitate a discussion beyond the presentation of concepts and definitions. To facilitate this, experts in TD research are consulted to discuss the understandability, completeness and relevance of the theoretical framework that is synthesized from literature. The interview is focussed on discussing the way in which the framework can

[*] The adaptation of the theoretical framework is described in Section XX.

structure the focus group discussion. Additionally, discussions with these experts that have experience with conducting TD research also increase the reliability of the framework as the experts review the theory, definitions and relationships between concepts and provide feedback. The detailed methodology for the expert interviews are discussed in Section 7.4.

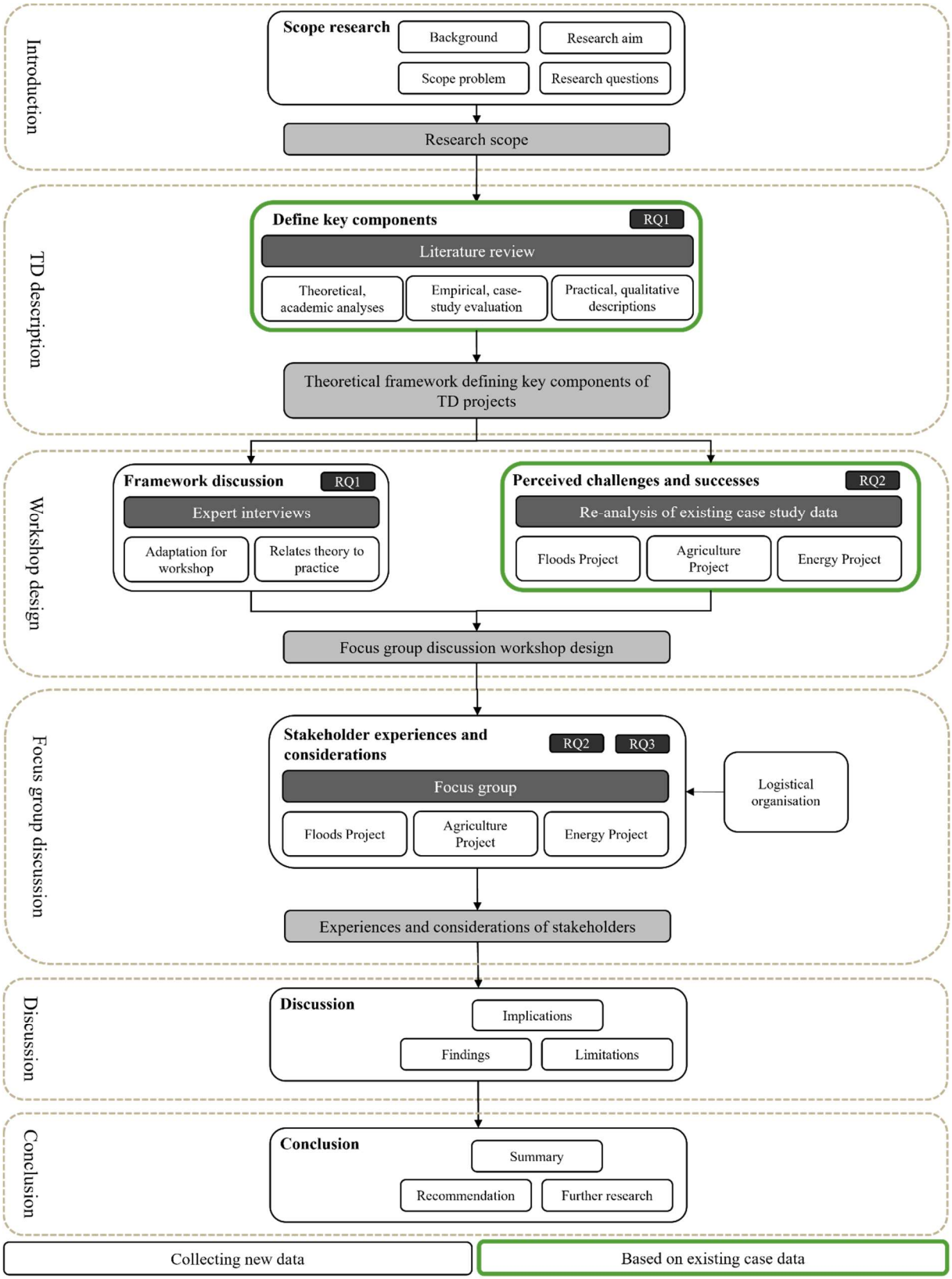


Figure 2. Research flow diagram.

4.3. VALIDATION AND RELIABILITY

Ensuring validity and reliability is crucial in the data collection process to enhance the trustworthiness and credibility of the research findings. Validity can be defined as "the precision in which the findings accurately reflect the data" (Noble & Smith, 2015, p. 1). Reliability is defined as "the consistency of the analytical procedures, including accounting for personal and research method biases that may have influenced the findings" (Noble & Smith, 2015, p. 1). To enhance the validity and reliability of the study, multiple strategies are employed. This section describes the strategies employed to promote validity and reliability in the data collection phase.

The reliability of data can be a challenge in comparative case studies. The accuracy and consistency of data across different cases may vary, particularly if the data is obtained from different sources or collected using different methods (Harrison et al., 2017). This is mitigated by using a structured discussion guide based on the theoretical framework to ensure consistency across focus group discussions (Noble & Smith, 2015). The guide includes open-ended questions and prompts that align with the research objectives. This approach allows all participants to have equal opportunities to express their perspectives and share their experiences, promoting reliability and enabling comparability across different focus group discussions.

In order to foster an environment for open and honest dialogue, efforts are made to establish rapport and trust with the participants. Clear explanations are provided regarding the research purpose, confidentiality measures, and the voluntary nature of participation. This encourages participants to feel comfortable sharing their views and experiences, enhancing the validity of the collected data by promoting authentic and uninhibited responses (Noble & Smith, 2015).

To further enhance the reliability of the data analysis, the re-analysis of the coding from previous studies is reviewed by a second researcher. This approach mitigates potential individual biases and increases the robustness of the analysis. The second researcher is the first supervisor of this study and provides feedback to the researcher on the coding that had been conducted. By implementing these methodological strategies, the validity and reliability of the collected data are strengthened. This results in robust and credible findings that effectively contribute to achieving the research objectives.

4.3.1. ETHICAL CONSIDERATIONS

This study will adhere to ethical guidelines, ensuring informed consent, confidentiality, and voluntary participation of all participants. Ethical approval is sought from the relevant institutional review board to ensure compliance with ethical standards and protect the rights and well-being of the participants.

Prior to participating in the focus group discussions, participants are provided with clear and comprehensive information about the research purpose, procedures, potential risks, benefits, and their rights as participants. Informed consent is obtained voluntarily and in writing. Participants have the option to withdraw from the study at any point without repercussions.

Participants' confidentiality is strictly maintained. Personal identifiers and any information that may reveal participants' identities are removed from the data and transcripts. This is with the exception of the roles participants fulfil in the projects. As different stakeholders participate in the focus group discussions, it is important to identify what type of stakeholder noted a particular experience. To minimize the risk of re-identification, the names of participants are not recorded in the writing and they are only referred to by the roles they fulfil in the projects. The storage of the data is done securely and sufficiently protects the participants' privacy and confidentiality. The storage time of two years is enforced by the responsible researchers and communicated to participants.

5. CASE DESCRIPTIONS

This section describes the case studies that were analysed in the previous studies and are compared in this study. All case studies focus on a topic related to climate adaptation. The first case study focusses on developing more adaptive river interventions to deal with extreme climate events such as floods. The second case study focusses on facilitating collaboration for sustainable agricultural development and management. Lastly, the third case study coordinates initiatives for future energy citizenship leaders.

All three case studies were accessible to this research as they all have a connection to or are based from the TU Delft, which is the same university for which this thesis project is conducted. Besides that, one supervisor to the thesis is involved in all case studies and therefore provides access. The limitations and potential conflicts of interests associated with this connection are discussed in Section 4.1.1. Lastly, the existing case data that was available on these case studies are reason for them to be included in this comparative case study.

This section first provides a description of the case studies that form the basis for this thesis. The issue the project aims to address, the subsequent objectives of the project and the variety of stakeholders that are involved are discussed for each case individually. The description of these cases are based on conversations with the project leaders and the online webpages describing the cases. However, due to privacy restrictions, the source material for these descriptions cannot be disclosed and is therefore referenced in anonymously.

5.1.1. FLOOD MANAGEMENT

The first case study included in this research is the TD project addressing the development of more adaptive river interventions to deal with extreme climate events, such as floods, in the Limburg province of the Netherlands. The case consists of one working group that is part of a larger, interdisciplinary initiative at the TU Delft. The working group focusses on the Limburg area that was affected by extreme floods in the summer of 2021. The goal of the working group is to aid in the development of a sustainable and resilient delta in the Meuse region of Limburg (Floods Project source 2). Specifically, the group focusses on research into flood risk management, flood damage, climate adaptation, hydrological assessments and historical comparisons (Floods Project source 2). This case is referred to as the Floods Project in the remainder of this thesis.

The primary objectives of the interdisciplinary initiative at the TU Delft are research, education and capacity building, collaboration and partnerships, and innovation and knowledge transfer. The Floods project also aims to contribute to these objectives by facilitating a collaborative and educational space for students and researchers in which participants are encouraged to exchange knowledge, data and advice during their research process (Floods Project source 1). Table 1 presents an overview of the stakeholders that are involved in the Floods Project. The table describes which stakeholders are involved, what their involvement entails and the motivation for participation in the project.

Table 1. Stakeholder description of the Floods Project, based on the project's website and Limburg (2023).

Stakeholder	Involvement	Motivation
Researchers **e.g. BSc and MSc students, PhD candidates, researchers doing an internship**	Participate voluntary in workshops aimed at facilitating the exchange of data, advice and experiences. Do research into topics relevant to practice.	Participating in the workshops helps researchers tackle problems and find the data they need for their research. Also, the workshops enable an open discussion of problems researchers run into during their research and facilitates overcoming these problems through discussion of advice and experience with other participants.
Policy practitioners **e.g. employees of the municipalities and regional water**	Have contact with the participants to provide practical insights and make data needed for research available to participants.	Coming into contact with the researchers conducting the researchers provides practitioners with new knowledge on how their systems can be optimized and their data can be analysed. Researchers provide

authorities		them with advice and do research that practitioners use in practical applications.
Field coaches **e.g. non-academic stakeholders with experience in the field of water management, flood management or other delta related industries**	Organize workshops aimed at facilitating the exchange of data, advice and experiences. They lead the discussion between participants and provide advice from their experience.	Leading the discussions on problems researchers face provides them with insights into the research that is being conducted in the working group. By organizing the workshops, coaches gain access to new knowledge being created and are able to provide their expertise in overcoming issues researchers face.
Coordinators	Coordinate and organize the workshops for participants and maintain contact with practitioners. They schedule field visits where participants and practitioners come together and exchange knowledge.	By coordinating the activities that make up the Floods Project, the coordinators ensure that collaboration between researchers and practitioners is facilitated. This is something they deem important for academic research and practice.

5.1.2. COASTAL AGRICULTURE

The second case study included in this research is the TD project enabling collaboration for sustainable agricultural management. The project focuses on coastal agricultural systems and brings together experts from various fields to develop sustainable solutions for coastal regions in the northern coastal region of the Netherlands. Specifically, the project addresses the issue of salination of freshwater used in agriculture, a problem that is exacerbated by a changing climate. The project aims to develop technologies and co-create knowledge to address this issue from multiple dimensions. The working groups that are part of the project focus on the pre-treatment of water, subsurface water storage, polder water management, crop resilience to salination and transition management of the adaptation to salination in agriculture. (Agriculture Project source 1) This case is referred to as the Agriculture Project in the remainder of this thesis.

The primary objectives of the Agriculture project are aiding in the development of sustainable coastal agriculture, integrated coastal zone management and facilitating knowledge transfer and collaboration (Agriculture Project source 1). The first objective addresses the development of sustainable agricultural practices specifically tailored to coastal regions. These practices will take into account the unique characteristics and challenges of such environments, including salination, soil erosion, and a changing climate. Besides that, the project seeks to promote an integrated approach to coastal zone management that considers both agricultural activities and the preservation of coastal ecosystems. It aims to find synergies between agriculture and coastal conservation, ensuring the long-term resilience and health of these vital coastal areas. Lastly, the project aims to facilitate knowledge transfer and collaboration among researchers, policymakers, farmers, and other stakeholders. By facilitating collaboration between academic and non-academic stakeholders, the project intends to bridge the gap between scientific research and practical application, resulting in innovative and sustainable solutions (Agriculture Project source 2). Table 2 presents an overview of the stakeholders that are involved in the Agriculture Project. The table describes which stakeholders are involved, what their involvement entails and the motivation for participation in the project.

Table 2. Stakeholder description of the Agriculture Project, based on the project's website and Koopal (2023).

Stakeholder	Involvement	Motivation
Commercial stakeholders **e.g. companies active in the agricultural industry**	Use the academic knowledge that is created in practice. They provide facilities and resources to implement the created knowledge or technology.	Using the created knowledge in practice provides them with practical, state-of-the-art solutions that are affecting their businesses. By participating in the project, they are able to engage with agricultural innovations and gain commercial benefits from the implementation of the technologies.

Non-governmental organizations (NGOs)	Contribute experience in sustainable agricultural practices. They ensure the project aligns with environmental protection goals and promote the long-term sustainability of coastal areas.	Contributing experience allows them to contribute to the preservation of coastal ecosystems and the well-being of coastal communities. They are able to raise awareness about environmental issues and promote their organizational mission.
Policy practitioners **e.g. employees of the municipalities and regional water authorities**	Facilitate the interaction between researchers and commercial stakeholders. They provide the information on regulations and offer their well-connected network to the project.	Facilitating the development of new technologies ensures that commercial stakeholders will be able to follow future regulations and comply with climate adaptation legislation. By enabling the collaboration between researchers and commercial stakeholders, the development of innovative technologies to mitigate salination issues is warranted.
Practitioners **e.g. farmers and other agricultural practitioners**	Use the academic knowledge that is created in practice. They provide insight into the reality of coastal agriculture and provide facilities and resources to implement the created knowledge as pilots or proof of concept tests.	Using the academic knowledge in practice helps them improve their farming practices, enhance productivity, and address the specific challenges faced in coastal areas. They gain knowledge and can access new technologies which increase the resilience of their business to salination of fresh water.
Researchers **e.g. professors, PhD candidates and students**	Do academic research on the topics placed central to the work packages. They collaborate across disciplines to create academic knowledge that is applicable in practice.	Doing research to develop solutions to the salination issues in agricultural coastal areas advances the academic knowledge on the topic and develops their academic profession. By collaborating with practice, they ensure the knowledge they create in academic settings will be able to make a real-world impact.

5.1.3. ENERGY CITIZENSHIP

The third case included in this research is the TD project focussing on the coordination of initiatives for future energy citizenship leaders. The project focuses on promoting citizen participation in the energy transition to achieve a just and inclusive decarbonization pathway, underscoring the significance of fostering an informed and engaged society to meld a sustainable energy future (Energy Project website source 1). Specifically, it aims to share knowledge and practices that encourage a diverse range of citizens to contribute to decarbonization efforts. The project involves studying real-life decarbonization initiatives to create a typology of energy citizenship for various citizen communities. These insights are intended to be integrated into models to understand the impact of energy citizenship on decarbonization pathways. This case is referred to as the Energy Project in the remainder of this thesis (Energy Project source 1).

The primary objective of the Energy project is to define, contextualize, and incorporate energy citizenship into decision-making processes. The project aims to achieve this by aggregating, operationalizing and disseminating energy citizenship concepts and inspire a wide population to engage in the energy transition (Energy Project source 2). The project also establishes an academy to share knowledge about energy citizenship, opportunities for the energy transition, and strategies for collaborative decision making with citizens and NGOs. The academy aims to mobilize actions for decarbonization, particularly among communities with limited participation in civic processes (Energy Project source 3). Table 3 presents an overview of the stakeholders that are involved in the Energy Project. The table describes which stakeholders are involved, what their involvement entails and the motivation for participation in the project.

Table 3. Stakeholder description of the Energy Project, based on the project's website and Zegveld (2023).

Stakeholder	Involvement	Motivation
Consortium partners **e.g. companies and consultancies active in the energy sector or other related industries**	Use the academic knowledge that is created in practice. They provide resources and practical expertise to promote the scalability of energy citizenship initiatives.	Using the academic knowledge in practice enables commercial stakeholders to align their practices with the goals of energy citizenship and demonstrate their commitment to environmental responsibility. They are able to identify innovative solutions that help them foster a sustainable energy industry.
Non-governmental organizations (NGOs)	Represent the interests of citizens and advocate for their needs in the Energy Project. They promote inclusivity and facilitate the participation of citizens in the project.	Representing the interests of citizens ensures the promotion of social and environmental justice. Their aim is to empower citizens in the energy transition and foster equality and a sustainable transition.
Policy practitioners **e.g. government employees at local, regional and national levels**	Incorporate the concept of energy citizenship into policy frameworks and decision-making. They raise awareness about the significance of inclusive decarbonization.	Incorporating the concept of energy citizenship into policy ensures that energy policies align with societal needs. They gain insight and evidence to support their decision-making processes.
Researchers **e.g. professors and PhD candidates**	Do research on the project's objectives and generate knowledge on inclusive decarbonization. They create models that contribute to evidence-based decision-making.	Doing research on the topics relevant to energy citizenship advances the academic knowledge on the topic and develops their academic profession. By collaborating with practice, they ensure the knowledge they create in academic settings will be able to make a real-world impact.

6. EXISTING CASE DATA

This section provides an overview of the methods that were used to collect data in the previous studies. During the data collection, the previous studies coordinated their methods to ensure the data that was collected would be comparable in a follow-up study. This was done by aligning the theoretical frameworks that were used to organize the concepts used in the studies. The theoretical framework was used as the foundation for semi-structured interviews with project coordinators and work package leaders. First, the theoretical framework is discussed, followed by the structure of the interviews.

6.1.1. THEORETICAL FRAMEWORK

To align the concepts of the previous studies, a theoretical framework was developed to organize the concepts of TD projects relevant to the studies. The theoretical framework is aimed at describing a desired TD research process and the concepts that are relevant to achieving this (Koopal, 2023). The theoretical framework that is described in this study (Section 7.1) is based on the aligned framework of the previous studies. This section provides an overview of the aligned framework that was used in the previous studies and provides context to the method with which the existing case data was collected. A detailed description of the theoretical framework that is used in this study is provided in Section 7.1.

The aligned framework of the previous studies describes the context and input to TD projects as initial conditions (Section 7.1.3) and highlights TD project phases (Section 7.1.2). Besides that, the requirements for successful collaboration are included in the framework (Section 7.1.4). These requirements are the same for all cases match the requirements included in this study. To assess the success of the projects, three success criteria are included in the framework (Section 7.1.7). Lastly, the results of the project are described as outputs, outcomes and impacts (Section 7.1.6).

Consulting additional literature, the aligned framework from the previous studies has been adapted for this study. The definitions of the components have been reviewed and further specified if necessary. Besides that, three components have been added. First, a phase 0 has been added to the project phases through which a TD project iterates (Section 7.1.2). Second, this study considers communication an additional requirement to the framework (Section 7.1.4). Lastly, the theoretical framework includes activity mechanisms to describe the types of activities performed during the project phases (Section 7.1.5). Figure 3 provides an overview of the theoretical framework used in this study.

6.1.2. CASE STUDY INTERVIEWS

For each case, interviews with work package leaders and project coordinators were conducted aimed at identifying challenges and successes in the project. The data collected in these interviews and the results of the analysis have been made available as input for this thesis and are used in analysis. The following section describes the method with which the existing case data was collected in the previous studies. All existing case data is re-reviewed in this study and serves as input to the analysis. Section 7.2 describes the way in which the existing case data has been re-analysed.

INTERVIEWEES

For the previous studies, a total of eighteen people were interviewed. The interviewees were selected based on their involvement in the projects and were intended to represent both the academic and non-academic stakeholders involved in the projects.

The study on the Floods Project conducted interviews with five people of which two were non-academic stakeholders. The academic stakeholders were involved in coordinating roles and can be categorized as coordinators. The academic stakeholders are from the Technology, Policy and Management, Civil Engineering and Architecture faculties of the TU Delft. The non-academic stakeholders were involved as field coaches in the Floods Project. Their professions are in the real estate sector and a member of the water authority. It should be noted that the interviews with project coordinators and work package leaders for the Floods Project did not solely focus on the stakeholders involved in the Limburg working group but also included coordinators from

other working groups. Nevertheless, the results are deemed applicable to the focussed perspective of the Limburg working group.

The study on the Agriculture Project conducted a total of six interviews with both academic and non-academic stakeholders. The five academic stakeholders are from the Social Sciences (2), Water Engineering and Plant Physiology disciplines. They are all involved in the project as researchers. The non-academic stakeholder that was interviewed can be categorized as a policy maker as they are an employee of the local water authority.

The study on the Energy Project conducted a total of seven interviews with both academic and non-academic stakeholders. They interviewed four academic stakeholders from three different work packages. The three non-academic stakeholders that were interviewed were involved in two work packages. All stakeholders that were interviewed had some leading role in the project.

INTERVIEW STRUCTURE

The interview questions of the previous studies were divided into three parts, initial conditions, requirements and expected results. All parts consisted of open ended questions with the exception of Part 3 in which two 1-10 rating questions were included. The goal of the questions in Part 1 was to collect information on the challenges and successes related to the initial conditions of the project. This part also included a general impression of whether TD collaboration was a desired way of working in the project and an overview of the stakeholders that are involved in the projects. Next, the interviewees were guided through the initial conditions (defined in Section 7.1.3) and asked to describe challenging and successful aspects related to these conditions. Part 2 of the interview focussed on the requirements (defined in Section 7.1.4) in the same way as in Part 1. Lastly, Part 3 included a general impression of the results that are expected from the projects and the planning. Next, the interviewee was asked to rate the effectiveness and efficiency of the project on a scale of 1-10. The interviewee could choose to further elaborate on their rating or leave their answer at the rating. To conclude the Part 3 and the interview, the interviewee could add any comments or remarks that had not been mentioned in the interview.

DATA ANALYSIS

To analyse the rich data collected from the interviews, the previous studies used content analysis to systematically examine and interpret the transcripts collected from the interviews (Koopal, 2023). By doing this, the data from the interviews was organized into quotes describing a specific topic. This quote was then categorized and coded based on the concepts in the aligned framework. This way, the rich data collected from the interviews could be used to identify and interpret perceived challenges and successes present in the case studies.

7. RESULTS

The methods as described in Section 4.2 have been conducted and used to collect data. This section presents the results of the data that was collected. First, the Theoretical framework is discussed. Next, the re-analysis of the existing case data is described and the perceived challenges and successes are summarized. Then, the interviews with experts are described and the workshop design for the focus group discussions is explained. Lastly, the results from the focus group discussions are presented.

7.1. THEORETICAL FRAMEWORK

TD research is a complex knowledge creation approach dependent on many different components and interactions. Literature often tries to capture this complexity and simplify the components to be able to specify which parts of the TD project are relevant to the study. This mostly results in a set of components being defined and linked in a framework. These frameworks focus on different details of TD projects and describe their components by different concepts. Concepts that are used are, for example, TD phases, TD criteria, focal areas of TD research and TD research steps (Djenontin & Meadow, 2018; Knickel et al., 2019; Lang et al., 2012; Polk, 2015). This section aims to integrate these different concepts into one framework to structure the key components of TD projects used in this study. By synthesizing a theoretical framework from existing TD research literature, the definitions and concepts used throughout the study can be defined and aligned. First, the method with which the theoretical framework was developed is described. Then, an explanation of the framework itself is provided. Lastly, a visualisation of the framework is depicted.

7.1.1. LITERATURE SEARCH

For this study, the theoretical framework is based on the literature review conducted in the previous studies analysing the three case studies. As described in Section 6.1.1, the previous studies used an aligned theoretical framework to structure the interviews with project coordinators and work package leaders (Koopal, 2023; Limburg, 2023; Zegveld, 2023). The review is enriched through forward snowballing and literature recommended by the supervisors overseeing this thesis. The collected literature has been thoroughly reviewed and a collection of concepts, definitions and relationships is identified. Using the identified concepts, the aligned framework developed in the previous studies is adapted to the theoretical framework used in this study. Section 6.1.1 provides an overview of the adaptations that were made. The theoretical framework serves as the basis for the analysis of the existing case data (Section 7.2.1) and provides a structure to the focus group discussion (Section 7.4).

The framework that is proposed aims to describe the ‘ideal’ TD project and TD research (Klenk & Meehan, 2015; Lang et al., 2012). Though, no ‘ideal’ execution of TD research exists, a comparison of the processes observed in the case studies can be compared to the framework’s description of the processes. The framework also serves as a structure for the focus group discussion as described in Section 7.4. The development of this framework is based on the theoretical frameworks synthesized in the previous studies as described in Section 6.1.1. This section provides an description of the framework and definitions that are used in this study. Appendix C - Table 1 provides an overview of the varying definitions that were used in the previous studies alongside the definitions used in this study.

7.1.2. TRANSDISCIPLINARY PROJECT PHASES

A research paper often referenced in literature describing TD research is the paper by Lang et al. (2012). They provide an overview of the TD project’s process and its activities. Their conceptual model describes TD projects in three phases in which scientific practice and societal practice collaborate to create knowledge. This collaboration occurs in an ‘interface practice’ in which research questions are triggered by societally relevant problems. The ideal-typical research process is an idealized representation of TD knowledge creation approaches that addresses real-world problems through problem solution in societal practice and scientific innovation in scientific practice (Lang et al., 2012).

The first phase that is conceptualized by Lang et al. (2012), is collaborative problem framing and building a collaborative research team (*Phase A*). During this phase, it is crucial that the real-world problem is reframed into a boundary object that allows the results of research to be re-integrated into both societal practice and scientific practice. The scoping that is done in this phase provides focus for the next phase. *Phase B* is described as co-producing solution-oriented and transferable knowledge through collaborative research. During this phase, the research is conducted with which the research objectives are reached and societally-relevant questions are answered. In the implementation of research methods, the level of stakeholder involvement should be matched with the type of research activity (Lang et al., 2012). Lastly, *Phase C* (re-)integrates and applies the co-created knowledge. This phase focusses on the (re-)integration of the results into both societal and scientific practice. This is enabled by the framing of the boundary object in Phase A (Lang et al., 2012).

Though the description of the phases can be interpreted as a linear sequence, in practice, the phases are often performed iteratively (Lang et al., 2012). Moving between phases often is a result of the emergence of new information or challenges requiring adjustments of the earlier phases. For example, during Phase B information is uncovered that requires the redefinition of the boundary object to ensure (re-)integration of the results remains achievable.

During a research project, all three phases are (iteratively) performed. However, Horcea-Milcu et al. (2022) determine that initiating a research project and reaching the start of a project also requires specific steps to be performed. They argue that these steps can be conceptualized in a '*Phase 0*' which exists before the research project is started. During this phase, the case study is selected, the context of the case is being understood and premises for coming together are fostered. As the framework constructed for this paper aims to integrate frameworks and describe the concepts of TD knowledge creation beyond the scope of the project, the Phase 0 is included alongside the three phases described by Lang et al. (2012) and is positioned before Phase A.

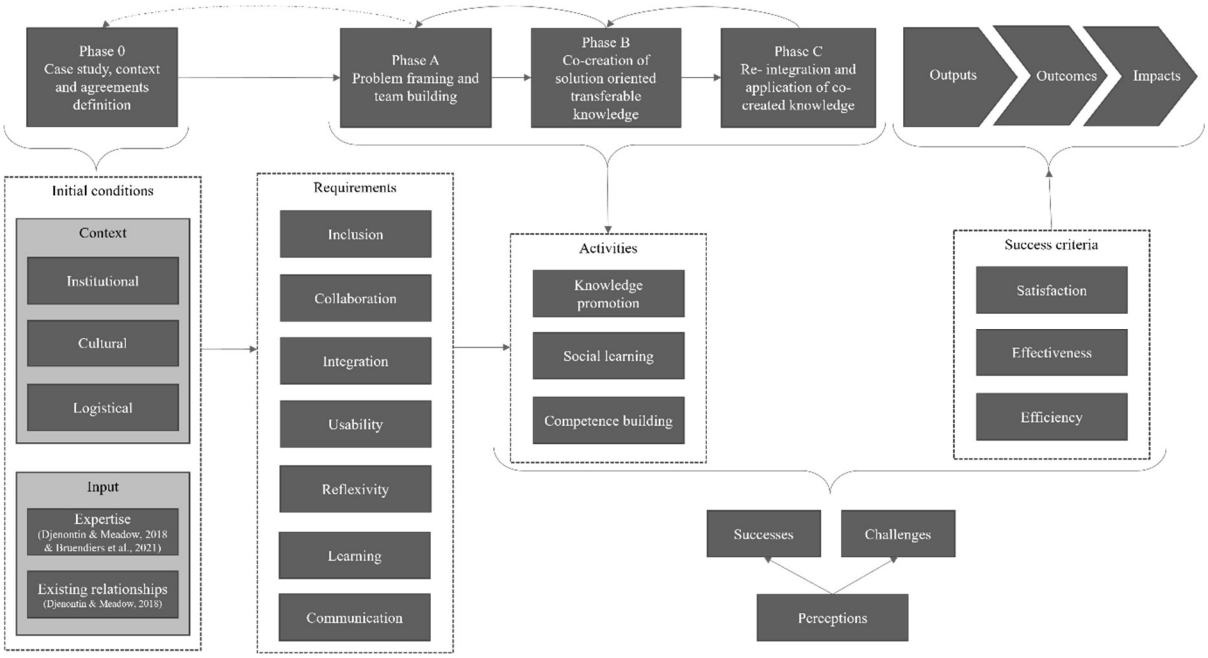


Figure 3. The visualisation of the theoretical framework.

7.1.3. INITIAL CONDITIONS

As described by Horcea-Milcu et al. (2022), TD projects are not limited to the project boundary. Activities preceding the start of the project and the conditions of the environment also limit or enable TD projects within the project boundaries. The activities that precede the start of the project are captured in Phase 0. However, the context-related concepts that do not involve activities performed by stakeholders in Phase 0 are not captured by the description of Horcea-Milcu et al. (2022). Djenontin & Meadow (2018) describe context concepts and co-production inputs that affect the processes in TD projects. These concepts can be argued to form the external or

input conditions to TD projects at the start of the project. Therefore, this paper describes these concepts together as *initial conditions* of TD projects.

CONTEXT CONDITIONS

The framework presented by Djenontin et al. (2018) does include a description of the context in which TD projects occur. They define the context as the environment of TD projects and factors beyond the control of the involved stakeholders. First, *institutional factors* are an important concept in describing the environment of a project. Management structures, funding regulations and academic institutions influence the way in which activities can be performed in TD projects. Besides that, *cultural differences* play an important role in the context of the project. Cultural norms can differ across organizations, institutions and countries and can affect the perception of TD projects in terms of expectations, communication and work-ethics (Djenontin & Meadow, 2018; Karcher et al., 2021). Lastly, *logistical factors* are identified as any limiting resource that affects the research process of TD projects, e.g. distance between actors, locations of research sites and time constraints. Specifically, case-specific locations can enable or inhibit the contact between stakeholders and the ability to conduct research (Djenontin & Meadow, 2018).

INPUT CONDITIONS

The environment in which the context of cases is described, is subject to slow changes. Specifically institutional and cultural changes can be compared to the institutional environment which is described to change over periods between ten and 1000 years (Williamson, 1998). These changes require significantly more time than the running time of TD projects and are therefore be assumed to be fixed during the project. With this assumption, the context of a project can be taken as an input that shapes TD projects. This relates to another concept relevant to the start of TD projects that is described by Djenontin et al. (2018) as the co-production inputs.

EXPERTISE

The co-production inputs entail the resources that are available to the project, e.g. funds, time and expertise. The first input is defined as the proficiency and *expertise* for knowledge production and entails the experiences stakeholders have with facilitating and participating in collaboration and knowledge creation efforts (Brundiers et al., 2021; Djenontin & Meadow, 2018). Crucially, this also includes the communication of research results to society. Even though this activity is part of Phase C of TD projects, the experience and ability to properly communicate results is at a certain level at the start of the project. Therefore, expertise forms an input to TD projects. Other competencies that are present at the start of the project and are therefore input expertise are the key competencies for sustainability (Brundiers et al., 2021). These competencies describe a Systems-thinking, Futures-thinking, Values-thinking, Strategic-thinking, Collaborative competency and an Integrated problem-solving competency as key competencies relevant to sustainability science. As climate adaptation projects, especially when they implement a TD knowledge creation approach, closely relate to sustainability science, these competencies are significant in TD projects (Brandt et al., 2013). Nevertheless, expertise is not something that serves as a static input at the start of a project. Section 7.1.5 describes activities in which these competencies can be developed.

EXISTING RELATIONSHIPS

Besides expertise, co-production inputs includes legitimacy and trust (Djenontin & Meadow, 2018). Trust is a crucial component of successful collaboration and requires effort to build and maintain (McGreavy et al., 2022). Building and fostering trusting relationships is especially important at the beginning of a project in the absence of already existing relationships. The specific term of trust is replaced in the framework by *existing relationships* as this effectively is the input that exists at the start of the project (Horcea-Milcu et al., 2022). Where trust building is an important activity in the early stages of the project, the relationships that already exist and the (dis)trust they bring about are present before the start of the project.

A similar argument holds for legitimacy and inclusivity. Legitimacy can be included as an input to the project as it can also require more effort at the start of the project (Djenontin & Meadow, 2018). However, similarly to trust building, creating legitimacy of the relationships, research and results is an activity that requires more effort

in the early stages of the project and is therefore not included as a separate condition in the initial conditions. Rather, the legitimacy that already exists at the start of a project is captured by the existing relationships. Lastly, inclusivity of the project is included as input by Djenontin & Meadow (2018), but in their definition rather serves as a requirement for the activities that are performed during the project. Therefore, inclusivity will be discussed and defined in Section 7.1.4.

7.1.4. REQUIREMENTS

Knowledge that is created in TD projects is expected to be (re-)integrated in societal and scientific practice when it is communicated as results. To comply with these expectations, requirements that TD projects should fulfil can be described. These requirements serve as goals for the activities performed in the TD project or internal project requirements. Achieving these goals ensures the (re-)integrative ability of the created knowledge. Requirements can be used to support, manage and evaluate activities with TD projects. Polk (2015) describes such requirements for TD knowledge production.

The first requirement is *inclusion*, meaning that stakeholders from both societal and scientific practice are represented in and have power over the entire knowledge production process (Polk, 2015). This is the same concept as the input of inclusivity described by Djenontin et al. (2018). However, as the concept requires activities that are performed in the TD project to be inclusive (e.g. all stakeholders are equally included in and entitled to the knowledge creation process), the concept is included as a requirement in the framework. The second requirement is *collaboration*, which means the activities, way of working and roles that lead to in-depth contributions to the knowledge creation from both societal and scientific practice (Polk, 2015). Besides that, the requirement of *integration* requires activities in TD projects to assimilate, combine and synthesize both societal and scientific perspectives, values, knowledge and expertise (Polk, 2015). The goal of this integration is to be able to capture the complexity of the issue that is being addressed. Also, *usability* requires stakeholders to assess and reflect upon whether the activities create knowledge that is socially robust (e.g. accessible and understandable) and has a transformative capacity (e.g. applicable and relevant) (Polk, 2015). Lastly, *reflexivity* requires for continuous scrutinization of and reflection on activities and their preceding or subsequent choices from both societal and scientific perspectives.

The five requirements as described by Polk (2015) are intended to describe all facets of TD research. However, different sources suggest that there are more requirements that the activities in TD research need to fulfil. For example, Knickel et al. (2019) suggest a total of 44 criteria to assess the TD research process. In other literature, two more requirements are often described as imperative in TD projects. These requirements are learning and communication. *Learning* describes the extent to which involved stakeholders are able to and willing to learn and develop certain competencies with, to and from other involved stakeholders and the process (Brundiers et al., 2021; Hoffmann et al., 2017; Knickel et al., 2019; Siebenhüner, 2018). *Communication* describes the dissemination of results within and beyond the delineation of the project (DeLorme et al., 2016; Gaziulusoy et al., 2016; Knickel et al., 2019). Together, these seven requirements enable the way in which activities should be initiated, managed and performed. Besides that, the requirements serve as goals and quality requirements for the results that are produced through the activities.

7.1.5. ACTIVITIES

Once the project has started, several activities are performed by the stakeholders involved. The ultimate goal of these activities is to generate lasting impact for climate adaptation. However, as described in Section XX, the evaluation of societal and scientific impact remains a challenge for TD projects (Brandt et al., 2013). This also results in difficulties identifying the ways in which impact is generated (Schneider et al., 2019).

Lang et al. (2012) specifically call for the active design of stakeholder participation in TD projects. They propose design principles consisting of activities or tasks that can be assigned to specific stakeholders participating in TD projects. However, the activities they describe are narrowly defined in terms of what action should be performed and which goal should be fulfilled. Schneider et al. (2019) posit that larger, more abstract impact generating mechanisms can be identified in TD projects. These mechanisms describe activities that closely relate to the

requirements described in Section 7.1.4. This is because the requirements can be used to support, manage and evaluate activities with TD projects and are therefore directly related to the activities.

The first mechanism is promoting system, target and transformation knowledge for more informed and equitable decision-making (Schneider et al., 2019). The knowledge that is created within the project is transferred to other people where it triggers action. For this to happen, the knowledge that is created through the collaboration within the project should be of proper quality and useful to practice. This means that the knowledge should fulfil the requirements described in Section 7.1.4. The promotion of this knowledge is mostly focussed on stakeholders that are involved in the project. This means that there is active knowledge exchange of the three types of knowledge between stakeholders through close collaboration. Besides that, the promotion of knowledge beyond the delineation of the project is also part of this activity. This involves the presentation and teaching of the created knowledge to stakeholders that are not necessarily involved in the project (Schneider et al., 2019). This mechanism is closely related to the requirement of communication in which the results that are created in the project should be disseminated beyond the delineation of the project.

The second mechanism for impact generation is fostering social learning for collective action. This mechanism aims to enhance the agency of stakeholders involved in the project and motivates initiatives for joint action. The collaboration of stakeholders in TD projects and subsequent knowledge creation is a result of coordinated actions and can actively be initiated (Lang et al., 2012; Schneider et al., 2019). This mechanism closely relates to the requirements of inclusion, collaboration, integration, usability and learning, as is focusses on including the relevant stakeholders in the collaboration and integrating their knowledge to create usable knowledge and learn from their experiences.

The final mechanism is enhancing competences for reflective leadership. Specifically, by engaging in collaboration with research providers and research users encourage learning, self-reflection and competence building. The mechanism that is described by Schneider et al. (2019) only describes competencies for reflective leadership. However, the input expertise for the TD project, described in Section 0, includes more competencies than only those related to reflective leadership. This paper includes all the expertise that is part of the initial conditions as competencies that are developed in this mechanism. This is because stakeholders develop a broader set of competencies when engaging in the active learning that is part of TD projects (Brundiers et al., 2021). The impact that can be generated in this mechanism is the improved expertise of stakeholders, which again serves as an initial condition for any future TD project the stakeholders participate in. This mechanism is closely related to the requirements of reflexivity and learning as it describes the way in which competencies can be developed (learning) which includes reflection on the process.

Comparing the generic mechanisms for impact generation in sustainability transformations to the design principles proposed by Lang et al. (2012), leads to the conclusion that the mechanisms are a higher level of analysis encompassing more than the activities described in the design principles. Therefore, these impact generating mechanisms are included in the framework.

7.1.6. PROJECT RESULTS

Finally, there are concepts that can be used to describe the results of TD projects. The results are produced by stakeholders performing activities in a certain way. Like the activities, these results can be evaluated with the requirements described in Section 7.1.4. By ensuring the results fulfil the requirements of TD research, the quality of the created knowledge and its relevance to the real-world issue that is addressed by the project can be assessed.

The results can be grouped in three categories based on the timeframe of the result. First, the short-term management and communication of results are categorized as outputs. This specifically includes the dissemination of the created knowledge and making it available to stakeholders. These stakeholders can be involved in or outside the scope of the project (Djenontin & Meadow, 2018). The next timeframe of results are the outcomes. These types of results are the ones with which the success of a project is often assessed. Outcomes are often described by the objectives of the project and are the envisaged, immediate result that are aimed to be produced by the project (Djenontin & Meadow, 2018; Schneider et al., 2019). The longest timeframe of results

are the impacts that are generated by the project. These are the long-term changes that occur as a result of the projects efforts. Measuring this impact on the societal plane of TD projects is highly complex and remains a challenge (Hessels et al., 2018; Schneider et al., 2019).

7.1.7. SUCCESS CRITERIA

While the success of a TD project is often measured in the ability to achieve the projects objectives or attempted to be assessed by measuring societal and scientific impacts, internal process evaluation is also relevant in evaluating the success of TD projects (Karcher et al., 2021; Mann & Schäfer, 2018). Defining success criteria for the evaluation of the success of the project's process can be useful in this evaluation.

These criteria can be based on the perceptions stakeholders have of how successful the project's process is, as stakeholders have direct experiences with the process. Specifically, the level of satisfaction of the stakeholders involved, the effectiveness and the efficiency in the project are ways in which the project's success can be captured. The *satisfaction* of stakeholders with the project is measured in a general level of happiness and pleasure stakeholders gain from the project (Knickel et al., 2019). Besides that, *effectiveness*, i.e. the ability to succeed and produce the intended results, can be used as a measure of success in TD projects. This criterion is closely related to the general measurement of success, i.e. the ability to achieve the project's objectives. However, effectiveness not only measures the project's objectives but also evaluates the project's internal deliverables and ability to reach deadlines (Knickel et al., 2019). Lastly, the efficiency, or ability to achieve the results without wasting resources, is included in the framework as a success criterion. This criterion is influenced by the individual perception of wasting resources as not every stakeholder will view the use of resources in the same way (Hessels et al., 2018).

7.1.8. VISUALISING THE COMPONENTS OF TD RESEARCH

As described, many different components are relevant to TD research. This section has aimed to collect and relate the key components that are present in TD projects. These components are grouped in the project phases, initial conditions, requirements, activities, results and success criteria. In these groups, the initial conditions are the external conditions that are set in the context of the project and cannot be influenced by the stakeholders. The requirements are the internal project requirements that can be influenced by stakeholders by changing the way they organise their activities. The activities are performed by stakeholders in certain project phases and produce results that should be in compliance with the requirements of the project. The success of the project and its results can be evaluated with the success criteria. As the project progresses, challenges and successes arise. The activities, challenges and successes and success criteria are perceived by stakeholders that are involved in the project. Figure 3 presents the components and their relationships in a framework that will be used for this study. With this framework, the many components related to TD projects are defined and organized. The following sections describe how this framework can be used to structure the experiences of stakeholders involved in TD projects.

7.2. ANALYSIS OF EXISTING CASE DATA

To ensure the existing data from the previous studies are analysed using the same definitions and coding scheme as this study, the re-analysis of the coded interviews is required. The re-analysis included a re-categorisation of the codes extracted from the interviews with work package leaders and project coordinators using the definitions from the adapted framework described in Section 7.1. The re-analysis also includes a synthesizing step in which the most important challenges and successes are summarized and used as input to the focus group discussions. This section provides an overview of the existing data, describes the re-coding process and presents the results that are used as input for the focus group discussions.

7.2.1. ANALYSIS OF EXISTING CASE DATA

The three case studies that have been selected have been analysed individually in three, separate, previous studies. So, data from interviews with work package leaders and project coordinators exists and has been previously analysed. When collecting the data for the previous studies, efforts were made to coordinate the interview structures and analysis methods to ensure that results could be compared. This resulted in the theoretical framework, interview questions and way of analysing the interview transcripts following a similar enough structure for comparison. To accommodate for the contextual differences between cases, some liberties were taken in the concepts that were included in the theoretical framework. Though, the fundamental structure of the framework remained the same across studies.

RE-CODING OF THE EXISTING DATA

The interviews conducted in the previous studies were analysed through thematic coding of the interviews. This means that the codes extracted from the interview transcripts were categorized based on the theoretical framework used across the studies and new categories were created if codes did not fit the predetermined framework. The codes were also labelled as challenging, successful or suggesting an improvement.

The theoretical framework used in the case studies has a similar structure to the theoretical framework used in this study. However, some concept definitions have a different nuance and several components that were not included in the previous studies have been added to the framework. This means that the previous analysis of the interview transcripts will not entirely fit the framework and definitions used in this study. Therefore, the codes extracted from the interview transcripts of the previous studies are re-coded using the framework and definitions from this study. This way, the categorization of data matches the definitions presented in the focus group discussions.

To re-analyse the interviews from the previous studies, the interviews were re-categorized where the theoretical framework serves as a thematic categorization based on the key components of TD research. Within the key component categories, sub-categories are created of thematic ‘families’. These sub-categories are generalizable across the three cases and can be compared in analysis. The codes in the sub-categories are then further separated in specific descriptions for challenges and successes that were perceived by the interviewees in each of the cases. This further categorization is case-specific and not generalizable across cases. The label for challenge, success or improvement is also used in this re-analysis. The re-coded and re-analysed interviews provide case-specific input for the focus group discussions.

Through the re-coding of the interviews with work package leaders and project coordinators, an overview of the perceived challenges and successes can be synthesized. It should be noted that this re-analysis focusses on the challenges and successes, not the improvements that are suggested by the interviewees. By focussing on challenges and successes and asking participants to suggest improvements, the improvements that are suggested by participants during the focus group discussions can be compared with the previously collected data.

7.3. RE-ANALYSIS OF EXISTING CASE DATA

To analyse the interviews using the definitions provided in the theoretical framework from this study, the interview transcripts need to be re-reviewed. This section describes the process how the re-analysis of the existing case data was done and what the results from this re-analysis produced.

7.3.1. CODING SCHEME

For the analysis in the previous studies, the transcripts that were generated from the interviews were coded according to a coding scheme. This coding scheme was based on the theoretical framework including the definitions for the initial conditions and requirements. As described in Section 6.1.1, the definitions of the components was slightly different in the previous studies. Therefore the quotes that were extracted from the interviews in the previous studies are re-categorized to match the definitions used in this study. The coding scheme specifically focuses on the initial conditions and requirements as these were specifically discussed in the interviews with TD experts (described in Section 7.4.1). Quotes that do not fit this scheme are labelled with 'None'. Besides that, quotes are marked as a challenge, success or improvement.

To further categorise a quote, a category is created for quotes that describe a certain theme of challenges or successes. These categories are general and can be compared across cases. Within these categories, the case-specific description of the challenge or success is described. Quotes that were categorized under 'None' were further categorized in four themes, context, insufficiently substantiated, not in framework and TD definitions. These quotes were used by the researcher to generate a better understanding of the context of the projects and how TD research was defined during the interviews and are discussed in Section XX.

Table 4 provides the number of quotes per interviewee from the previous study (P) and from the re-coded analysis (C). It can be seen that the total number of quotes is higher for all cases, this is because some quotes have been split to form new quotes. By doing this, the categories could be better applied to the quote. Appendix D - Table 1 provides an overview of the overarching categories that are synthesized from the recoded quotes. These categories are generalized across cases. This appendix also provides an overview of the case-specific challenges and successes per category for each case that have been synthesized from the interviews.

Table 4. Overview of the interviewees and number of codes extracted from their interviews.

	Floods	P	C	Agriculture	P	C	Energy	P	C
	A-TPM	72	82	AGR01	37	44	WP1.AC	48	50
	A-Civil	39	46	AGR02	28	33	WP3.AC	35	38
	A-Architecture	45	48	AGR03	28	38	WP3.N-AC.1	26	27
	NA-Gov: Real estate	33	41	AGR04	28	31	WP3.N-AC.2	28	30
	NA-Gov: Waterboard	36	42	AGR05	31	39	WP6.AC.1	22	25
				AGR06	22	27	WP6.AC.2	25	27
							WP7.N-AC	27	32
Total		226	259		174	212		211	229

7.3.2. PERCEIVED CHALLENGES AND SUCCESSES

Once all quotes are reviewed, categorized and described, the challenges and successes as perceived by the work package leaders and project coordinators are summarized. To do this, the categories that are named most frequently by interviewees, i.e. have the most quotes assigned to them, and are mentioned by the most people, i.e. have the most interviewees mentioning them, are deemed the most important perceived challenges and successes for each project, i.e. the main challenges and successes perceived in the project. The categories of effectiveness, efficiency and satisfaction are not considered in this summary as they address success criteria and do not directly relate to the perceived challenges and successes. The codes in this category are used by the

research to gain a better understanding of the scores for effectiveness and efficiency that were given in the previous studies and are discussed in Section XX.

To select the codes that are most important, a threshold for a minimum number of quotes and interviewees mentioning the code is set. This threshold is set the at three quotes and two interviewees as these are the medians* of these statistics. From the quotes that are remaining, perceived challenges and successes are formulated. The summarized challenges and successes are presented to the participants of the workshop.

It should be noted that at the time of writing, the frequency of certain specific codes does not entirely match the frequencies on which the summary was based. This is due to the inter-coder reliability check being performed after the workshops took place. The challenge and success summaries needed to be generated before the workshops took place and due to time constraints the codes could only be checked after the workshops were conducted. Nevertheless, the codes that were deemed most important based on frequency remained the same. Changes that were suggested focussed on defining more specific inclusion criteria for code categories and sharpening the description of specific codes across cases. This did not significantly affect the code frequency within cases and the frequency of the specific codes after revision still matched the perceived challenges and successes in the summary. Though for transparency, this point is mentioned.

As focus group participants are asked to review the perceived challenges and choose challenges and successes they feel most experienced with, the number of perceived challenges and successes that is presented to participants needs to be considered. Therefore, the maximum number of items the human brain can process needs to be taken into account. According to Miller (1994), the human brain can only process a total of seven items against each other and compare a maximum of three items. The challenges and successes are presented as separate lists and participants are asked to choose three from each list. Not all challenges or successes could be summarized in a list of seven. However, this limit was exceeded twice to ensure that the distinct challenges and successes could be presented to the focus group participants. Specifically, 8 challenges were presented in the Agriculture Project's focus group and 9 successes were presented in the Energy Project's focus group.

A final step in summarizing the perceived challenges and successes of the projects is to ensure that the descriptions are understandable for participants. The summarized challenges and successes are highlighted in the following sections. For each project, some remarks are made about the nature of the challenges and successes and the context of the projects they are identified in. Table 5, Table 6, and Table 7provide an overview of the summarized challenges and successes that have been identified. Also, the components to which the underlying codes relate are included in the tables. The full tables describing the specific codes from which the challenges and successes have been synthesized is included in .

FLOODS PROJECT

As can be seen in Table 5, the challenges of the Floods Project are mostly related to initial conditions (institutional, cultural, logistical, expertise and existing relationships). Looking at the challenges that are described, this focus on initial conditions makes sense. Most challenges that are described can be directly related to the context of the Floods Project, i.e. university institutions, academic and non-academic cultures and a lack of existing relationships between university and practice, or the input that is provided to the project, i.e. expertise of coaches and coordinators and lack of time. Besides that, the informal program structure is related to the collaboration as it has an effect on the way in which collaboration activities are structured. This is also affected by the existing relationships that contribute to the project's organisation and the way in which the planning can be unstructured. Lastly, interviewees highlighted the variety of disciplines as a challenge for the Floods Project related to inclusiveness.

The successes identified in the Floods Project are more equally related to both initial conditions and requirements. Though the informal program structure has been identified as a challenge, the informality also facilitates flexibility, the ability to cater to the needs of the participants and attracts motivated participants. The

* A median is a value separating the higher 50% of datapoints from the lower 50% of a datasample.

Floods project is also dependent on less flexible, formal funding that enables the initiatives that are organised by the project. So, the informal project organisation does benefit from the more rigid institutions that are in place. Besides that, though the goals of academic and non-academic stakeholders are not aligned, participants and stakeholders from practice are learning from each other and integrate their knowledge. This is facilitated by the existing network of the coaches and coordinators. Trust and relationship building are marked as important aspects during these activities. Lastly, attention is paid to managing the variety that exists in the disciplines and stakeholders involved in the project to overcome cultural barriers and foster an inclusive environment.

Table 5. Summarized challenges and successes for the Floods Project

Challenge	Component
The program structure can be too informal	Collaboration (2), Existing relationships, Logistical
The university structure is limiting the flexibility of the Floods Project	Cultural (2), Institutional
Competencies required for the coaches and coordinators are missing definition	Expertise (2)
The variety in discipline is lower than aimed for	Inclusiveness (2)
There is too little time for organisational tasks	Logistical
The academic goals are not aligned with practical needs	Cultural (2), Existing relationships
Success	**Component**
The voluntary participation structure attracts motivated participants	Collaboration
The organisation is flexible and informal, addressing the particular needs of students	Collaboration (3), Integration
Emphasis is placed on building trust and relationships among participants	Existing relationships
There is good management of the variety of participants and involved stakeholders	Cultural (2), Inclusiveness, Expertise
The funding facilitates the organisation of the Floods Project	Institutional
Participants are involved with and learn from stakeholders from practice and vice versa	Existing relationships, Integration, Learning
Reflection on the process occurs at different stages and levels of the Floods Project	Reflexivity, Usability

AGRICULTURE

As shown in Table 6, the challenges of the Agriculture Project relate mostly to requirements for TD knowledge production. The individuality of the work packages has been identified as a challenge for collaboration between stakeholders. This can be exaggerated by the difficulty with using inclusive communication that is understandable for all stakeholders involved. Also, the cultural differences of time management and goal setting have been identified as a challenge. Lastly, the distance has been mentioned by several interviewees as a major challenge in the project. This also leads into the challenge of collaborating in a remote environment as a result of this distance.

The successes of the Agriculture Project are more related to the initial conditions in terms of understanding the urgency of involving different disciplines and their methods in the project, the importance of funding and how it creates structure and the crucial connections that are made by the water authorities that facilitate collaboration between stakeholders that trust each other. This also feeds into the close collaboration that occurs within work packages, though it still occurs independently as described in the challenge. Lastly, the usability of the knowledge that is created in the project is an important aspect of the collaboration and is reflected on. However, the knowledge has also been proven to be used by outside stakeholders as proof of concept experiments have been built.

Table 6. Summarized challenges and successes for the Agriculture Project

Challenge	Component
Work packages mostly work individually	Collaboration, Integration
Assigning roles in a remote working environment can be difficult	Collaboration
Difficulty with using language that is understandable for all stakeholders	Communication, Inclusiveness
Academic stakeholders have different goals than stakeholders from practice	Cultural, Usability
Expectations of timelines for academic stakeholders and stakeholders from practice differ	Cultural
Specific, program-wide rules and responsibilities have not been sufficiently divided	Institutional
Learning is not a priority in the project	Learning
Stakeholders are too far apart	Logistical
Success	**Component**
Stakeholders understand the importance of involving different disciplines	Cultural
The water authority facilitates connections and involvement of stakeholders that already trust each other	Existing relationships
Stakeholders already trust each other which increases the ease of collaboration	Existing relationships
Funding requirements provide structure to the project's organisation	Institutional
Stakeholders closely work together to facilitate integration	Integration
Stakeholders are reflecting on whether the created knowledge is usable outside the project	Usability
Stakeholders and others outside the project are using the created knowledge	Usability

ENERGY

Table 7 provides an overview of the challenges and successes identified in the Energy Project. Three challenges relate to the cultural initial condition and highlights the differences between cultures and disciplines. This project spans multiple continents and disciplines, the challenge of managing the different backgrounds is sensible. Operating in this international field also brings about challenges in terms of rules and regulations as these types of projects need to adhere to very strict funding requirements. In terms of stakeholders that are included in the project, interviewees indicated that not all relevant stakeholders are equally represented in the project. On the one hand, this is because they are not included in the consortium. On the other hand, some stakeholders that do not place high priority on the project are less included in the decision-making process. Lastly, the reflection on whether the created knowledge is relevant in the context of the project is posing a challenge in terms of usability.

Though the stakeholders that do not prioritise the project are less involved in the decision making process, the stakeholders that do place priority on the Energy Project also show a strong commitment and investment of time and effort. Besides that, the focus on adapting meetings to the needs of stakeholder and reflecting on the process further enables collaboration and reflexivity. Though not all meetings can be held in-person, stakeholders do acknowledge the benefits of doing so and confirm the trust that is built during these meetings. Interviewees also described how they were able to learn to accommodate and work with the other stakeholders involved in the project. They also applauded they ways in which perspectives and ways of working are shared and integrated. Lastly, though interviewees recognised not all relevant stakeholders are involved in the project, they also emphasised the effort and focus that is placed on involving as many stakeholders as possible.

Table 7. Summarized challenges and successes for the Energy Project

Challenge	Component
Different backgrounds and interests increase misaligned goals among stakeholders	Cultural
Different disciplines do not understand each other	Cultural
Differences in disciplines' way of working are ingrained in stakeholders and impede collaboration	Cultural
Not all stakeholders that are relevant to the problem are included in the project	Inclusiveness (2)

Strict regulations limit the flexibility of the project	Institutional
Not all stakeholders place sufficient priority on the project	Logistical (2)
There is little reflection on whether the produced knowledge is relevant in practice	Usability
Success	**Component**
Focus on the needs of stakeholders and adapting meeting settings to these needs	Collaboration
Commitment to invest time and effort is high among stakeholders	Collaboration
Getting to know each other in in-person meetings built trust	Existing relationships
The proposal was broad enough to provide sufficient flexibility to adapt to changes in the progress of the project	Institutional
Focus on including as many different types of stakeholders as possible	Inclusiveness
Perspectives and ways of working are shared and integrated by exchanging why and how things are done	Integration, Cultural
Stakeholders learn to better and more efficiently interact with each other	Learning, Inclusiveness
Proper management of the planning keeps the project on schedule	Logistical
Stakeholders take a step back to reflect on the process	Reflexivity, Collaboration

'NONE' CODES

As the quotes that did not fit a category described in the theoretical framework do include information on the perspectives of stakeholders involved in the projects, some results can be described based on these quotes. The 'None' codes specifically address the collaboration across disciplines and the TD definitions that are used in the projects.

All interviewees acknowledged that TD projects are necessary to address the complexity of climate adaptation. Collaborating across disciplines but especially with non-academic stakeholders was deemed as a crucial part of addressing climate adaptation by the academic stakeholders that were interviewed. The non-academic stakeholders mostly acknowledged that the collaboration with different stakeholders brought new perspectives without explicitly describing the collaboration with academic stakeholders. One interviewee from the Agriculture Project described "*There is a different reality from the perspective of the stakeholders, which means that the multidisciplinary approach means that you have to try different things in civil engineering. Because the solutions you have come up with so far no longer fit in this context [of the problem]*" – AGR06 – Agriculture Project[*].

Despite all stakeholders acknowledging the importance of TD projects and collaboration with different stakeholders to address the complexity of climate adaptation, the definition of TD research remain a challenging component of the project. Different stakeholders explained they understand TD collaboration as the collaboration between academic and non-academic stakeholders. However, which criteria should be linked to the concept remain unclear. As one interviewee from the Energy Project explained it "*How do you actually demonstrate that [whether TD collaboration is desired] because it's kind of fuzzy in the way that it's discussed in the criteria. And in fact, there are no explicit criteria for transdisciplinarity even though everybody knows that that's needed. So people are kind of grasping at, what could they mean?* – WP1.AC – Energy Project.

[*] "Er is vanuit de stakeholders een andere werkelijkheid en daarmee leidt de multidisciplinaire aanpak ertoe dat je civiel technisch andere dingen moet gaan proberen. Want de oplossingen die je tot nu toe hebt verzonnen, passen niet meer in deze context." – AGR06 – Agriculture Project

7.4. FOCUS GROUP DESIGN

Section 7.1 describes the theoretical framework that is used to organise the components of TD projects and is used to guide this study. The components in the framework are used to structure the focus group discussion that forms the primary data collection of this study. However, as the framework contains many components and cannot directly be used to collect the experiences from stakeholders involved in the case studies, it is necessary to adapt the framework to be able to facilitate an exercise beyond the presentation of components and definitions. The adaptation of the framework is done through interviews with TD experts that are related to the three projects. This section describes how the interviews with TD experts are structured, how the experts have been selected, what insights the interviews provided and how the framework was adapted into a focus group protocol aimed at collecting the experiences of stakeholders involved in TD projects.

7.4.1. INTERVIEWS WITH TRANSDISCIPLINARY EXPERTS

The synthesis of the theoretical framework is based on the previous studies which only focussed on individual interviews with work package leaders and project coordinators. However, the goal for this study is to conduct a focus group discussion not only with work package leaders and project coordinators, but also with other stakeholders that participate in the projects. Also, the goal is to compare the collected data across the three case studies. Therefore it is necessary to adapt the framework to be able to facilitate a discussion beyond the presentation of concepts and definitions.

To facilitate this, experts in TD research are consulted in an interview to discuss the understandability, completeness and relevance of the theoretical framework that is synthesized from literature. The interview is focussed on discussing the way in which the framework can structure the focus group discussion. Additional discussions with researchers that have experience with conducting TD research also increase the reliability of the framework as experts review the theory, definitions and relationships between concepts and provide feedback.

As the interviews function as an opportunity to collect feedback on the theoretical framework and adapt the framework to be able to structure a discussion setting, the interviews are conducted informally and in a semi-structured way. The discussion with the experts is guided by a list of questions designed to elicit a response on all components of the framework while leaving room for the expert to emphasise concepts or components they deem important. The interviews are recorded, transcribed and anonymously summarized. The summaries are checked with the original interview transcript for correctness and quality of the content. The theoretical framework is adapted in response to the feedback from experts. The final framework used in the focus group discussions is described in Section 7.4.3. The theoretical framework that was presented to the experts and the question list of interview questions that were asked to the experts are included in Appendix B - Figure 1.

SELECTION CRITERIA

To select experts that have experience with TD research, it is important to adhere to certain criteria to ensure that the expert has the knowledge relevant to the study. As the feedback that is aimed to be collected is specifically relevant to the focus group discussions that will be conducted with each case study, it is relevant for the experts to have a basic understanding of the projects. This is also relevant for the privacy regulations as these state that the names of the projects and involved stakeholders cannot be revealed. As all projects are considered to be TD, there are inevitably stakeholders involved or present in the network of the involved stakeholders who have experience with TD research. Therefore, the experts to review the theoretical framework are selected based on recommendations from the project leaders. Specifically, one expert from each case study will be selected resulting in a total of three experts that review the framework.

TRANSDISCIPLINARY EXPERTS

The TD experts selected for reviewing the theoretical framework, were selected from the network of the project leaders. Each project leader recommended one expert to be interviewed. Based on these recommendations, three TD experts were invited for an online interview. The project leader of the Energy Project happened to be a TD expert themself (referred to as Expert E), the Agriculture project leader recommended a work package leader as an expert in TD research (referred to as Expert A) and the Floods Project leader recommended an expert that is

familiar with the project but not involved in the working group (referred to as Expert F). The experts that were selected for the interviews were able to provide insight into the existing literature on TD research and their perspective on how the focus group participants would understand the exercise.

7.4.2. SET-UP OF THE FOCUS GROUP DESIGN

The goal of the focus group discussion is to collect the experiences of stakeholders on perceived challenges and successes that are present in their projects. To be able to collect these experiences, the theoretical framework serves as a structure with which the stakeholders can describe their experiences. To facilitate this, the theoretical framework is adapted to an exercise with which stakeholders can describe their experiences in a structured way. To ensure the exercise is understandable for stakeholders, TD experts were asked to review the exercise.

FIRST ITERATION OF THE FOCUS GROUP DESIGN

The exercise that was shown to the TD experts is similar to the framework presented in Figure 3 and is included in Appendix B - Figure 1. The goal of this exercise is to gain a deeper understanding of the perceived challenge or success by dissecting it using the key components of TD research. This exercise includes a 'dissecting area' additional to the components listed in the theoretical framework. This area is meant for the challenge or success the focus group participants place central to their exercise. They can write the challenge or success in the area and connect the key components they feel are related to this challenge or success to the dissecting area. While doing so, they can write down or vocally explain why this key component is related to the challenge according to their experience. The exercise is done by groups of three to four participants to stimulate conversation in an online setting.

FEEDBACK ON THE FOCUS GROUP DESIGN

During the interviews, experts were asked about the understandability of the exercise and the key components of TD projects presented in the framework. Besides that, they were asked about the completeness of the framework and the definitions of the components. Lastly, experts were asked whether they had any comments on other parts of the exercise or the way in which the exercise would be conducted.

UNDERSTANDABILITY

When asked about the understandability of the exercise, the TD experts generally agreed that the understandability of the exercise was a concern. The exercise appeared to present an overwhelming amount of information, which could lead to confusion and difficulty for focus group participants to grasp the content. Expert E specifically highlighted that the connections and layout of the exercise are not clear. Expert F also raised concerns about the complexity and overwhelming nature of the exercise due to the high number of components. They noted that the initial conditions and requirements are likely the most important elements but that the researcher should be very clear in defining these components in the presentation. They also pointed out that some participants can lose their attention when the concepts are not clear or do not seem important to them. They also suggested that some components could be grouped together to further simplify the exercise and make it more manageable for participants.

Expert A emphasized the importance of using common, human language instead of complicated literary terms. As the theoretical framework the exercise was based on jargon or technical terminology, the use of these terms could hinder participants' comprehension. Expert E also pointed out that the concepts of challenges and successes are not interchangeable, indicating that the exercise should differentiate between these two aspects to ensure accurate representation of participants' experiences. Additionally, Expert A acknowledged that practitioners may have different understandings or perspectives on the outputs, outcomes, and impacts, indicating potential ambiguity in these concepts between academia and practice. This suggests that operationalizing concepts in a manner that is understandable and meaningful to all participants is emphasized as crucial.

COMPLETENESS

The feedback on the completeness of the exercise provided a nuance in the meaning of a 'complete' exercise and when, or if, this can be achieved. Expert E mentioned that the framework may be complete, but it is challenging to determine its completeness in different contexts. They explained that each context may require emphasis on different components, and generalizing across contexts without redundancy or missing components is impossible. This suggests that the exercise had a comprehensive structure, but its applicability and relevance in various settings might vary. Therefore, participants may find it difficult to fully grasp the exercise's purpose and how it relates to their specific circumstances.

On the other hand, Expert F complemented the comprehensiveness of the framework and expressed their impression that is could be complete in certain contexts. Nevertheless, they pointed out that the framework lacks a focus on safety and creating an environment where participants can be vulnerable. Although this aspect may not be an explicit part of the framework itself, it is crucial for the focus group's success. Creating a safe and supportive environment allows participants to openly share their thoughts, experiences, and concerns. This suggests that the exercise needs to be complemented with instructions or guidelines on how to foster such an environment during the focus group.

Lastly, Expert A expressed that the completeness of the exercise is subjective, implying that different individuals may perceive it differently. They acknowledged that the framework would be complete enough to achieve the goals of the exercise. Conditional to this, a comprehensive presentation and explanation of each component would be necessary for participants to fully grasp the exercise's aim. They also proposed that having a discussion facilitated by someone knowledgeable about the exercise's components, who can collect diverse responses and prevent a consensus, could yield better results. This suggests that expert guidance and facilitation could enhance the effectiveness of the exercise. On the other hand, Expert E highlighted that the purpose of the exercise is unclear and suggested to focus primarily on participants' experiences rather than explaining the exercise's components. This implies that the exercise should be designed to prioritize participants' personal insights and reflections.

OTHER ELEMENTS OF THE EXERCISE

Besides the understandability and completeness of the exercise for the focus group discussion, the experts emphasised other considerations that were important to the success of the focus group. Expert F raised the point that the analysis and sharing of experiences should go beyond a solely example-oriented approach and incorporate a more generic perspective. This implies that the exercise should encourage participants to share broader perspectives and insights, rather than solely relying on specific examples. By providing examples that are not domain-specific, biased opinions can be mitigated and objective and diverse discussions can be encouraged. Additionally, Expert E emphasized that reflection should be a dynamic process that extends beyond frameworks and structures. This suggests that the exercise should encourage participants to engage in deeper introspection and analysis, moving beyond the limitations of predefined frameworks.

7.4.3. FINALIZED FOCUS GROUP DESIGN

Taking the feedback from the TD experts into consideration, the focus group exercise was revised to the version used in the data collection of this study. This section describes the focus group protocol that was included in the focus group. The focus group protocol consists of a focus group setting, presentation, four exercises that are completed by participants and a concluding, plenary reflection session. A description of the focus group participants is provided with the results of the focus group discussion (Section 7.5.1). This section solely provides an overview of the protocol that was set-up for the focus group discussion.

FOCUS GROUP SETTING

The focus group is organized in an online setting to ensure that all participants are able to attend the focus group and long travel times are prevented. The online meeting program of choice for the University is Microsoft Teams which has a recording and transcription function built in. Additionally, a collaborative space is set-up for participants so that they are able to write down additional comments and are guided through the exercise by

visuals. The collaborative space of choice is a MIRO board, which is a digital whiteboard, a brainstorming tool where participants can add post-its, create mind maps, load images and much more (MIRO, 2023). Both the presentation and exercise are located on this board to prevent technical difficulties when switching between presentation mediums. To ensure all participants are able to work with the MIRO board, a small, introductory exercise is asked from them when first entering the collaborative space.

To address the concern for safety and vulnerability described by Expert F, an effort is made to create a focus group setting that is comfortable and safe for all participants. The safe environment is accommodated by the researcher by having a friendly demeanour and welcoming all participants to the meeting. Besides that, the privacy and anonymity of the focus group and its results are discussed up front and emphasis is placed on the openness of the focus group by explaining that there are no wrong opinions and all experiences are relevant to the study. Lastly, during the exercises, the researcher also inquires about the progress, questions and struggles participants may experience. By doing so, the researcher attempts to accommodate a comfortable experience for all participants.

PRESENTATION

As described by the TD experts, it is important to clearly explain to participants what the goal of the focus group is, use language that relates to their practices and clearly define the concepts that are used in the exercises. The opening presentation provides an opportunity to address these concerns. The presentation includes a description of the goals of the meeting, an overview of the planning, addresses the ethical consent and provides an introduction to the concepts of TD collaboration, the previous studies and the goals of this study. After the presentation, the link to the MIRO board is shared to invite participants to the first exercise.

During the presentation, the goal of the focus group is made clear upfront. The goal is explained as an aim to "discuss and reflect on aspects that are challenging and so far successful in the project's collaboration". Also, sharing experiences with and on the collaboration and gaining a deeper understanding of the considerations, actions and decisions needed for addressing challenging aspects and enhancing successful aspects are addressed as goals for the meeting. By emphasizing these goals, the participants better understand what they can expect from the focus group. Additionally, the focus group planning is shared with the participants to further provide understanding of the goals and progression of the focus group.

As an introduction, an explanation of transdisciplinary collaboration is given to the participants. As described in Section 2.4, definitions of TD collaboration are diverse and diffuse in literature. Therefore, it is important to specifically address what is meant by the concept during the focus group, this was also recommended by Expert A and Expert F. The definition includes the collaboration between academics and stakeholders and aims to produce knowledge relevant for practice.

Lastly, to address the concern raised by Expert E on the differentiation between challenges and successes to ensure accurate representation of participants' experiences. To address this concern, challenges and successes are explained to the focus group participants. A challenge is defined as 'something that was so far challenging or difficult in the collaboration'. A success is defined as 'something that, so far, went well or was successful in the collaboration'. The goal of addressing challenges and successes in the project is explained as 'aiming to overcome aspects that are/were challenging and amplify aspects that are/were so far successful to achieve the objectives of the project'.

EXERCISE 1: INTRODUCTORY EXERCISE

Once participants are invited to the MIRO board via a collaborative link, they arrive at the introductory exercise. This exercise is aimed at familiarizing participants with the controls of MIRO and helps them with navigating the space. The first exercise asks participants to choose a role that best describes their involvement in the project. To ensure anonymity, this role corresponds to a specific colour omitting the need for names or other identifiers

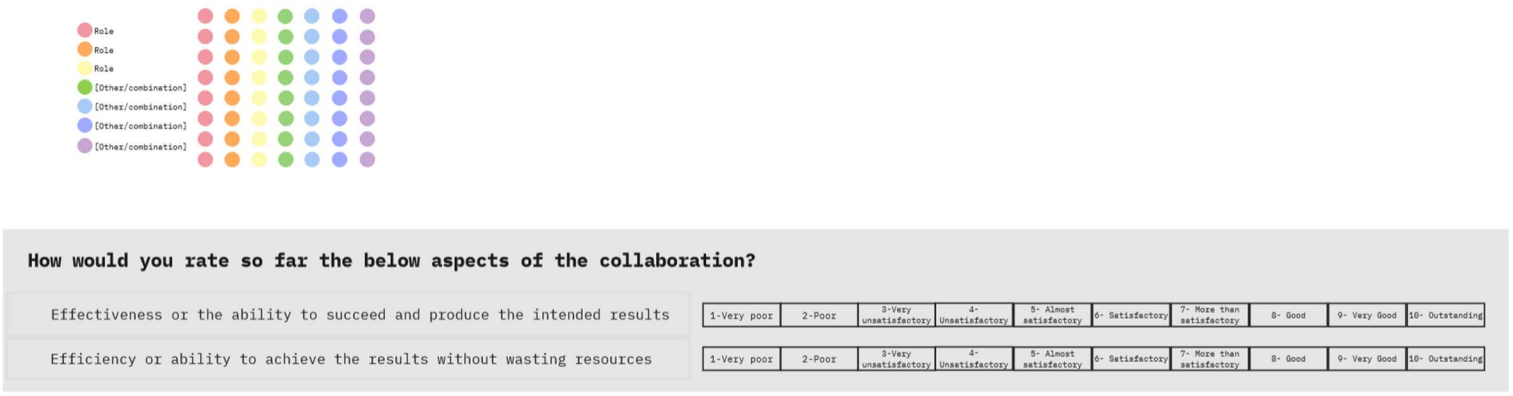


Figure 4. Introductory exercise, choosing a role and rating the effectiveness and efficiency of the project.

being recorded on the MIRO board. The exercise asks them to take a 'voting dot'* in the colour corresponding to their role and give a rating for the effectiveness and efficiency of the project so far. By asking participants to define their role and move a small object around on the board, they familiarize themselves with the controls of the program. The rating is based on a ten point scale and rates the experience of participants with the two success criteria. Figure 4 provides an overview of the space on the MIRO board used for this exercise.

EXERCISE 2: PRIORITIZING THE PERCEIVED CHALLENGES AND SUCCESSES

Once the participants have voted on the effectiveness and efficiency of the project, they are asked to move on the next exercise. During this exercise, the perceived challenges and successes synthesized from the previous studies are presented to the participants. They are asked to first place a 'voting dot' with the three challenges they feel most related to or have the most experience with. Once this is completed, they are asked to repeat the exercise with the successes. By asking them to move around on the board and use a similar voting system to the previous exercise, the confidence of participants with using the MIRO board will increase. Also, by prioritizing the challenges and successes, the participants begin their reflection on what challenges and successes are familiar to them and start thinking about their experiences with the challenges and successes. Figure 5 provides an overview of the exercise that was presented to participants.

Figure 5. Exercise 2: Prioritizing the perceived challenges and successes.

improvements. The questions were presented in four quadrants surrounding the challenge or success that was placed central to the exercise. Figure 5 provides an overview of the exercise that was presented to participants.

ADAPTED KEY COMPONENTS OF TD PROJECTS

In the interviews with TD experts, the concern of complicated terminology and the terminology not aligning with the participant's understanding was discussed. To address this concern, the terms used in the theoretical framework were adapted to fit with more common, human language. The translation of the academic, theoretical terms to common language was done based on personal opinion of the researcher. Though the new terms are more compatible with lay language, they are not represented in peer-reviewed literature and are therefore debatable. However, as the goal of the exercise has to be aligned with the perspectives of participants, the priority was given to a more debatable representation of the components.

To provide focus group participants with the opportunity to read a more elaborate definition of the components, the theoretical definitions of the components were provided next to the laymen terms. A close-up of the way in which the components were presented to focus group participants is included in Figure 6.

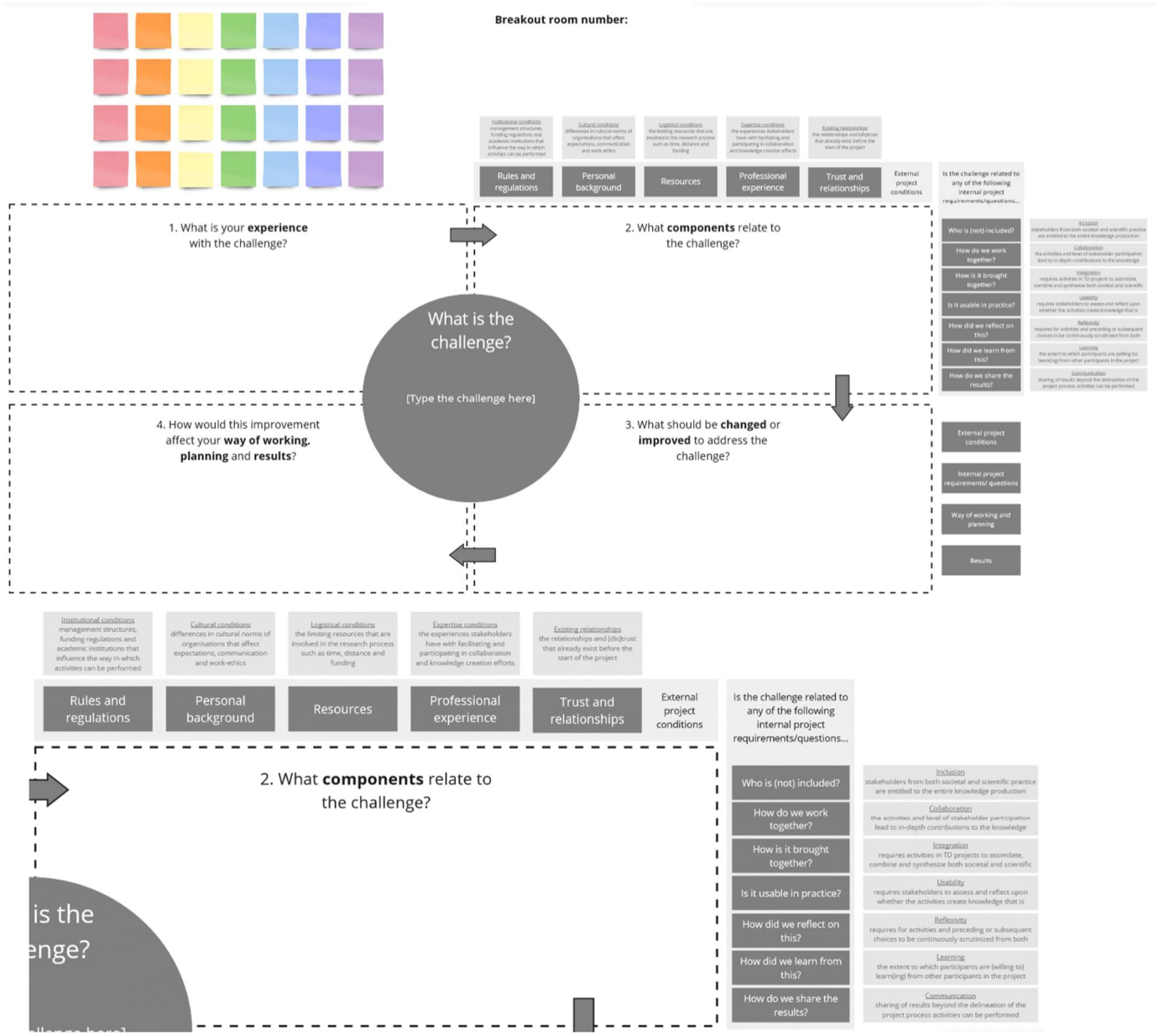


Figure 6. Exercise 3: Four questions to dissect a challenge.

Answering the exercise questions

First, participants are divided into groups of two or three to ensure all participants have a chance to talk in the online setting. Within these groups, participants choose a challenge they want to address in further discussion. This is the challenge they place at the centre of their exercise. Next, participants are asked to answer questions one through four. Question one asks “What is your *experience* with the challenge?". By answering this question, participants reflect on their experience and perceptions of the challenge. Question two asks “What *components* relate to the challenge?”. By answering this question, participants delve deeper into the context of the challenge and relate it to other parts of the project that are relevant. As the theoretical terms are replaced by words that relate more to participant’s language, they should be able to relate the components to their experience on a more personal level. Question three asks “What should be *changed* or *improved* to address the challenge?”. By answering this question, participants reflect on what they can improve to overcome the challenge and can use the related components to formulate this improvement. To further structure the description of improvements, four prompts are provided to inspire the participants in explaining the improvement. The prompts include components to which the challenge can be related, i.e. external project conditions and internal project requirements/questions. Additionally, the prompts include parts of the project on which the improvement could have an effect, i.e. way of working and planning, and results. Lastly, Question four asks “How would this improvements affect your *way of working, planning* and *results*?”. By answering this question, participants reflect on the effects the improvement would have on their personal involvement in the project.

Participants are asked to discuss their answers with the others in their respective groups and write down a summary of their discussion using the post-its in the colour corresponding to their role. They are given twenty minutes to complete the exercise and are then asked to move on to exercise 4.

Exercise 4: dissecting a success

The last exercise follows the same steps as exercise 3. However, this exercise places a success central to the discussion instead of a challenge. Also, the questions are adapted to describe a success instead of a challenge.

Concluding reflection

Once the participants have written down their experiences and completed both exercises, they are asked to re-join the plenary meeting. During this concluding plenary session, the participants are asked to reflect on the insights they gained from doing the exercises. An insight is explained as something they did not know or realise before the focus group and learned or realised during the focus group. Participants are also asked to reflect on the things that were addressed in the focus group they already knew. Participants are given the opportunity to speak up in the meeting or write their insights on the MIRO board. Additionally, participants are asked to share details about the discussions they had in their groups to give the other participants an idea of what was discussed in other groups. This is also facilitated by the opportunity to look around on the MIRO board during the reflection.

7.5. FOCUS GROUP RESULTS

Focus groups have been conducted with the three case study projects. The focus group protocol is described in Section 7.4.3. As described, the focus group consists of participants rating the efficiency and effectiveness of the projects, the prioritization of perceived challenges and successes, the focus group discussion and a plenary reflection session. This section first describes how the focus groups were organised including inviting participants and who participated in the focus groups. After this, the results that were collected from these focus groups are discussed. First, the rating and prioritization are discussed. Then, the results from the focus group discussions are described for all cases. Lastly, the results from the plenary reflection session is discussed.

7.5.1. FOCUS GROUP ORGANISATION

The goal of the focus group discussions in this study is to collect experiences from participants on perceived challenges and successes in the project. The purpose is to gain a deeper understanding of how the challenges and successes can be addressed to reach the objectives of the project. The discussions are structured by a predefined set of questions that will be discussed by participants. These questions are structured by the exercise that is based on the theoretical framework (Section 7.1). Input to the discussion is provided by the challenges and successes that are synthesized from the interviews from the previous studies (Section 7.4).

The focus group discussions are organised separately for each case, allowing for the presentation of case-specific challenges and successes and data collection and analysis for each case. The participants of the focus group are presented with the results, i.e. perceived challenges and successes, of the previous studies and have an opportunity to respond within a group of stakeholders who are also involved in and most likely familiar with the challenges and successes of the project. This approach is also in line with the privacy regulations as this prevents stakeholders from knowing which case studies are participating in this study.

FOCUS GROUP PARTICIPANTS

Participants for each focus group are purposefully selected based on their involvement and expertise in the respective case (Hennink, 2013). They include individuals who are directly involved in the case studies, e.g. practitioners, stakeholders, or individuals directly affected by the implementation. The participants were invited to the focus group via email. The information for sending the invitations was obtained though the project coordinators. The invitation included a description of the study, what will be expected of the participants and a proposal for three timeslots. More than one date and time is proposed to the participants to ensure as many participants as possible can join the focus group. The invitations were sent four weeks before the proposed timeslots to ensure participants would have time to join the focus group. Table 8 provides an overview of the number of invites that was sent for each project.

It should be noted that not all stakeholders from the Agriculture Project were invited to the focus group. Based on the advice from the project coordinator, only work packages 2, 3 and 6 were invited to the focus group. Work packages 2 and 3 focus on the pre-treatment system for desalination of the fresh water supplies used in agriculture. The project coordinator explained that these work packages made tangible progress which could be evaluated during the focus group. They also explained that the challenges and successes identified in the existing case data would be more relatable for stakeholders who had something tangible to discuss. Besides that, work package 6 was invited as this work package focusses on the transition management of the agricultural sector and the technology that is developed in the project. This work package focusses on the implementation of technology and the communication among stakeholders. This is the work package that is also considering the TD collaboration in the project and were thought to be interested in the focus group discussion. With these three work packages, the number of invites that was sent was deemed sufficient.

In total, sixteen people participated in the focus group discussion. Of these people, six also participated in the interviews of the previous studies leaving ten participants that have no previous experience with this study. Table 8 presents the number of participants participating in each focus group. The roles that are listed in the table are ones participants chose themselves to describe their involvement in the projects. If more than one participant chose a role, the number of participants selecting that specific role is indicated in brackets. The asterisks in

brackets indicate the participants who also participated in the previous studies (of each role only one was interviewed in the previous studies).

Table 8. Overview of the invites and participants of the case studies.

	Floods Project	Agriculture Project	Energy Project
Number of invites	23	23	35
Number of participants	4	5	6*
Number of teams	1	2	3
Roles of the participants	Coach [*]	Coordinator [*]	Work package leader (3)
	Researcher	Researcher [*]	Consortium partner (2) [*]
	Student (2)	PhD candidate	Researcher [*]
		Water authority employee (2) [*]	Other

The table indicates how many teams were discussing different challenges and successes. For the Agriculture and Energy Project, the different discussions were conducted in breakout rooms so that participants could discuss their experiences more easily. The discussions in the Floods Project did not occur in separate rooms as two of the participants only realized they needed to discuss a different challenge to be able to relate to it once the discussion has started. Specifically, the students realized they did not relate to the perceived challenge that was discussed and eventually discussed a different challenge they felt more experienced with. The perceived success that was discussed in the Floods Project was discussed among the four participants as all of them related to the perceived success.

DATA COLLECTION

The data that is collected from the focus group discussions has three different forms. First, the focus group discussions have been recorded and transcribed so that discussions between participants can be reviewed on a detailed level. This data provides insight into the considerations and interactions that shape the opinions and perceptions of the challenges and successes participants experience. Besides that, participants were encouraged to write down their experiences and opinions. This written data provides insight into the summary participants would make of their experiences and highlights the parts of their discussions they found most important. Lastly, participants were asked to vote on which challenges and successes they felt most related to or felt should be most important. This data provides insight into the prioritization participants would give to the challenges and successes in their projects.

7.5.2. FOCUS GROUP DATA ANALYSIS

For this study, the description of the data analysis focusses on the data collected during the focus group discussions as the re-analysis of existing case data has already been discussed in Section 7.2. The data that is collected from the focus group discussion takes three forms, i.e. votes, writing and verbal discussions. All three types of data are analysed to formulate an answer to the research question.

The rating that participants gave to the effectiveness and efficiency of their projects is compared to the ratings that were collected during the previous studies. Additionally, the votes collected on the challenges and successes participants feel most experienced with provides insight into the perceived challenges and successes that are most important to participants. This provides an initial idea of the parts of the projects participants experience as the most challenging or successful.

* Originally, seven participants joined the focus group discussion, however, one participant decided to withdraw their input. The input provided by their conversation partner is still included in the results. The withdrawn participant is referred to as having an 'other' role in the project.

To ensure the votes can be compared across cases, they are standardized with the number of participants that attended the focus group. As not all participants registered three votes when ranking the challenge or success, the number of votes for a specific challenge or success is standardized by the total number of votes per challenge or success, per case. For example, ten votes were registered for the challenges during the Floods Project focus group. This means the number of votes registered for the first challenge is divided by ten to control for the number of votes.

Besides that, the challenges and successes comprise multiple components as indicated in Table 5, Table 6, and Table 7. As the participants voted for the challenges and successes they felt most experienced with, their experience with the component that is related to that challenge or success is equally important. This means the votes are not controlled for the number of times a component occurs in relation to a challenge.

The analysis of the discussion data is done thematically and involves the categorization of the discussions. The participants were asked to discuss their answers to the questions and elaborate their answers in written text. As the discussions are structured by the questions participants are asked to answer in the exercise, the transcripts obtained from the discussions are already categorized. Therefore, systematic coding of the focus group discussions is not required. Instead, the transcriptions are analysed based on the exercise questions and used to substantiate and clarify the written text collected during the focus group.

7.6. EFFICIENCY AND EFFECTIVENESS COMPARISON

The introductory exercise on the MIRO board was the rating of the effectiveness and efficiency of the project's process so far. All participants attributed a numerical rating to these two success criteria as they seemed fit with the performance of the process. The scores can be compared to the scores collected from the previous studies. As some participants also participated in the previous studies, the presentation of the scores is indicated for the previous studies, the focus group participants that were also interviewed and the focus group participants that did not participate in the previous studies.

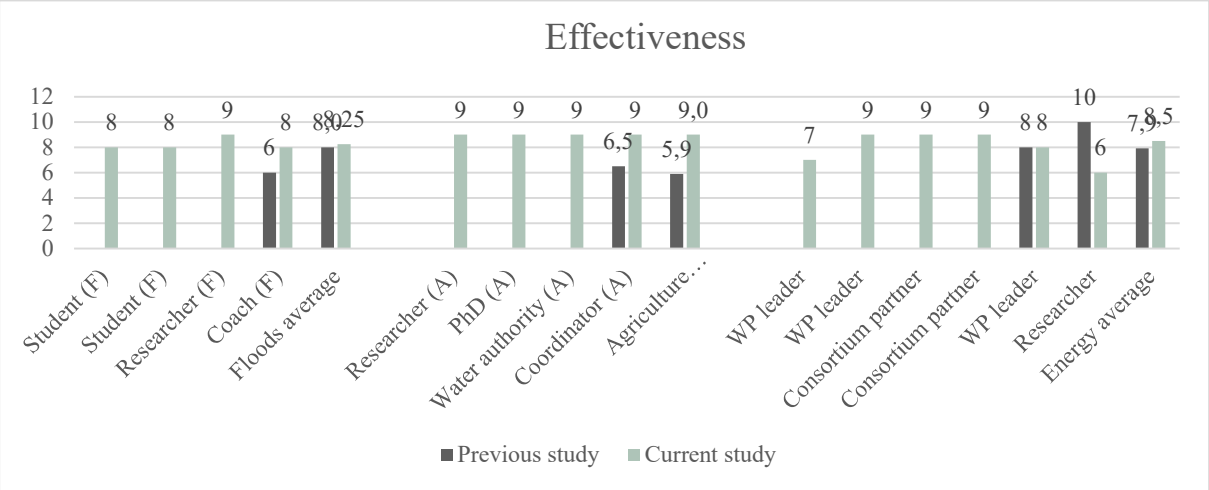


Figure 7. Effectiveness scores given by participants for each project in current and previous study.

As only sixteen participants joined the focus groups, the statistical significance of the quantitative data is not high. However, two trends can be observed in the rating of the effectiveness and efficiency of all the projects. First, all participants who voted during the focus group thought the effectiveness and efficiency of their projects was at least satisfactory. Second, compared to the previous studies, almost all projects had a higher average effectiveness and efficiency. This means that since the previous studies, stakeholders thought the success criteria of their projects have improved. The only exception to this observation is the Floods Project who have a lower score on the efficiency of their projects. During the focus group discussion, no specific argument was given for a lower score for efficiency. However, the researcher and coach both added a challenge related to capacity problems of the project which had not been identified in the existing case data. This challenge could be related to the decreased rating for efficiency in the Floods Project.

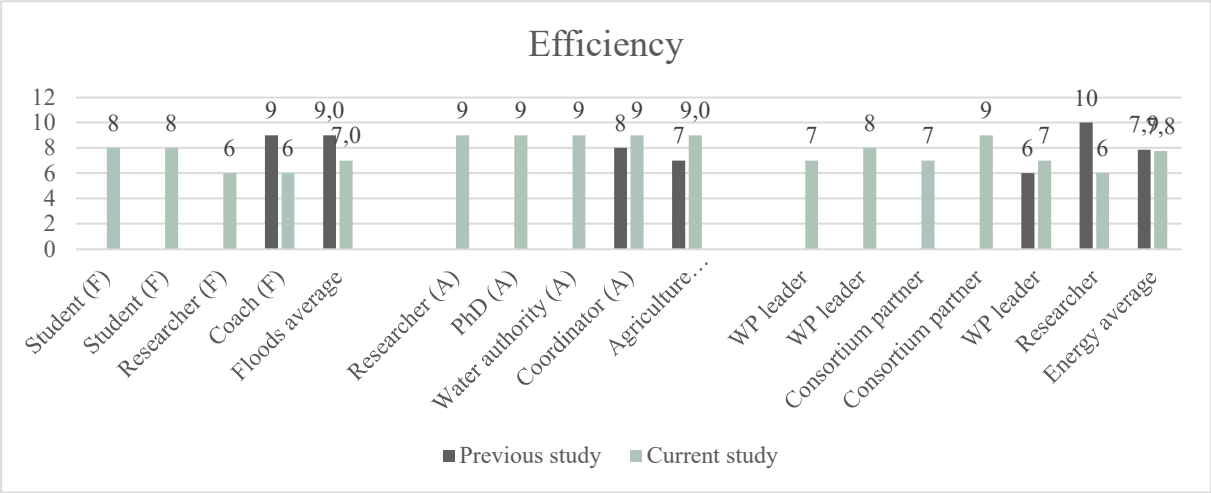


Figure 8. Efficiency scores given by participants for each project in current and previous study.

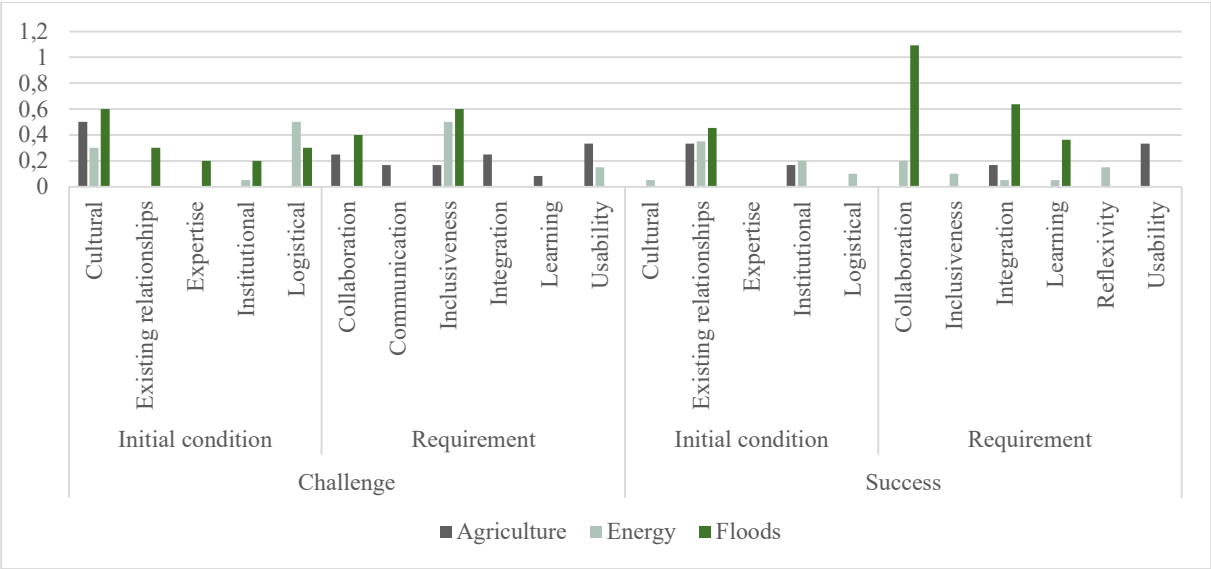


Figure 9. Standardized votes per component for each project.

7.7. PRIORITIZED CHALLENGES AND SUCCESSES

The second exercise in the focus group is the prioritization of the perceived challenges and successes synthesized from the previous studies. As described in Section 7.4.3, the participants were asked to vote on the three challenges and three successes they felt most experienced with or related to. First, the results of the voting session are discussed, followed by the comparison of challenge and success categories across cases using their categories. Lastly, the missing challenges and successes suggested by the participants are discussed in relation to the perceived challenges and successes that were not included in the summary. The total number of votes did not always match three times the number of participants as not all participants registered three votes.

As can be seen in Figure 9, the cultural initial conditions and inclusiveness requirements received the most votes when considering challenges. All three projects registered votes related to these key components and on average, the number of votes attributed to these components is relatively high. In terms of successes, existing relationships and integration are deemed important for all projects. The number of votes attributed to these components can also be considered relatively high. In terms of project specific votes, culture and inclusiveness are the most important components for the challenges related to the Floods Project. Collaboration is votes as one of the most important contributors to successes for this project which the highest score in general. For the Agriculture Project, culture is the most important component related to the project's challenges. Existing relationships and usability are voted to be the most important contributors to the successes of the project. Lastly,

logistics are deemed the highest contributor to challenges for the Energy Project whereas successes are mostly attributed to integration.

7.7.1. MISSING CHALLENGES AND SUCCESSES

Participants were also asked to add any challenges and successes they felt were missing from the presented list. Overall, these challenges and successes can all be related to categories that are identified from the previous studies but were not included in the summary as they were not mentioned in enough interviews or quotes. The following table provides an overview of the challenges and successes that were mentioned in each focus group, the participant who suggested the challenge or success and the category and component to which the suggestion can be related.

As can be seen in Table 9, the capacity problems that are mentioned by two participants of the Floods Project can be categorized under the category 'lack of resources'. However, though the lack of time is identified as a challenge in the previous studies, capacity problems are not highlighted by the interviewees. This challenge would be placed in a separate specific code called 'problems with allocating sufficient capacity'. Besides that, the two cultural challenges mentioned by the coach in the Floods Project, are not specifically identified from the interviews. However, they would be attributed to the specific code 'Program ways of working not matching with university structure' which was included in the pre-defined list of challenges.

Table 9. Missing challenges and successes suggested by focus group participants.

Project	Missing challenges	Participant	Category	Component
Floods	Capacity problems at the practice organisations involved	Coach	Lack of resources	Logistical
Floods	Stakeholder participation is limited due to capacity problems	Researcher	Lack of resources	Logistical
Floods	Virtual meetings are challenging	Coach	The way in which collaboration activities are organized inhibiting collaboration	Collaboration
Floods	Meeting time investment is not flexible/structured	Coach	Lack of resources	Logistical
Floods	Concept of connecting education, research and valorisation is complex for the organisation	Coach	Different backgrounds and methods inhibiting the process	Cultural
Floods	University is hierarchically organised rather than a network	Coach	Different backgrounds and methods inhibiting the process	Cultural
Agriculture	Lack of time to follow up with water authority on e.g. current state of the project	Researcher	Different expectations inhibiting the process	Cultural
Agriculture	How well and extensive should the pre-treatment of the drainage water be?	Coordinator Water Authority Water Authority	Rules and regulations limit the process	Institutional
Energy	There is usually no/limited mechanisms in place to make stakeholder inputs more actionable	Consortium partner	Not all stakeholders are entitled to the process	Inclusiveness
Energy	How do we reach the right people/audience (e.g. when disseminating material and information or engaging with stakeholders)?	Researcher Work package leader Consortium partner	Lack of resources	Logistical
			Lack of trust	Existing relationships
Project	**Missing successes**	**Participant**	**Category**	**Component**
Floods	Results from the groups were directly adopted by practice	Coach	Results are relevant for stakeholders	Usability
Floods	Large group of students involved and interested	Coach	Stakeholders show commitment to the project	Collaboration
Floods	Deeper understanding of the application by talking to other disciplines	Student	Different backgrounds and methods benefit the process	Cultural
Floods	Connection with students or researchers who can help you with your own research	Student	Existing connections facilitate collaboration	Existing relationships

	(without the Floods Project you would not know what they were doing)			
Agriculture	The skills of all the different players (academics, companies, farmers, authorities) are I think very well appreciated among each other. The reams realised each added benefit and toles	Coordinator	Different backgrounds and methods benefit the process	Cultural
Agriculture	The developed pre-treatment system is very effective	Coordinator Water Authority Water Authority	Assimilating and combining different perspectives	Integration
			Results are relevant for stakeholders	Usability
Energy	A success on our project is the willingness to adapt some of our work to better fit what is produced by other WEPs, not necessarily because the proposal was broadly written but because there is effort to integrate our work from some of the partners	WP leader	Assimilating and combining different perspectives	Integration
Energy	Meaningful engagement with targeted stakeholders and/or audiences	Researcher Work package leader Consortium partner	Building and fostering trust	Existing relationships
			Having an open mindset	Inclusiveness

The successes that were missing from the pre-defined list are also categorised and listed in the table. The coach of the Floods Project suggested the success where results from the project were directly adopted by practice is categorised as 'results are relevant for stakeholders'. The specific code that would be linked to this success is the 'Stakeholders and others outside the project are using the created knowledge' which was identified in the Agriculture Project. Besides that, the success of gaining a deeper understanding of the application by talking to other disciplines would be attributed to 'Different disciplines bring interesting, new perspectives' which was identified in the Energy Project. The Agriculture Project suggested the success that all the skills of the different stakeholders were very well appreciated. This success is related to different backgrounds and methods benefitting the project and can be attributed to the specific code 'Different ways of working exist but are understood and respected by the different stakeholders involved'. Lastly, the work package leader of the Energy Project explicitly highlight the integration in the does not only occur because the proposal was written containing sufficient flexibility. This success can be related to the specific code of 'Perspectives and ways of working are shared and integrated by exchanging why and how things are done' as this describes how adaptations to the ways of working are made to facilitate integration in the Energy Project.

In the Agriculture Project and the Energy Project, two challenges and successes that were not added by participants as missing in the pre-defined list were discussed. These challenges are added in grey to Table 9. These challenges and successes can be related to specific codes, categories and components by linking it to a set of specific codes that was not included in the summary. Using Appendix D - Table 1, the new challenges were linked to the specific code, category and component listed in the table. The specific codes, categories and components that were linked during analysis are indicated in grey.

7.8. FOCUS GROUP DISCUSSION CHALLENGES AND SUCCESSES

During the focus group, the participants were asked to discuss one challenge and one success in further detail with a smaller group of participants. This section describes the results that were collected from these discussions. First, the results from the challenges are described. These results are supported by the findings collected on the MIRO board. The discussions are sorted by discussion topic and first describes the discussion around the challenges followed by the improvements that were suggested. After this, the same structure is followed for the description of the results from the successes.

Table 10 and Table 11 provide an overview of the challenges and successes that were discussed during the focus group, which stakeholders discussed the challenge and to which categories and components the challenges and

successes are related. As participants had the freedom to choose a challenge they felt most experienced with, two groups decided to discuss a and success that was not in the pre-defined list.

7.8.1. CHALLENGES

The challenges that were selected by the participants were the challenges that received the most votes and are presented in Table 10. As can be seen in the table, the challenges discussed during the focus groups focussed mostly on initial conditions. Specifically, challenges related to culture, institutions, logistics and existing relationships were discussed. Besides that, the requirements that were included in the challenges were inclusiveness.

The key components that were selected by the participants mostly overlapped with the components identified during the analysis of the existing case data. An exception to this overlap is the challenge related to the inclusiveness of the Floods Project. Participants related this challenge to culture, collaboration, integration and communication rather than to inclusiveness. This is mostly because they described which components related to their desired situation instead of explaining which components they are currently missing in their experience with the challenge.

Also, most participants related more key components to the challenge in their discussion compared to the components selected in the analysis. Especially participants of the Floods Project selected more components than identified during the analysis. They were also the only participants to select requirements together with one group from the Energy Project.

INSTITUTIONAL CHALLENGES

In all projects, at least one challenge was related to institutional aspects. In the Floods Project, the challenge related to the University structure and how it does not match with the flexibility that is required by the project was discussed. According to the coach's experience, the university funding structure focusses on the pillars education, research and valorisation. They describe that this increases the difficulty for the Floods Project to receive funding as the TD project operates across these pillars. They also highlight how the thesis projects (which is part of the Floods Project's focus) is regarded as a disciplinary project and the benefit of collaborating across disciplines and supervisors is not sufficiently recognised. Nevertheless, the university does pay attention to interdisciplinary work in specific courses and has funding available for these projects, but the leeway to cross disciplines and faculties in thesis projects is experienced as limited.

In the Agriculture Project, the challenge related to institutions was not included in the pre-defined list. They focussed on discussing the extent to which the filtration that is being developed by the Agriculture Project should filter pesticides, nitrate and phosphates. One Water Board employee describes how they experience difficulties with the permits that need to be granted for the filtration systems to be installed. They describe how the regulations are strict and require all nitrate and phosphate to be removed. Yet, the water board employees both agree that these chemicals are not necessarily harmful in the peat areas they operate in and are more an issue in other regions. They express the frustration with the permit authorities who do not show flexibility in these types of regulations. The coordinator (also involved as an academic stakeholder) corroborates these frustrations by explaining how the technology currently in development focusses on and is successful in the filtration of pesticides but not nitrate and phosphate. Due to these characteristics, the technology does not receive a permit while it can provide relief to the freshwater shortages due to salination.

In the Energy Project, a work package leader and the 'other' participant discussed the challenge related to the strict regulations limiting the flexibility of the project. The work package leader first explains how the regulations make their data collection more difficult and how the protocols do not encourage investigating emergent or unexpected results as all expected results need to be communicated beforehand in proposals.

The participants of the Energy Project discuss how the improvements for their institutional challenge most likely transcend the scope of the project and acknowledge that this is a challenge experienced by many projects. They

suggest that allowing for unexpected, emergent outputs would help overcome this challenge within the project, but that the problem should be addressed at a systemic level (i.e. external project conditions/initial conditions).

This in line with the experiences of the other participants who mostly describe the challenges as something that is external to the scope of the project. However, the participants of the Energy Project describe how they do not feel they will be able to address the challenge within the timeline of the project whereas the Agriculture and Floods Project participants describe how they could address the challenge within the project. In the Floods Project describe how they could influence this challenge by creating legitimacy for TD collaboration in the university by crediting authors equally in research outputs. They envision the improvements bringing about the adoption of the TD ways of working across the university which strengthens the internal education and research network of the university.

The participants of the Agriculture Project think that meeting with the stakeholders who enforce the strict regulations to discuss the possibility of an exception for the drainage and filtration systems. They describe how implementing this improvement would allow for academics to focus their research on technologies that are "in the end really needed" instead of complying with regulations that do not necessarily achieve the goals. The collaboration with the permitting authorities would need to be improved which would benefit the integration of perspectives between the different stakeholders. However, as the permitting authority is not included in the project, involving them in close collaboration can be more of a challenge.

The participants discussing these challenges realized that implementing the improvements would have an effect on their way of working and the results they would be able to produce. The coach and researcher of the Floods Project acknowledged that their way of working would be affected by the improvement as more legitimacy for TD collaboration would enable a closer and easier collaboration across faculties, disciplines and research supervisors. Besides that, the researcher anticipates "novel, problem-based TD research" is stimulated by creating legitimacy for TD research within the university. In the Agriculture Project, the way of working is expected to change for the water authority employees as they would need to start collaborating with permit authorities to enable a more flexible interpretation of nitrate and phosphate regulations.

In these improvements, the participants describe how creating a sense of urgency for their efforts, e.g. collaborating across disciplines and implementing desalination technologies, would help them overcome their institutional challenge. Though challenges related to institutions were discussed across all projects and improvements are suggested, there are no improvements identified in the existing case data that relate to external institutions or how they can be addressed. Nevertheless, the improvement of creating more legitimacy for the project has been identified and related to inclusiveness. Specifically, the improvement describes how more legitimacy for the Floods Project would enable the participation of a more diverse set of stakeholders.

Another improvement that could have an effect on the sense of urgency for TD collaboration would be to educate stakeholders on the benefits of collaborating with different stakeholders. This improvement is identified in the Floods Project and categorized as an improvement in the culture of stakeholders rather than institutions. However, as the participants of the Floods Project identified in their discussion, the culture of stakeholders can affect the prioritization of certain institutional changes. Also, the participants of the Energy Project note that regulations allowing for unexpected and emergent outputs would bring about a more reasonable understanding of the messy nature of TD projects and would allow for practice to refine the theory that is being developed.

Table 10. Challenges discussed in the focus group discussions.

Project	Challenge	Participants	Votes	Focus group components	Specific code	Category	Component
Floods	The university structure is limiting the flexibility of the organisation of the Floods Project	Coach Researcher	Coach Researcher	Cultural Institutional Resources Existing relationships Collaboration Learning Communication	The Floods Project's way of working does not match University culture	Different ways of working inhibit the process	Cultural
					The Floods Project goals are not matching with the university's expectations	Different goals inhibit the process	Cultural
					The project is limited by university rules and regulations	Rules and regulations limiting the process	Institutional
Floods	The variety in discipline is lower than aimed for	Student Student	Student Student Coach	Culture Collaboration Integration Communication	Variety in stakeholders is less than aimed for	Lack of stakeholder differentiation	Inclusiveness
					Not all stakeholders are equally included in the project's decision-making	Not all stakeholders are entitled to the process	Inclusiveness
Agriculture	Academic stakeholders have different goals that stakeholders from practice	Researcher PhD	Coordinator Researcher PhD Water authority	Culture Expertise	Academic stakeholders have different goals than stakeholders from practice	Different expectations inhibiting the process	Cultural
Agriculture	How well and extensive should the pre-treatment of the drainage water be?	Coordinator Water Authority Water Authority	-	Institutional	-	Rules and regulations limit the process	Institutional
Energy	How do we reach the right people/audience (e.g. when disseminating material and information or engaging with stakeholders)?	Researcher WP leader Consortium partner	-	Existing relationships Logistical	Stakeholders' time is limited	Lack of resources	Logistical
					Audiences do not trust the researchers conducting the research	Lack of trust	Existing relationships
Energy	Strict regulations limit the flexibility of the project	WP leader Other	Researcher	Institutional Existing relationships Logistical	Strict regulations limit the flexibility of the project	Rules and regulations limiting the process	Institutional
Energy	Not all stakeholders place sufficient priority on the project	WP leader Other	WP leader WP leader Consortium par12tner Consortium partner Other	Logistical	Working across continents and time-zones is difficult	Distance between stakeholders inhibits the process	Logistical
					Not all stakeholders place sufficient priority on the project	Lack of resources	Logistical
Energy	Not all stakeholders place sufficient priority on the project	WP leader Consortium partner	WP leader WP leader Consortium partner Consortium partner Other	Existing relationships Expertise Collaboration Integration	Working across continents and time-zones is difficult	Distance between stakeholders inhibits the process	Logistical
					Not all stakeholders place sufficient priority on the project	Lack of resources	Logistical

Table 11. Successes discussed in the focus group discussions.

Project	Success	Participants	Votes	Focus group components	Specific code	Category	Component
Floods	Participants are involved with and learn from stakeholders from practice and vice versa	Coach Researcher Student Student	Coach Researcher Student Student	Culture Expertise Existing relationships Usability Reflexivity	Personal networks provide access to coaches and other specialists	Existing connections facilitate collaboration	Existing relationships
					Participants are involved in and learn together with stakeholders from practice	Assimilating and combining different perspectives	Integration
Agriculture	The water authority facilitates connections and involvement of stakeholders that already trust each other	Researcher PhD	Coordinator Researcher PhD Water authority	Culture Existing relationships Collaboration	Water authority facilitates connections and involvement of stakeholders that already trust each other	Existing trust facilitates better collaboration	Existing relationships
Agriculture	The developed pre-treatment system is very effective	Coordinator Water Authority Water Authority	-	Collaboration Integration Usability	Stakeholders closely work together to facilitate integration	Assimilating and combining different perspectives	Integration
					Stakeholders and others outside the project are using the created knowledge	Results are relevant for stakeholders	Usability
Energy	Meaningful engagement with targeted stakeholders and/or audiences	Researcher WP leader Consortium partner	-	Expertise Existing relationships Inclusiveness	Emphasis is placed on building trust and relationships among stakeholders	Building and fostering trust	Existing relationships
					Stakeholders are willing to listen to each other	Having an open mindset	Inclusiveness
Energy	The proposal was broad enough to provide sufficient flexibility to adapt to changes in the progress	WP leader Other	WP leader WP leader Consortium partner Researcher	Institutional Expertise	Proposal was broad enough to provide sufficient flexibility to adapt to changes in the progress of the project	Proposal enables changes in accordance with unexpected progress	Institutional
Energy	Getting to know each other in in-person meetings built trust	WP leader Consortium partner	WP leader WP leader WP leader Consortium partner Consortium partner Researcher Other	Existing relationships Collaboration Integration	Getting to know each other in in-person meetings builds trust	Building and fostering trust	Existing relationships

LOGISTICAL CHALLENGES

Besides institutional challenges, participants of the Energy Project discussed challenges related to logistics. Specifically, the challenge of stakeholders not placing sufficient priority on the project were discussed by two groups. A work package leader and a consortium partner discussed how they experienced other stakeholders prioritizing other projects and not being able to meet the deadlines of the Energy Project. The work package leader describes that some stakeholders are also not interested in integrating their results but mainly work towards a direction they deem important for their own goals. This inhibits the project's ability to generalise results across and outside the project. They describe how there are issues with trust due to stakeholders failing to meet deadlines. Also, they describe a lack of clarification in the proposal of the projects for how priorities should be placed on the project, how the collaboration is organized and how results should be integrated. Besides that, it could be argued that culture could also play a role in this challenge as the differences in expectations and goals in the Agriculture project stem from having different backgrounds.

The other group, consisting of another work package leader and the 'other' participant, decided to discuss another challenge as they finished early. Similarly to the other group, the work package leader describes their experience with the 'projectification' of many climate adaptation research work where some relevant results are not used as they do not fit the scope of the specific project it was generated in. They explain that this way, good research work gets left behind and is wasted between projects. They explain that they observe this not only in SME projects but in academia as well.

The work package leader from the first group suggests that increasing the way in which criticisms are shared among stakeholders involved in the project could serve as an improvement to address this challenge. The work package leader highlights they feel as though no one is sharing constructive criticism or advice as stakeholders place a focus on achieving their own goals and lack an urgency for integration and skill development within the project. The consortium partner agrees with this improvement and suggests that more meetings across work packages could also aid in strengthening the integration and sharing of critique and advice. They envision these improvements would result in more on-time achievements of deadlines and more successful integration through frequent and structured cross-work package meetings. The work package leader from the second group explains that the solution to this problem is most likely longer term funding or funding that remains available after the project is completed. They describe that this improvement would place stakeholder's focus more on disseminating results and would leave more time to build and explore the successes of the projects they participate in.

Overall, the improvements from the participants focus on both the internal and external ways in which the challenge can be addressed. By improving internal feedback and acquiring more external, long-term funding, the stakeholders participating in the projects would be motivated to improve their involvement but also be more incentivised by the resources that would be available. In the existing case data, the necessity to improve internal feedback or increase long-term funding is not explicitly identified. However, improving the reflection on the process has been identified in the existing case data of the Energy Project. This improvement is categorised under reflexivity and describes how more reflexivity could be incorporated in the meetings of the Energy Project. The other projects also address this improvement and acknowledge a need for more reflection on their processes.

CULTURAL CHALLENGES

Challenges related to culture were discussed by participants from both the Agriculture and Energy Projects. The researcher and PhD candidate from the Agriculture Project discussed the challenge of academic and non-academic stakeholders having different goals. They both experience that the hypothetical optimum referenced in academic literature often does not match with the best possible scenario implemented in practice. The researcher gives an example of wells being placed optimally in a circle but in practice, this configuration takes up too much space on the farmer's land. They also describe how they experience the difference between the definition of a successful project. The PhD describes that they are still working on the first research project while the water

authority managing the projects has already moved on to another project as the findings in the first project were positive. This also somewhat relates to the missing challenge that was suggested by the researcher as there is a lack of time to follow up with the water authority on current states of the projects.

The Agriculture Project participants discussed their experience of non-academic stakeholders moving to new projects once the results seem promising and attributed this to cultural differences between academic and non-academic stakeholders. Where non-academic stakeholders need to move quickly, academic stakeholders tend to dwell on projects to ensure their results are sound. Besides that, the researcher focussed on the experience of the theoretical knowledge versus real-world boundary conditions that do not always match. They related this to expertise as they argued this experience was mostly driven by differences in professional experience.

For the Energy Project, a researcher, work package leader and consortium partner discussed a challenge related to culture. This challenge was not included in the pre-defined list and focussed on reaching the right audience to disseminate results to. They discussed that in general, finding the right audience or research participants can be challenging. However, they specifically experience this issue with disseminating the results from the Energy project to the right audience. They mostly attribute this challenge to a lack of resources and a lack of trust from the audiences that need to be reached. They describe how a lack of trust from audiences in researchers can be a result from previous experiences or a lack of relationship building that is done on the researcher's end. Though the challenge was not explicitly identified in the previous study, the challenges of lack of resources does occur in the Energy and Floods projects. Specifically, limited time is mentioned as a limiting resource.

The participants discussing challenges related to stakeholder's culture described that they could be overcome by improving the alignment among stakeholders. The Energy Project consortium partner explained that the challenge could be overcome by training partners that are involved in the project so that "everyone is on the same page as to what is needed/expected" (Consortium partner, Question 3). They describe how an awareness of other's experiences and skills can contribute to being able to reach the right audiences. The Agriculture Project participants mostly described alignment in the way of working in the project. They envision that a more transparent and centralized decision-making can serve as a solution to the cultural challenge they face in the project. They explain that a centralized decision-making can aid in prioritizing and aligning goals of stakeholders. However, as the goals are different, concessions need to be made on which goals are prioritized and deliberation between academic and non-academic supervisors is needed to ensure usable results for both parties. They note that only taking one perspective into account can lead to a solution that is even less optimal than an alternative generated through consensus.

Though the challenge of stakeholder's goals not being aligned has been identified as a challenge in the existing case data, improvements to overcome the challenge have not been identified. Besides that, none of the improvements related to other components describe a need to improve the alignment between stakeholders.

Besides aligning perspectives and goals, the Energy Project researcher describes the improvement in terms of building a larger network and sending more people to events and conferences to reach the right audience. They explain that the existing relationships should be improved to be able to make the necessary connections. The work package leader adds that the flexibility of the approach and responsiveness of the engagement strategies could aid in this improvement as well. Though the challenge of insufficient connections and diverse methods has been identified in the existing case data, improvements regarding these challenges have not been identified.

OTHER CHALLENGES

The two students that participated in the Floods Project focus group were the only groups that discussed a challenge related to inclusiveness. They focussed on the lower variety of disciplines than aimed for that is

participating in the project[9]. They describe their experience with the challenge as having less links with other disciplines and lacking insights from the different perspectives that other disciplines can bring to their own research. The two students related the challenge to key components by describing their desired situation. One student relates the challenge to expertise and collaboration as they describe they would like to engage with other disciplines to learn from their ways of working. The other student related the challenge to culture, collaboration, integration and communication as they would like to integrate and collaborate different perspectives. They think the different personal backgrounds of other disciplines would provide these perspectives. Lastly, they describe the communication of results and integrating generated data as something they would like to experience in the Floods project.

The students realised that the changes that would be required for these desired situations to become reality, the way of working and planning would have to change. Specifically, bringing together more disciplines with a larger variety in backgrounds would require changes in the way collaboration is organised. They did not feel in the position to provide ideas on how these improvements should be achieved is something. Though, if the attraction of a larger variety of disciplines would be successful, they envision the interaction could be facilitated by an online discussion board where questions and results can be posted.

The improvement of stakeholder differentiation has been identified in the existing case data of the Floods Project. Specifically, creating more legitimacy for the project is expected to improve the ability to attract a more diverse group of stakeholders. Besides that, attracting more international stakeholders to increase the diversity of the group has been identified as an improvement.

7.8.2. SUCCESSES

The successes that were selected by the participants were the successes that received the most votes and are presented in TABLE X. As can be seen in the table, the successes discussed during the focus groups focussed mostly on existing relationships with at least one success related to this component for each project. Besides that, most successes that were discussed related to requirements. The requirements that were included are integration, inclusiveness and usability. Lastly, one success related to institutions.

The key components that were selected by the participants mostly overlapped with the components identified during the analysis of the existing case data. An exception to this overlap is the success related to the involvement of stakeholders from practice in the Floods Project. Participants related this success to existing relationships which matched with the analysis. However, participants chose to also relate the success to culture rather than to integration. This is mostly because they described which components they thought were brought to the Floods Project by the stakeholders rather than the possibility for integration with which the success was initially identified.

Also, most participants related more key components to the challenge in their discussion compared to the components selected in the analysis. Yet, the number of components that were linked to successes were significantly less than the number of components linked to each challenge. This could be related to the increased difficulty participants indicated they experienced when answering the questions for successes compared to the challenges.

EXISTING RELATIONSHIPS SUCCESSES

In all projects, one success that was discussed by participants was related to the existing relationships in the project. The success that was discussed in the Floods Project's focus group was focussed on how the participants are involved with and learn from stakeholders from practice and vice versa. All four participants participated in

[9] It should be noted that the students initially participated in the challenge about university structure but found they could not contribute sufficient experience to this challenge. Therefore, the discussion on this challenge is somewhat limited due to a shorter time for discussion.

this discussion. The coach described how the collaboration with outside stakeholders was very effective. The students agreed with this and explained they experienced that stakeholders from practice have more experience with and can provide insights into the relevant data and state-of-the-art research. One student mentioned that they learned from the practical application of the data. The researcher related this success to the culture of the stakeholders involved as they were able to learn from the different perspectives. The coach also related the success to culture but added that the existing connections in their network also contribute to the success. This effect of the existing network was also identified in the previous study. The students related the success to learning from the expertise of stakeholders from practice. Besides that, one student also related usability and reflexivity to this success as they learn how the data is usable and reflected on in practice.

The researcher and PhD candidate from the Agriculture Project discussed the success related to the existing relationships of the water authority and how these facilitate connection between and involvement of stakeholders that already trust each other. The PhD explained that they experienced easy access to specific research locations due to the connection the water authority provided to them. They experienced that stakeholders easily exchange ideas and communicated a lot about the project's progress. They add that the connections are also not limited to agricultural topics but span the entire network of the water authority. The researcher added they experienced the trust that already exists through the speed with which ideas are implemented. They experienced a learning by doing approach and explain that a polit plant has been built very quickly so that data could started to be collected. The researcher relates this to the way in which the collaboration occurs and explains that what is necessary gets facilitated. However, they note that outside this facilitation there remains little time for other collaboration efforts between the work packages. Besides that, the participants agree that the success is most likely related to the culture of the water authority and how they approach collaborations. They note that the existing trust and relationships impose a willingness to collaborate.

In the Energy Project focus group, one work package leader, consortium partner and researcher discussed the meaningful engagement with stakeholders[10]. The consortium partner described that when partners are aligned to the same approach, miscommunication is far less common than when the alignment is not successful. The work package leader adds to this that the development of trust typically leads to more fruitful engagement. The researcher continues that meaningful engagement often requires a mutual understanding and acknowledgement of mistakes and benefits among stakeholders. The participants relate this success to expertise, building and fostering trust and an open mindset and willingness to learn. The latter two can be related to existing relationships and inclusiveness and are identified as successes in both the Energy Project itself (inclusiveness) and the Agriculture Project (existing relationships).

Lastly, another work package leader and a consortium partner from the Energy Project discussed the success of building trust and getting to know one another during in-person meetings. The work package leader describes their experience comparing the current way of working to the start of the project which was during COVID-19 times. They explain that they feel the project has become significantly more efficient, especially due to the in-person meetings that have occurred since the start of the project. They explain that during these meetings goals could be aligned and adaptations could be made to accommodate the conditions and needs of the project in a dynamic way. The consortium partner relates the success to the integration and collaboration of the project. They explain that being present, in-person helps create openness for new perspectives and allows for more relationship building compared to an online environment. The work package leader adds that in-person collaboration also brought forth new ideas and insights more naturally. The participants acknowledged that it is complex to attribute a success to one specific element of the collaboration but admitted that the importance of building and fostering trust was a crucial aspect of in-person meetings.

[10] The participants in this discussion interpreted the success as something that was desired in the project and not necessarily something they think is going well in the project. The description of the success follows the same structure as previous ones, though the remarks are more nuanced and less project specific.

The improvements that are suggested to grow the success are mainly related to the initial conditions and ways of working. Most participants suggested increasing the emphasis that is placed on strengthening the intensity of the collaborations that are already taking place. For example, the researcher from the Agriculture Project suggests that to grow the success, more time should be invested in exchanging with others beyond only the necessary interactions. They add that this could be facilitated by more official meeting moments as those will receive priority. A similar point is brought up by a consortium partner from the Energy project. They suggest to continue the in-person meetings and describes how this could also contribute to more on-time delivery of milestones. This directly relates to the challenge of lacking priority on the project which they discussed as a challenge. The work package leader in this group concludes with the remark that the in-person meetings also contribute to improved communication between partners. This relationship with communication was also identified by the other Energy Project group. The parts they mentioned contributing to growing this success were the organisational structure, internal communication and gaining hands-on experience with the matter. They explain that when these improvements are present in the project, a team spirit and trust and a relationship within the project and with outside stakeholders can be created.

Besides that, the Floods Project students suggested that the connections between the project and stakeholders could be even stronger by reaching out more to stakeholders from practice and asking them questions. They explain that creating connections with stakeholders outside the project could grow the success of collaborating and learning from stakeholders outside the project. The coach adds to this that the results could be communicated even further outside the project and to more people. One student added that doing this would also improve their results as stakeholders would be able to provide more useful information about the area of interest and practice.

The improvements that are suggested by the participants have not been explicitly identified in the existing case data. However, improvements in increasing the activities focussed on trust building at the start of the project have been identified. Nevertheless, making improvements at the start of the project are only relevant for new projects that are starting up. For example, ensuring that all stakeholders have met and know each other is something that would build trust but is no longer feasible in the current phase of the project. If stakeholders have not yet met in the project, building trust between them would be more difficult at this stage as many goals and perceptions have already been materialized for these stakeholders.

OTHER SUCCESSES

Besides successes related to existing relationships, two more successes were discussed. These successes relate to institutions in the Energy Project and the integration and usability of the Agriculture Project. A work package leader and the ‘other’ participant discussed the institutional success which focussed on the proposal of the project and how it provided sufficient flexibility to anticipate unexpected results. The work package leader specifically mentions that the funding body for the Energy Project provides considerable flexibility to deal with these types of changes compared to other funding bodies. They describe their experience in other projects and acknowledge the principle that it is important to find a balance between a clear plan and having flexibility to adapt to unanticipated and emerging results. This success can be seen as contradicting to the rules and regulations limiting the flexibility of the project. This institutional challenge was also discussed by this group of participants. The work package leader acknowledges this contradiction in their notion that a balance between a fixed plan and flexibility needs to be found when setting up a project. This means that too much flexibility would lead to a challenge in the lack of direction, aligned goals and coordination which have all been identified in the other projects. They related the institutional and expertise key components to this success. They explained that the regulations allow for the flexibility but also the structure that is necessary in projects. Additionally, the expertise of stakeholders for writing good, sufficiently structured as well as flexible proposals is something that is required to create the balance between fixed and flexible project plans.

A way to grow the success suggested by the work package leader and ‘other’ participant is to redesign the deliverable formats to be more impactful. The work package leader explains that the deadlines for deliverables and the way deliverables are described is often strict and specific leaving little room for flexibility. No

improvements related to deliverables have been identified in the existing case data. However, as this data was collected in early stages of the project, improvements in deliverables could be unrecognised as not many deliverables have been generated yet.

Besides an institutional success, the two water authority employees and the coordinator of the Agriculture Project discussed how the pre-treatment and filter system has been implemented and proven very effective in filtering pathogens out of the water. The coordinator explains that they feel the successful implementation of the filtering system is a direct result from the streamlined collaboration that occurred between the farmers, water authorities, companies and academic stakeholders. They explain that each stakeholder has an expertise that is relevant to the implementation of the technology (e.g. university creates the theoretical knowledge, farmers provide the necessary resources and the water authority provides the connections for successful implementation). It can be argued that this success is closely linked to the successes of stakeholders working closely together to facilitate integration (integration) and stakeholders and others outside the project using the created knowledge (usability).

The improvements that are suggested to grow the success are that there should be more room to continue the pilots that are implemented long term. The water authority explains that currently the pilots that are implemented work well but projects often reinvent the wheel as there are new projects initiated in quick succession and close together yielding similar results. Ensuring that the projects run in phase ensures a more efficient development of the technology. This improvement would require longer term funding but the coordinator explains that this approach most likely benefits society more on the long term.

7.8.3. INSIGHTS FOR PARTICIPANTS

To conclude the focus group, the participants were asked to reflect on the focus group and the insights they gained from doing the exercises. This section describes these insights and how the participants reflected on their project's process.

A work package leader from the Energy Project explains that "it's not just about challenges on delivering the project, but challenges on delivering the project from a transdisciplinary perspective". They highlight that the traditional idea of what a project is does not necessarily match with the activities that are related to TD research. They acknowledge that the focus group exercises helped emphasise the differences between traditional projects and the more "messy nature" of TD projects. Similarly, the researcher participating in the Agriculture Project mentioned that they gained a better understanding of the challenges and successes through this exercise and realized that this is important to have. They highlight the value of reflecting on these aspects, which they may not have done regularly otherwise. The coach from the Floods Project noted a similar point and added that they think other initiatives can learn from how these types of collaborations can be structured and reflected on.

The coordinator of the Agriculture Project highlighted the need for discussions to address the extent of water treatment and the different opinions among water boards and lawmakers. Though this is a case specific remark, the need for more discussion and communication was also mentioned by a work package leader from the Energy Project. They explain that the discussion of experiences among stakeholders prompts internal conversations and clarifies the focus on TD aspects of the project.

A consortium partner from the Energy Project expressed they found it insightful to discuss challenges in the project in the way the focus group was structured. They also explained they found it difficult to perform the analysis of a challenge for successes, specifically mentioning the difficulty of identifying how to sustain a certain success beyond continuing the current practices.

Lastly, a student from the Floods Project acknowledged that the focus group brought attention to the inherent complexities in the project they had a gut feeling about. They appreciate the opportunity to combine various elements in their research, recognizing the potential for valuable outcomes when different ideas and disciplines are brought together. Both students recognized the value of having pre-written notes that encompassed

previously encountered or researched concepts. They explain that this method stimulated their thinking process and enabled them to consider past experiences and their implications more thoroughly. The researcher from the Floods Project mentions the recurrence of similar issues faced by both students and researchers which they recognized and emphasized the need for increased stakeholder involvement, interdisciplinary collaboration, and knowledge exchange.

DISCUSSION

The goal of the study is to identify how TD projects for climate adaptation can better address the challenges and successes they experience in their projects. The previous section presented the results that were collected during this study. This section discusses these results and provides a comprehensive analysis and interpretation of these results. First, the main findings are presented. As the focus group including the focus group discussions served as the primary data collection, the discussion is structured by the main findings of these discussions. The findings are followed by the implications that can be made. Then, limitations of the study and further research are discussed.

7.9. MAIN FINDINGS

During this research, several results were collected and described in the previous sections. This section aims to present the main findings from these results. To structure this section, the findings are organised by theme and types of results, e.g. the theoretical framework, the expert interviews, the re-analysis of existing case data and the focus group discussions.

7.9.1. TRANSDISCIPLINARY DEFINITIONS

In both the literature and the existing case data, the concept of TD research is described as insufficiently defined.

The first knowledge gap of insufficiently defined definitions describing TD projects was identified in the literature review of this study. To fill this knowledge gap, a theoretical framework was developed defining the concepts relevant to TD project and relating them in a framework. In the existing case data, the challenge of diffuse concepts was also identified. However, the challenge did not only describe the diffuse definitions of concepts describing TD projects in general, but specifically identified the differences of definitions between stakeholders as a challenge.

In the 'None' codes, the challenge of 'fuzzy' concepts related to TD projects was referenced. Also, during the focus group discussions, the differences in what participants identified as a success or achieved goal were identified as challenges that should be addressed in the projects. The differing priorities of stakeholders involved in the Energy Project were explicitly referenced as a challenge. Differences in definitions, methods and goals also seemed to amplify the challenges that were faced in the projects. Therefore, it was important for stakeholders to improve the agreements on definitions of concepts, goals and successful collaboration.

During the reflective sessions, participants from all case studies mentioned that the pre-defined list of initial conditions and requirements was experienced as a useful tool in their discussion. They explained that the definitions were clear and supported their discussion. This is in line with the adaptations that were made as a result of the suggestions provided by TD experts. They pointed out that the concepts explained in the theoretical framework were too theoretically oriented for a discussion among participants who do not necessarily have experience with facilitating TD collaboration. Simplifying the terms that were used but providing additional, theoretical definitions to participants provided sufficient support for participants to structure their discussions.

7.9.2. PRIORITIZED CHALLENGES AND SUCCESSES

Considering the votes that were placed on the challenges and successes of the projects, two patterns in the components to which the challenges and successes are related can be observed. First, all three projects prioritized challenges that were related to culture and inclusiveness. Taking the amount of quotes related to cultural challenges identified in the previous studies into account, the prioritization of cultural challenges is no surprise. 18% of quotes related to challenges that were analysed were categorized as related to culture making it the largest component followed by logistical with 14% of the challenge quotes. The categories that the component is comprised of describe backgrounds and expectations as the challenges that are faced by stakeholders in all three projects.

Besides that, inclusiveness is marked as a component that is related to challenges in all three projects. This can be associated with the challenge of not involving all relevant stakeholders in the project. This challenge was included in the pre-defined lists of the Floods and Energy projects and was in both projects the challenge that received the most votes. For the Agriculture Project, the challenge that is related to inclusiveness is the difficulty with using language that all stakeholders understand which received only two votes.

On the other hand, the components that are related to the successes for all three projects are existing relationships and integration. Especially the existing relationships can be identified as something that was experienced as very successful in the projects. Besides the codes that are related to this component, the participants in all focus group discussions mentioned trust and relationships as a factor that was very successful in their project. Though they acknowledged in the Energy case that there were some challenges with trust as well, most participants related the existing relationships to success. This could be because relationships are a more explicit experience that can be recalled by participants or because the building and fostering of trust comes easier to these types of collaboration projects.

Besides that, a striking component related to success is the collaboration in the Floods Project with the highest score in all the challenges and successes. This is remarkable but not unexpected as 25% of the Floods Project quotes related to success were attributed to collaboration. Besides that. more than one success included in the summary was related to collaboration and each success that did received a high number of votes. This successful experience of collaboration could be related to the way in which the Floods Project organises their activities. Opposed to the Agriculture and Energy Projects which have the goal of producing certain knowledge through collaboration of a fixed consortium of stakeholders, the Floods Project operates in a more informal manner focussing on facilitating collaboration between academic and non-academic stakeholders. Therefore, the focus on how activities are organized could be more pronounced in the Floods Project. Specifically, a stronger focus on what the benefits of participating are could have a stronger emphasis as the set of stakeholders that are involved need to be motivated to participate. This could be something that could be implemented in the other projects as well to increase the success of the collaboration.

7.9.3. SIMILAR CHALLENGES AND SUCCESSES ACROSS CASES

Considering the categories and specific codes that were synthesized from the previous project, an observation that can be made is that many of the challenges and successes that are faced in one case study are also faced in the other case studies. Though the context of the challenges and successes are different, the a particular pattern can be observed that is similar across contexts.

For example, in the Floods Project discussed the challenge of the mismatch between the university structure and the required flexibility for TD collaboration in the project. They emphasized how the university's funding structure posed challenges for the legitimacy of the Floods Project. This is because the recognition and support for collaboration across disciplines or faculties is lacking, especially in the research projects that are done at the university. This can be because the benefits and learning objectives related to TD collaboration lack sufficient definition. This then contributes to a lack of institutional legitimacy as the university is unable to specifically define the impacts that are generated and the competencies that are developed by students and researchers.

This is a challenge that is specific to the context of the Floods Project. However, the both the Agriculture and Energy Project face challenges related to institutions. Specifically the Energy Project also described how the flexibility of the project is limited by funding structures and regulations determining the structure of the project. They describe how they are not sufficiently able to engage with the emergent results that are generated by the project. Because of this, data and insights are left behind as the project needs to move forward to meet its deadlines. This lack of flexibility is, like for the Floods Project, related to a lack of flexibility in the institutional environment of the projects.

On the contrary, some projects also experienced a success which was perceived as a challenge in another project. For example, in the Energy Project, the challenge of reaching the right audience to disseminate project results

was discussed. This challenge was attributed, in part, to a lack of trust and resources. In the Agriculture Project, the dissemination of results beyond the delineation of the project was experienced as successful. They identified easy access to research locations, trust-building, and rapid implementation of ideas as key factors contributing to this success. This challenge was not specifically discussed by participants. However, in both discussions, the successful implementation and ability to reach practitioners that are willing to implement the developed technology were emphasized. They attributed these successful aspects to collaboration, culture, existing relationships, integration and usability. It is noteworthy that the existing relationships are referenced in all discussions. This leads to the conclusion that either the presence or lack of existing relationships provokes the experience of challenging or successful communication of results.

Though only a limited number of challenges and successes was discussed during the focus group discussions, the similarities between the experiences of stakeholders across cases is uncanny. Also, consulting the specific codes in the code categories reveals that many projects share specific codes. When considering the quotes that are related to these specific codes, the same similarities as revealed in the examples discussed here can be observed. Therefore, it could be argued that, on a certain level of abstraction, challenges and successes are similar across cases regardless of the organizational structure of the project or the issue that is addressed as both differ vastly between the case studies.

To address the challenges that are identified in all three cases, a more systematic approach is necessary. This means that changes at an institutional level, i.e. the university, funding bodies and government organisations, are required. An issue that is identified in specifically the Floods Project is that the people influencing the university regulations are not yet sufficiently aware of the restrictions the regulations pose to TD projects. This observation can also be made at funding bodies and government organisations as they are not yet able to implement regulations facilitating emergent results or allowing exceptions in government regulations.

7.9.4. DIFFERENCES BETWEEN PARTICIPANTS

An observation that was made during the review of the focus group discussions regards the limited way in which participants discussed concepts outside of their personal background. This means that participants limited their comments in the discussion to their own experience and only interacted with comments from other participants if it directly related to their experience. During these discussions, a divide could be made between the stakeholders who related to the comments that were being made and the stakeholders who did not. The latter group was often drowned out by the first group.

Specifically the discussions of the Agriculture Project and the Floods Project showed this. In the Agriculture Project's focus group, this observation was made in the discussion between the two Water Authority employees and the coordinator. One Water Authority employee mostly leads the discussion and expresses their experiences with the regulations and permits that are needed for the implementation of certain pilots. Often, the other Water Authority employees agreed with the comments that are made and adds their similar experiences. The coordinator, who has an academic background, at several instances attempts to relate the comments to their experiences in the academic world. However, the coordinator's perspective is not explicitly acknowledged by the Water Authority employees and is not incorporated in their experience as an additional perspective.

Though the discussion is providing insight into the experiences of the Water Authority employees, the coordinator's perspective is not integrated in the discussion. Mostly, the two different stakeholders wait for their turn to provide an explanation for their experience and do not interact with the comments made by the other participants. Especially the coordinator was often overruled in the discussion despite attempts to interfere and share their experiences. This could be because the coordinator realized that their role is to acknowledge and bring together the different stakeholders and was interested in the perspective of the Water Authority employees without feeling the need to address their own perspective. Nevertheless, the Water Authority employees did not show interest in the academic perspective on the challenges they were facing.

This observation was also made in the Floods Project's focus group. During this discussion, the coach and researcher commented on the challenge relating to the inflexible university regulations limiting the project whereas the students did not feel they could contribute their experience to the discussion. It should be noted that in the Floods Project's focus group, participants did not explicitly discuss the challenge but mostly focussed on writing down their individual perspectives and experiences. Though conversation was encouraged by the researcher and a question was initiated by a student, a lively discussion about the topics did not occur. This exaggerates the lack of interaction between the participants and could be the reason for the students not feeling as though they could contribute.

On the other hand, the experiences of the coach and researcher involved intimate knowledge of how the university functions. This was knowledge the students did not have and could not relate to their experience. However, even though the challenge relates to the coordination of the Floods Project, only the coach is actively involved in this process. The researcher also contributed their experience with inflexible university regulations and related them to the project. The lack of interaction between the participants with and without specific experience could suggest a lack of integration of these types of knowledge within the project. This type of knowledge (related to the university structure) is not included in the objectives of the Floods Project. However, the awareness of regulations limiting the flexibility of the project can be relevant for understanding the importance of TD collaboration and the need to change the institutional structure to enable this.

Overall, in both discussions, a divide between the stakeholders with and without a certain experience can be observed. The interaction between the two groups is limited and knowledge is not necessarily integrated across these groups. Rather, the knowledge that is shared is related to the perspective of one group and the relatability for other stakeholders is not necessarily taken into account. This lack of integration can be a result of the roles stakeholders feel they need to fulfil, e.g. a coordinator who prioritizes the experiences of the other stakeholders or a student who should focus on their study domain rather than the university structure.

Otherwise, the lack of acknowledgement for other perspectives can be a result of the feeling stakeholders' problems are not being addressed. By dominating the discussion, they could feel they are doing something to address their problem but in the process disregard the experiences of others. In both discussions, the dominating stakeholders (e.g. Water Authority employees and the coach and researcher) explain they experience challenges and feel as though they are not yet sufficiently addressed.

By educating all involved stakeholders on what the processes of TD projects can bring them, they could gain more insight into the perspective of other stakeholders who can help them develop solutions to their issues. This includes providing clear goals and reflecting on whether goals are achieved in accordance with stakeholder's expectations. In the Energy Project, sharing criticism among stakeholders was one improvement that was emphasised. Focussing on the learning and development of stakeholders' personal goals is aided by providing constructive feedback and reflection. Educating stakeholders on why and how criticism and reflection are crucial parts of collaboration could address this issue.

7.9.5. REFLECTION ON CHALLENGES VERSUS SUCCESSES

Besides similarities in discussion, different participants across case studies expressed a greater difficulty describing their experiences with successes and envisioning improvements compared to challenges. They explained that envisioning an improvement for challenges came easier that envisioning a greater success. Also, some discussions did not focus on a success in the project they had experience with but rather explained a challenge and how they would envision an ideal situation. Though this is also an interesting discussion, the conclusion that reflecting on successes in the project requires more structure and guidance than criticizing the challenges. This reflection in the project and emphasis on what is going well should receive more attention. More explicit discussion of the successes of a project would also contribute to a better understanding of the benefits of TD research compared to only focussing on things that are not going well.

7.9.6. PARTICIPANTS SUGGESTED NEW IMPROVEMENTS

As described in the results of the focus group discussions, most of the improvements that were suggested by participants were not identified in the existing case data. Only one improvement that was suggested in the Floods Project was also identified in the existing case data. Nevertheless, the improvements that were suggested by participants could be related to other challenges or improvements suggested in other projects. This means that during the interviews, the project coordinators and work package leaders acknowledged the challenges and successes that were present in the projects and suggested improvements. However, the improvements that were suggested by the participants during the focus groups either did not consider difficulties with implementing certain improvements (e.g. the suggested improvements could be identified in the challenges) or suggested entirely new perspectives for improving the project (e.g. the suggested improvements were not identified in the existing case data).

The mismatch between improvements identified in the existing case data and suggested in the focus groups could be caused by the differences in timing of the projects. During the interviews with project coordinators and work package leaders, the projects were in their early stages. During the focus group, more time has progressed and more goals have been achieved. Therefore, participants could be able to point out other types of improvements compared to the earlier stages. On the other hand, participants only discussed a limited number of challenges and successes and therefore only suggested improvements for these challenges and successes, whereas the existing case data includes improvements related to a range of challenges and successes. Therefore, it is likely that the improvements identified in the existing case data are more scattered across challenges and successes and do not match with the more focussed improvements suggested during the focus groups.

7.10. LIMITATIONS

Despite the valuable insights gained from this study, there are several limitations that should be acknowledged.

7.10.1. GENERALIZABILITY

The study focused on a limited number of case studies, which may limit the generalizability of the findings. The specific contexts and characteristics of these case studies may not fully capture the diversity and complexity of all TD projects in climate adaptation. Specifically, the perceived challenges and successes of the case studies included in this research do not reflect the broad spectrum of challenges and successes that may arise in TD projects focussed on climate adaptation. Additionally, the sample size of the focus group participants is limited. Of the 81 invites that were sent, only 15 participants provided input to the focus group discussion (< 20%) which is arguably a too small sample size to confidently draw generalizable conclusions. Nevertheless, the conclusions that can be drawn are based on rich data that at minimum provides insight into the perceptions of challenges and successes in the three case studies.

Additionally, the study primarily focused on the organizational and implementation aspects of TD projects. Though a comparison between previous studies and the current study were made, it did not extensively explore the long-term impacts and sustainability of these projects. This is especially important regarding the long running times by which TD projects are characterized

For these reasons, the findings synthesized from the results collected from these case studies may not be representative of and applicable to other TD projects. In future research, the generalizability of the results will inevitably remain a challenge for case study research designs. However, collecting results from a larger group of focus group participants and a larger set of case studies could increase the generalizability of the results to other projects.

Lastly, the focus group design that is presented in Section 7.4.3 formed the structure with which data was collected across case studies. Effectively, the same focus group setting was presented to the participants of all three case studies to ensure the comparability and generalizability of the results within the three case studies. Though minor differences inevitably existed between the three focus groups (e.g. the Floods Project did not have

breakout rooms for discussion, the researcher's wording in the explanation of the assignment varied based on questions from participants and the dynamics between participants varied across discussion groups) the overall structure of the focus group was the same across cases. This enables the data that was collected to be comparable across the case studies and the findings to be generalizable within the thesis. The same notion holds for the existing case data that was used as input for the focus group as explained in Section 7.3.

Future studies could use this focus group design to collect data from other case studies to identify and evaluate the perceived challenges and successes present in the project. By using the focus group design and collecting data in a similar way, the results from future studies could be compared. If similar findings are synthesized from the results, these findings can be generalized across the cases that are analysed. Future research could also delve into the long-term effects and evaluate the scalability and transferability of successful TD approaches through the structures that are developed in this study.

7.10.2. LIMITATIONS OF THE FOCUS GROUP DISCUSSIONS

In general, the focus group discussions facilitated interaction between different stakeholders. They discussed their experiences and related them to the structure provided by the focus group design. Though an effort was made to ensure all three focus group discussions were as similar as possible, some differences occurred. First, during the Floods Project's focus group discussion, the students that participated in the focus group realized they did not have sufficient experience with the challenge that was selected for discussion after the exercise started. Because of this, the session did not have breakout rooms and the Students discussing another challenge completed the assignment in the same meeting as the coach and researcher. Also, all participants contributed the discussion of the success in the floods project in the same meeting. This contributed to a lack of interaction between focus group participants in the Floods Project. The responses that are recorded for this case study mostly rely on the written answers to the questions that were posted on the MIRO board.

Besides that, participants in the Energy Project had difficulty finding the right MIRO board sections, the different components on the board and were not necessarily sure on how to use them. As the focus group participants were divided into three breakout rooms, the researcher was unable to provide timely and adequate assistance to prevent participants from wasting time. Nevertheless, the focus group participants asked questions and were able to eventually manage to contribute to the MIRO board. Besides that, the discussion that was had by the participants was fruitful and insightful.

7.10.3. BIASES IN THE DATA

The data collection primarily relied on focus group discussions, and expert interviews. While these methods provided rich qualitative data, they are subject to inherent biases and limitations. As the TD experts were selected from and related to the case studies, bias in their perspectives could have influenced the results. Nevertheless, they were able to provide useful insights into the context in which the stakeholders would apply the concepts proposed in the theoretical framework. Besides that, the participants' perspectives and experiences may not fully represent the entire spectrum of stakeholders involved in TD projects. Especially as the number of participants that participated in the focus groups was lower than expected, this limited representativeness of the sample group could be amplified. Therefore, caution should be exercised when generalizing the findings to other contexts. Additionally, this study mainly relied on self-reported data from participants, which may be subject to social desirability bias or inaccuracies in recall.

Despite these limitations, this study provides valuable insights and sets the stage for further research to address the complexities and challenges of TD research in climate adaptation.

8. CONCLUSION

In conclusion, this study aimed to address the knowledge gaps in the three TD projects for climate adaptation by investigating how these projects can better address their perceived challenges and successes. By examining three distinct TD projects and engaging with stakeholders through the re-analysis of case data, expert interviews, and focus group discussions, several key findings emerged, shedding light on knowledge gaps and potential avenues for improvement in TD research. The study identified three main knowledge gaps: a lack of specific definitions for TD research, limited understanding of the benefits and risks of TD research, and a need for assessment criteria to reflect on the subjective aspects of the TD project's process.

The main findings of this research shed light on various aspects of TD projects for climate adaptation. Notably, the challenge of insufficiently defined concepts within TD projects was identified both in the literature and among stakeholders. To address this, a theoretical framework was developed, providing clarity on the key components relevant to TD projects. Moreover, the importance of harmonizing stakeholder perspectives on key definitions and objectives emerged as a critical factor for successful collaboration.

The prioritized challenges and successes across the case studies revealed commonalities, such as the significance of cultural considerations, inclusiveness, and existing relationships. These patterns suggest that certain challenges and successes may transcend the context and nature of the projects, reinforcing the need for strategies to address challenges on a systemic level. Furthermore, the divide between stakeholders with different backgrounds highlighted the importance of integrating diverse perspectives and knowledge within TD projects, fostering a more holistic understanding of the perceived challenges and successes.

Returning to the research questions that guided this study, the findings provide insightful responses.

The developed theoretical framework identified and clarified essential components of TD projects, providing a structure that aids stakeholders in addressing challenges and amplifying successes. This provides answer to which key components are relevant to TD projects. By emphasizing the role of definitions, goals, and successful collaboration, the framework promotes a shared understanding among stakeholders and fosters effective TD collaboration.

The analysis of the main challenges and successes demonstrated that cultural considerations, inclusiveness, and existing relationships are pivotal components influencing the outcomes of TD projects. The similarities across the cases underscored the need for systematic approaches to address these challenges and leverage these successes in TD collaborations.

The reflection on improvements provided by stakeholders highlighted a strong focus on addressing challenges through collaboration, clearer communication, and trust-building. The difficulty in envisioning greater successes indicated a potential area for growth in TD project discussions. Challenges related to institutional structures, funding constraints, and collaboration were observed in multiple projects, emphasizing the need for greater flexibility and support for TD approaches. Similarly, successful outcomes were often associated with existing relationships, trust-building, and collaboration.

The study also highlighted the importance of structured reflection and the sharing of critique and advice in TD projects. Participants recognized the value of regular evaluation, but often overlooked the benefits of continuous reflection in project structures. By providing a framework for discussion and explicitly addressing successes, stakeholders were able to gain a deeper understanding of the benefits of TD research and envision improvements for their projects. Furthermore, promoting structured reflection and prioritizing learning objectives can foster a culture of continuous improvement and skill development among stakeholders. By promoting structured reflection on successes, stakeholders could enhance the understanding of positive outcomes and benefits.

While this study offers valuable insights, its generalizability is limited by the scope of the examined case studies and the relatively small sample size of focus group participants. Future research endeavours should seek to

broaden the sample size and encompass a wider range of case studies to enhance the applicability of findings. Additionally, exploring the long-term impacts and sustainability of TD collaborations could provide deeper insights into the effectiveness and lasting benefits of these projects.

In conclusion, this research contributes to the understanding of how TD climate adaptation projects can effectively address challenges and harness successes. By developing a theoretical framework, uncovering shared challenges and successes, and emphasizing the importance of integrating diverse perspectives, this study offers a roadmap for stakeholders to navigate the complexities of TD collaborations. The insights gained here pave the way for more informed, impactful, and sustainable TD projects in the realm of climate adaptation.

9. APPENDIX A – LITERATURE REVIEW

Appendix A - Table 1. Papers included in the literature review.

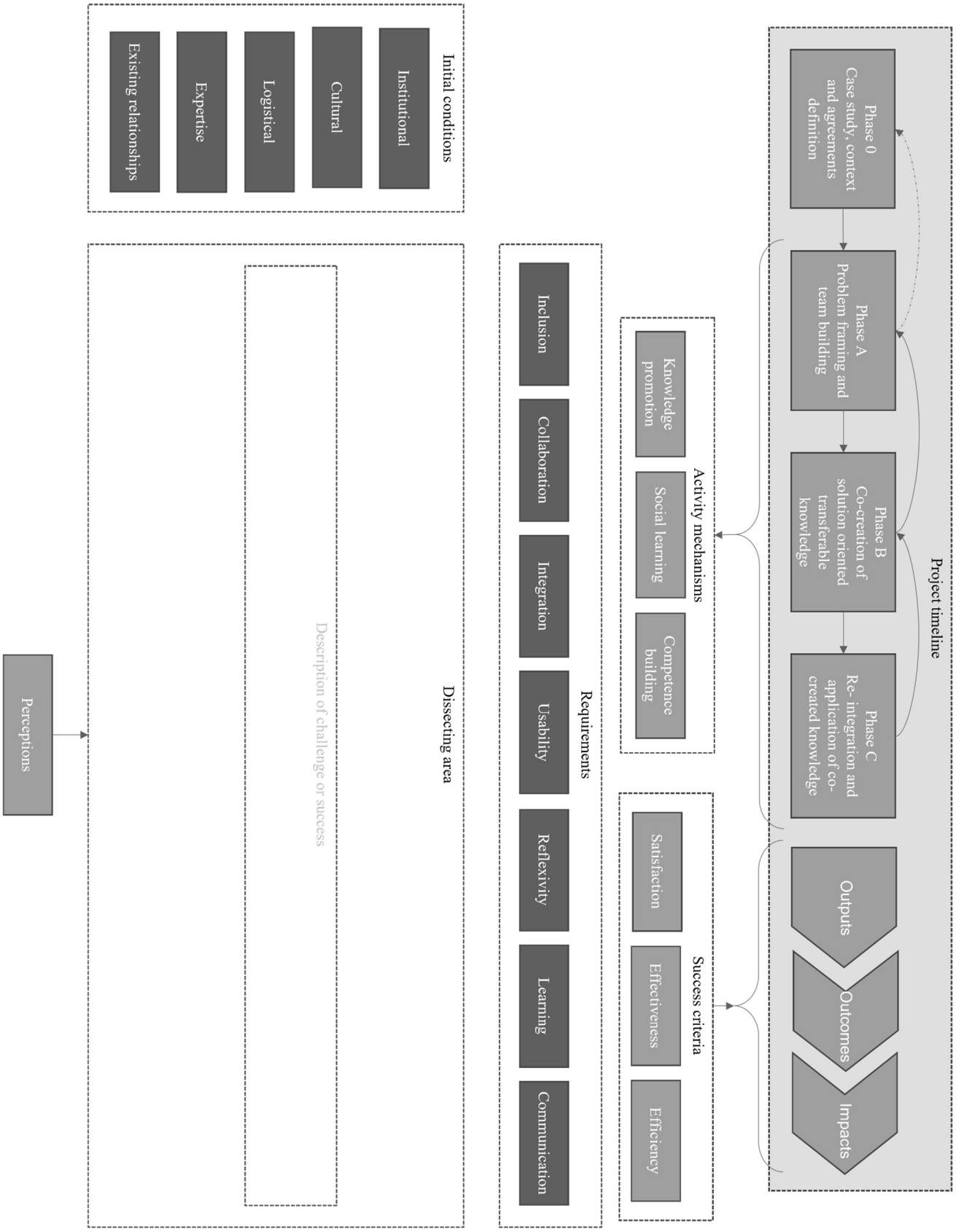
1.	Basche, A. D., Roesch-McNally, G. E., Pease, L. A., Eidson, C. D., Lahdou, G. B., Dunbar, M. W., Frank, T. J., Frescoln, L., Gu, L., Nagelkirk, R., Pantoja, J., & Wilke, A. K. (2014). Challenges and opportunities in transdisciplinary science: The experience of next generation scientists in an agriculture and climate research collaboration. *Journal of Soil and Water Conservation*, *69*(6), 176A-179A. https://doi.org/10.2489/jswc.69.6.176A
2.	Basta, C., Kunseler, E., Wamsler, C., van der Jagt, A., Baró, F., Balenciaga, I., Bach, M., & Wickenberg, B. (2021). Inclusiveness, Equity, Consistency, and Flexibility as Guiding Criteria for Enabling Transdisciplinary Collaboration: Lessons From a European Project on Nature-Based Solutions and Urban Innovation. *Frontiers in Climate*, *3*(August). https://doi.org/10.3389/fclim.2021.630075
3.	Brandt, P., Ernst, A., Gralla, F., Luederitz, C., Lang, D. J., Newig, J., Reinert, F., Abson, D. J., & Von Wehrden, H. (2013). A review of transdisciplinary research in sustainability science. *Ecological Economics*, *92*, 1–15. https://doi.org/10.1016/j.ecolecon.2013.04.008
4.	Bréthaut, C., Gallagher, L., Dalton, J., & Allouche, J. (2019). Power dynamics and integration in the water-energy-food nexus: Learning lessons for transdisciplinary research in Cambodia. *Environmental Science and Policy*, *94*(August 2018), 153–162. https://doi.org/10.1016/j.envsci.2019.01.010
5.	DeLorme, D. E., Kidwell, D., Hagen, S. C., & Stephens, S. H. (2016). Developing and managing transdisciplinary and transformative research on the coastal dynamics of sea level rise: Experiences and lessons learned. *Earth's Future*, *4*(5), 194–209. https://doi.org/10.1002/2015EF000346
6.	Heilmann, A., & Pundt, H. (2021). Methods of Transdisciplinary Collaboration Within Sustainable Research and Development Projects. In *World Sustainability Series* (pp. 81–90). https://doi.org/10.1007/978-3-030-63399-8_16
7.	Hessels, L. K., de Jong, S. P. L., & Brouwer, S. (2018). Collaboration between heterogeneous practitioners in sustainability research: A comparative analysis of three transdisciplinary programmes. *Sustainability (Switzerland)*, *10*(12). https://doi.org/10.3390/su10124760
8.	Hoffmann, S., Pohl, C., & Hering, J. G. (2017). Exploring transdisciplinary integration within a large research program: Empirical lessons from four thematic synthesis processes. *Research Policy*, *46*(3), 678–692. https://doi.org/10.1016/j.respol.2017.01.004
9.	Jakobsen, C. H., Hels, T., & McLaughlin, W. J. (2004). Barriers and facilitators to integration among scientists in transdisciplinary landscape analyses: A cross-country comparison. *Forest Policy and Economics*, *6*(1), 15–31. https://doi.org/10.1016/S1389-9341(02)00080-1
10.	Karcher, D. B., Cvitanovic, C., Colvin, R. M., van Putten, I. E., & Reed, M. S. (2021). Is this what success looks like? Mismatches between the aims, claims, and evidence used to demonstrate impact from knowledge exchange processes at the interface of environmental science and policy. *Environmental Science and Policy*, *125*, 202–218. https://doi.org/10.1016/j.envsci.2021.08.012
11.	Klenk, N., & Meehan, K. (2015). Climate change and transdisciplinary science: Problematizing the integration imperative. *Environmental Science and Policy*, *54*, 160–167. https://doi.org/10.1016/j.envsci.2015.05.017
12.	Knickel, M., Knickel, K., Galli, F., Maye, D., & Wiskerke, J. S. C. (2019). Towards a reflexive framework for fostering co-learning and improvement of transdisciplinary collaboration. *Sustainability (Switzerland)*, *11*(23), 6–8. https://doi.org/10.3390/su11236602
13.	Lang, D. J., Wiek, A., Bergmann, M., Stauffacher, M., Martens, P., Moll, P., Swilling, M., & Thomas, C. J. (2012). Transdisciplinary research in sustainability science: Practice, principles, and challenges. *Sustainability Science*, *7*(SUPPL. 1), 25–43. https://doi.org/10.1007/s11625-011-0149-x
14.	Lawrence, M. G., Williams, S., Nanz, P., & Renn, O. (2022). Characteristics, potentials, and challenges of transdisciplinary research. *One Earth*, *5*(1), 44–61. https://doi.org/10.1016/j.oneear.2021.12.010
15.	Luetkemeier, R., Mbidzo, M., & Liehr, S. (2021). Water security and rangeland sustainability: Transdisciplinary research insights from Namibian–German collaborations. *South African Journal of Science*, *117*(1–2), 1–9. https://doi.org/10.17159/SAJS.2021/7773
16.	Mann, C., & Schäfer, M. (2018). Developing sustainable water and land management options: reflections on a transdisciplinary research process. *Sustainability Science*, *13*(1), 205–217. https://doi.org/10.1007/s11625-017-0451-3
17.	McGreavy, B., Haynal, K., Smith-Mayo, J., Reilly-Moman, J., Kinnison, M. T., Ranco, D., & Leslie,

	H. M. (2022). How Does Strategic Communication Shape Transdisciplinary Collaboration? A Focus on Definitions, Audience, Expertise, and Ethical Praxis. *Frontiers in Communication*, *7*(February), 1–14. https://doi.org/10.3389/fcomm.2022.831727
18.	McGregor, S. L. T. (2017). Challenges of Transdisciplinary Collaboration : A Conceptual Literature Review Special Qualities of Transdisciplinary Collaboration. *Integral Leadership Review*, *May*.
19.	Mitchell, M., Moore, S. A., Clement, S., Lockwood, M., Anderson, G., Gaynor, S. M., Gilfedder, L., Rowe, R., Norman, B., & Lefroy, E. C. (2017). Biodiversity on the brink: Evaluating a transdisciplinary research collaboration. *Journal for Nature Conservation*, *40*(December 2016), 1–11. https://doi.org/10.1016/j.jnc.2017.08.002
20.	Polk, M. (2015). Transdisciplinary co-production: Designing and testing a transdisciplinary research framework for societal problem solving. *Futures*, *65*, 110–122. https://doi.org/10.1016/j.futures.2014.11.001
21.	Siebenhüner, B. (2018). Conflicts in Transdisciplinary Research: Reviewing Literature and Analysing a Case of Climate Adaptation in Northwestern Germany. *Ecological Economics*, *154*(July), 117–127. https://doi.org/10.1016/j.ecolecon.2018.07.011
22.	Siew, T. F., & Döll, P. (2012). Transdisciplinary research for supporting the integration of ecosystem services into land and water management in the Tarim River Basin, Xinjiang, China. *Journal of Arid Land*, *4*(2), 196–210. https://doi.org/10.3724/SP.J.1227.2012.00196
23	Zhuang, J., Löffler, F., & Sayler, G. (2021). Closing transdisciplinary collaboration gaps of food-energy-water nexus research. *Environmental Science and Policy*, *126*(January), 164–167. https://doi.org/10.1016/j.envsci.2021.10.004

10. APPENDIX B – EXPERT INTERVIEW MATERIALS

This appendix contains the questions and summaries of the interviews with TD experts. Also, the framework they were shown is included in this appendix.

10.1. THE FRAMEWORK



Appendix B - Figure 1. The Theoretical framework adapted to an exercise (first iteration).

10.2. INTERVIEW INFORMATION

Goals of the interview:

- Verify the framework
- Ensure it is understandable for workshop participants
- 'Teaching' participants about TD

Interview questions:

- Do you think the framework will be sufficiently clear and understandable for participants?
    - Does the placement of the concepts make sense?
    - Taking into consideration that participants will enjoy a presentation of the concepts and the framework, is the amount of information too overwhelming to comprehend?
- Are the definitions of the concepts correct?
    - Is anything missing?
    - Do you have any suggestions for other literature that I could consult?

10.2.1. THE SETUP OF THE WORKSHOP

00:00 - 00:10 arrival of participants + delay buffer (0-10 min)

00:10 - 00:20 welcome + introduce meeting objectives (5-10 min)

00:20 - 00:40 discuss challenges and successes (c&s) from previous study (10 min)

00:40 - 00:50 add missing c&s + share experiences with c&s (15 min)

00:50 - 01:05 explanation of theoretical framework + exercise (15-20 min)

01:05 - 01:35 in groups do the framework exercise (30 min)

01:35 - 01:50 discussion of results + reflection on the relevance of the framework (10-15 min)

01:50 - 02:00 plenary closing (5-10 min)

10.2.2. HOW THE FRAMEWORK CAN BE USED (WORKSHOP EXERCISE)

By following the steps, participants should be able to gain more insight into the challenges and successes they face in their TD projects. By dissecting a challenge or success in requirements and initial conditions, more informed decisions can be made in overcoming challenges and amplifying successes.

The exercise will be conducted using a MIRO board. On this board, the definitions of each concept will be visible when zooming in on the concept (e.g. small text). This way, participants will be able to revisit the definitions during the exercise. Besides that, the following steps will be provided on the MIRO board. All initial conditions and requirements will be boxes that can be dragged and dropped. Writing will be recorded on post-its by participants.

1. Describe the challenges or success that will be dissected
2. Identify where in the project's timeline this challenge occurs
3. Drag the requirements that are relevant to the dissecting area
    I Write down how these requirements relate to the challenge or success being dissected
4. Drag the initial conditions that are relevant to the dissecting area
    I Write down how these requirements relate to the challenge or success being dissected
5. Discuss how the initial conditions and requirements can be used to overcome the challenge or amplify the success
    I Write down the strategy that can you discussed
6. Discuss how the perceptions of the challenge or success differ among participants
    I Write down the differences in perceptions

11. APPENDIX C – RESULTS FROM RE-ANALYSIS EXISTING CASE DATA

This appendix provides an overview of the different definitions that were used by the previous study and places them next to the concepts that are used in this study.

11.1. DEFINITIONS USED ACROSS STUDIES

This section provides an overview of the definitions that are used across the three case studies and this MSc thesis. The definitions from this MSc thesis are elaborated on and referenced in Section 7.2.

Appendix C - Table 1. Cross-comparison of definitions used in case studies and MSc thesis.

Concept	Flood	Agriculture	Energy	MSc thesis
TD definition	research that integrates across academic disciplines and with non-academic stakeholders to address societal challenges (DeLorme et al., 2016)	characterised by collaborative partnerships that bridge the gap between various fields of research and modes of inquiry, as well as academic and non-academic actors (DeLorme et al., 2016).	"a partnership that crosses boundaries among fields of research and modes of inquiry and between academic and non-academic actors" (DeLorme et al., 2016).	"a reflexive, integrative, method-driven scientific principle aiming at the solution or transition of societal problems by differentiating and integrating knowledge from various scientific and societal bodies of knowledge" (Lang et al., 2012, pp. 2–3) in which "the problem definition starts from the sustainability deficit expressed by local actors" (Hakkarainen et al., 2022, p. 2).
Institutional	entails the management structure of the actors involved. This includes important aspects such as the funding mechanisms used throughout the collaboration, the formal rules that make the collaboration possible (or not) and, the level of support for transdisciplinary collaboration.	Management structure of the actors involved	aspects management structure, funding mechanism and level of support for collaborative research	Management structures, funding regulations and academic institutions that influence the way in which activities can be performed
Cultural	based on the accepted standards or the way of working within the collaboration. These standards are decisive for how resources and time are prioritized within the collaboration.	Accepted standards or way of working of the actors involved to prioritise resources and time in collaborative and innovative activities	refers to the accepted standards of the actors involved to prioritize resources and time.	Differences in cultural norms of organisations that affect expectations, communication and work-ethics
Logistical	the logistics of a collaboration can be defined as what the limiting resources in the collaboration are. Examples are the distance between the actors involved, time and planning.	Distance between the actors involved, time constraints and any other limiting resources	describes the distance between the actors involved, time constraints and any other limitation of resources	Any limiting resources that are involved in the research process

Expertise	the skills and experiences of the actors involved are key in this initial condition. This factor is also important for the support of the successful design and implementation of the collaborative research.	Skill and experience of the actors involved to support the successful design and implementation of the collaborative research	includes the skill and experience of the actors involved to support the successful design and implementation of the collaborative research	The (disciplinary) experiences stakeholders have with facilitating and/or participating in collaboration and knowledge creation efforts
Existing relationships	the part of the collaboration in which previous experiences with working with the actors involved, trust and any other prejudices towards each other come into play	Previous experiences working with the actors involved, trust and any other prejudices towards each other	describes the previous experiences working with the actors involved, trust and any other prejudices towards each other	The relationships, prejudices and (dis)trust that already exist before the start of the project
Inclusiveness	the entire knowledge production process is open to many stakeholder groups from both research and practice.	Representation and power on the collaboration of relevant disciplines, (non) academic, societal actors and any other under-represented groups	refers to the representation and power on the collaboration of relevant disciplines such as (non)-academic, societal and other underrepresented groups.	The representation of stakeholders from both societal and scientific practice in and their power over the knowledge production process
Collaboration	contributions from research and practice are produced as a result of the methodology used for participation in the collaboration, and the quality of said participation	Way of managing and working together in the collaboration to achieve the intended results	is described as the way of managing and working together the collaboration to achieve the intended results, this refers to the degree and quality of participation in the group process	The activities, way of working and roles that lead to in-depth contributions to the knowledge creation from both societal and scientific practice
Usability	gained knowledge is reflected on, and assessed in terms of effectiveness, accessibility and relevance.	What makes the available and co-created knowledge more applicable for the researchers and non-academic actors involved	describes what makes the available and co-created knowledge accessible, sharable, understandable, timely, and more applicable for the researchers and non-academic actors involved	The assessment and reflection upon whether the activities create knowledge that is socially robust (e.g. accessible and understandable) and has a transformative capacity (e.g. applicable and relevant)
Integration	different knowledge types (practice and scientific) are combined in a certain integrated manner	The way and extent to which multiple actors bring together their knowledge in the process and outputs	refers to the way and extent to which multiple actors bring together their knowledge in the process and outputs.	The assimilation, combination and synthesisation of both societal and scientific perspectives, values, knowledge and expertise
Reflexivity	a moment to reflect and assess the choices made individually as well as collaboratively, and to discuss the total experience of the collaboration.	Moments and ways in which the individual and group assessment and reflection on the experience and satisfaction is considered in the process and its results	the "Moments and ways in which the individual and group assessment and reflection on the experience and satisfaction is considered in the process and its results"	The continuous scrutinization of and reflection on activities and their preceding or subsequent choices from both societal and scientific perspectives
Learning	way and extent in which desired competencies for integrated problem-solving, interpersonal relations, strategy, value, futures and systems thinking are considered throughout the process and results (Suškevičs et al, 2018).	Way and extent in which desired competencies for integrated problem-solving, interpersonal relations, strategic, value, futures and systems thinking are considered throughout the process and results	refers to the learning objectives of different key competencies. the key competencies consist of: the way and extent to which desired competencies for integrated problem-solving, interpersonal relations, strategic, values, futures and systems thinking are considered throughout the process	The extent to which participants are (willing to) learn(ing) and develop certain competencies within and from other participants in the project

			and results	
Communication				Dissemination of results beyond the delineation of the project
Political processes taken into account			concerns the extent of taking legitimacy, national or regional political processes during the project process into account.	

Appendix D - Table 1. Frequency table of general and specific categories of the perceived challenges and successes.

Challenges	A	E	F	T	Row Labels	A	E	F	T
Collaboration (Req)	**20**	**7**	**8**	**35**	**Collaboration (Req)**	**6**	**18**	**26**	**50**
Difficulty engaginging stakeholders in long-term commitment		**2**	**3**	**5**	**Activities contributing to better collaboration**	**5**	**7**	**8**	**20**
Stakeholders' commitment is volatile			3	3	Actively facilitating collaboration between stakeholders			4	4
Stakeholders lose interest and are less commited once the activities have progressed for some time		2		2	Assinging tasks and responsibilities to stakeholders with relevant expertise		2		2
Elements inhibiting collaboration	**6**	**5**	**1**	**12**	Close collaboration between coordinators	1	1	1	3
Difficulty assigning tasks	1			1	Fulfilling agreements that are made about collaboration	1			1
Lack of communication	3			3	Implementing new ideas and improvements bottom-up			2	2
Lack of guidance from coordinator	2	2	1	5	Regular meetings within workpackages	1			1
Online meetings bring forth a less relaxed collaboration		1		1	Transparent communication	1	4		5
Project goals are unclear or misaligned		1		1	Visiting other stakeholders on-site	1		1	2
Stakeholders dictate the way of working to their experience		1		1	**Commitment to the collaboration**	**1**	**6**	**1**	**8**
Informal project structure			**4**	**4**	Commitment to invest time and effort is high among stakeholders		4		4
End of the program is lacking structure			1	1	In-person meetings contribute to higher stakeholder commitment		2		2
Meetings and overall planning is structured informally			3	3	Providing interesting and tangiable meeting content encourages stakeholders to join meetings	1		1	2
Lack of collaboration across work packages	**14**			**14**	**Organisation and settings contributing to better collaboration**		**5**	**17**	**22**
PhD candidates are starting up and work mostly individually	4			4	A voluntary program attracts motivated stakeholders		1	6	7
Stakeholders have a difficulty asking questions across work packages	1			1	In-person meetings produce results that are not possible in an online setting		1		1
There are insufficient meetings with all the work packages	3			3	Learning-by-doing is applied and activities are adapted to the lessons learned		1	1	2
Work packages work mostly individually	6			6	Online communication facilitating accessible interactions			4	4
					Progress and questions are shared during meetings		1		1
					Small teams enable more conversation between stakeholders			1	1
					Stakeholders are challenged to be engaged during meetings			1	1
					The network and expertise of coaches fit with the needs of the stakeholders			2	2
					The project team is balanced in terms of academics and stakeholders		1		1
					The project's organization is flexible and informal			2	2
Communication (Req)	**4**			**4**	**Communication (Req)**	**2**		**3**	**5**
Difficulty with communication of results beyond the delineation of the project	**4**			**4**	**Successful dissemination of results beyond the delineation of the project**	**2**		**3**	**5**
Difficulty with presenting results in a way that is understandable for all stakeholders	1			1	Implementing the technology facilitates the information reaching the stakeholders that are interested in the technology	1			1
Difficulty with using language that is understandable for all stakeholders	3			3	Publishing the results of the Floods Project in a tangiable format reaches parties that are interested in the created knowledge			3	3
					Results are actively communicated to interested parties outside the project	1			1
Cultural (Ini cond)	**20**	**12**	**19**	**51**	**Cultural (Ini cond)**	**4**	**8**	**8**	**20**
Different backgrounds affect engagement of stakeholders		**2**	**1**	**3**	**Different backgrounds and methods benefit the process**	**1**	**5**	**3**	**9**

Different backgrounds result in varying engagement		2	1	3	Academics were pleasantly surprised by the speed of practical implementation	1			1
Different backgrounds and methods inhibit the collaboration	**8**	**8**	**8**	**24**	Different backgrounds bring new perspectives		5	1	6
Differences in backgrounds are ingrained and impede collaboration	1	3	4	8	Different ways of working exist and are understood and respected by the different stakeholders involved			2	2
Different stakeholders do not understand each other	7	5	1	13	**Specific expectations benefit the process**	**3**	**1**	**5**	**9**
Stakeholders deem certain knowledge types superior to others			3	3	Open mindsets facilitate integration			4	4
Different expectations inhibit the process	**1**	**1**		**2**	Stakeholders know what to expect from different mentalities at different organizations		1		1
Expectations of a discipline do not match with what the discipline does	1			1	Stakeholders understand the importance of involving different disciplines	3		1	4
Political contexts influence the expectations stakeholders have of the project		1		1	**Specific ways of working benefit the process**		**2**		**2**
Different goals inhibit the process	**11**		**3**	**14**	Stakeholders were used to working in similar ways		2		2
Academic stakeholders have different goals than stakeholders from practice	11			11					
The Floods Project goals are not matching with the university's expectations			3	3					
Different ways of working inhibit the process		**1**	**7**	**8**					
Different ways of working are not compatible in collaboration		1	2	3					
The Floods Project's way of working does not match University culture			5	5					
Effectiveness (Succ criteria)	**2**	**1**	**1**	**4**	**Effectiveness (Succ criteria)**		**9**	**4**	**13**
Effectivenes is almost sufficient			**1**	**1**	**Focus on effectiveness rather than efficiency**			**1**	**1**
Stakeholders are not yet content with the effectiveness of the project			1	1	The purposefulness described by effectiveness is a better measurement that efficiency			1	1
Goals are not being achieved	**2**	**1**		**3**	**Goals are being achieved**		**9**	**3**	**12**
Collaboration project wide is not yet effective	1			1	Stakeholders are content with the effectiveness of the project		2	2	4
Meetings and deliverables are not being fulfilled as planned	1	1		2	Stakeholders are content with the effectiveness of the project but realise it is early in the process		5		5
					Stakeholders are content with the effectiveness of the project even though not all deadlines have been met		2		2
					The practical application in the project increased effectiveness			1	1
Efficiency (Succ criteria)	**4**	**2**		**6**	**Efficiency (Succ criteria)**	**4**	**5**	**3**	**12**
No efficient use of resources	**4**	**2**		**6**	**Efficient use of resources**	**4**	**3**		**7**
Resources are wasted on doing double work		2		2	Resources are not being wasted		1		1
The project lost momentum	1			1	Stakeholders are content with the efficiency of the project	1			1
Time is being wasted	3			3	Stakeholders are content with the efficiency of the project but realize a lack of transdisciplinary activities	1			1
					Stakeholders are content with the efficiency of the project, though improvements can be made		1		1
					Stakeholders are working hard and efficient on the project's deliverables	1			1
					The balance between meetings and making progress is efficient	1			1
					Time is managed efficiently		1		1
					Elements contributing to efficiency		**2**	**3**	**5**
					Focussing on the added value			1	1

					Having limited resources		1	1	2
					Online meetings			1	1
					Transparent communication		1		1
Existing relationships (Ini cond)	**9**	**3**	**10**	**22**	**Existing relationships (Ini cond)**	**7**	**10**	**13**	**30**
Difficulty creating connections		**1**	**6**	**7**	**Building and fostering trust**		**3**	**5**	**8**
Current network is not providing sufficient connection			4	4	Emphasis is placed on building trust and relationships among stakeholders			3	3
Joining the project is difficult is a stakeholder is not connected already		1		1	Focus on educating stakeholders on how to build and foster trust in their collaborations			1	1
Not all stakeholders are able to provide new connections			1	1	Getting to know each other in in-person meetings builds trust		3	1	4
The Floods Project is too unkown to effectively recruit stakeholders			1	1	**Existing connections facilitate collaboration**	**4**		**6**	**10**
Existing relationships create preference between stakeholders	**4**			**4**	Connections between stakeholders provide input for future projects			1	1
Stakeholders prefer to collaborate with who they already know	1			1	Personal networks provide access to coaches and other specialists			4	4
The connections of the Water Authority are confusing to other stakeholders involved	3			3	Stakeholders have a strong interaction outside the project			1	1
Lack of building and fostering trust	**4**		**3**	**7**	The Water Authority facilitates connections and involvement of stakeholders that already trust each other	4			4
Building trust and relationships takes time and effort	1		2	3	**Existing trust**		**1**		**1**
Difficulty building a personal connection and relationship across work packages	2			2	Previously existing trust facilitated a better collaboration		1		1
Lack of existing connections makes building trust difficult	1			1	**Existing trust facilitates better collaboration**	**3**	**4**	**2**	**9**
Relationships between stakeholders are not actively maintained			1	1	Stakeholders already trust each other which increases the ease of collaboration	3	4		7
Lack of existing trust	**1**	**2**	**1**	**4**	There is trust between stakeholders			2	2
Many stakeholders did not yet know each other	1	2		3	**Preventing distrust**		**2**		**2**
Stakeholders do not agree with or trust each other			1	1	There is a focus on maintaining credibility by meeting deadlines		2		2
Expertise (Ini cond)	**1**	**3**	**8**	**12**	**Expertise (Ini cond)**	**5**	**3**	**7**	**15**
Lack of experience with facilitating and participating in collaboration		**2**	**7**	**9**	**Experience with facilitating and participating in collaboration is present**			**1**	**1**
Coach competencies are lacking definition			2	2	Expertise in facilitating collaboration is present			1	1
Coaches do not have sufficient expertise in facilitating collaboration			2	2	**Expertise in facilitating and participating in collaboration is present**		**1**	**4**	**5**
Stakeholders are not trained how to collaborate across disciplines		2	3	5	Expertise in facilitating collaboration is present		1	3	4
Missing expertise	**1**	**1**	**1**	**3**	Lacking expertise is brought in from outside the project			1	1
Not all relevant expertise is covered by the project's stakeholders	1			1	**Expertise in facilitating and participating in collaboration is required**	**1**	**1**	**2**	**4**
Some stakeholders possess insufficient skills to contribute effectively to the project		1	1	2	Expertise in facilitating collaboration is necessary	1			1
					Expertise in facilitating collaboration requires accomodating different cultures and backgrounds		1	2	3
					Expertise is dynamic	**1**			**1**
					Expertise required in TD projects depends on the activities and is dynamic throughout the process	1			1
					Expertise is sufficiently present	**3**	**1**		**4**
					All necessary expertise is present in the project	3			3
					Work package leaders bring expertise in their field		1		1
Inclusiveness (Req)	**8**	**8**	**12**	**28**	**Inclusiveness (Req)**	**3**	**15**	**5**	**23**

Lack of stakeholder differentiation	**3**	**7**	**7**	**17**	**All stakeholders are promoted to be entitled to the process**	**3**	**4**	**2**	**9**
Not all relevant stakeholders are included in the project	3	3	1	7	Focus on equal entitlement to the entire project process and decisions		1		1
Underrepresented groups are not sufficiently represented in the stakeholders that are involved		3		3	Focus on the needs of stakeholders and adapting activities to these needs	1	3	1	5
Variety in stakeholders is less than aimed for		1	6	7	The aim is to involve many stakeholders in the decision-making of the project	2		1	3
Not all stakeholders are entitled to the process	**5**	**1**	**5**	**11**	**Focus on including different stakeholders**		**5**	**3**	**8**
Farmers are not involved in the project's decision-making	2			2	Focus on including as many different types of stakeholders as possible		4	3	7
Not all stakeholders are equally included in the project's decision-making	2		3	5	Focus on including different types of stakeholders early in the process		1		1
Some stakeholders overpower others	1		1	2	**Having an open mindset**		**6**		**6**
Stakeholders that are less committed are less entitled to the project's decision-making		1	1	2	Stakeholders are accepting and respectful to new stakeholders joining		1		1
					Stakeholders are aware of others' perspectives		1		1
					Stakeholders are willing to listen to each other		4		4
Institutional (Ini cond)	**13**	**11**	**14**	**38**	**Institutional (Ini cond)**	**9**	**9**	**5**	**23**
Funding body requirements inhibiting the process	**3**			**3**	**Funding structures benefit the project**	**7**	**1**	**5**	**13**
Funding body requires goals that do not seem feasible to stakeholders	1			1	Funding body and university regulations facilitate collaboration	2			2
Funding body requires work packages to be connected which is not necessarily relevant	2			2	Funding body requirements provide structure to the project's organization	3			3
Lack of external rules and regulations		**4**		**4**	Funding body requires projects to incorporate transdisciplinarity	1	1		2
Regulations at national levels are insufficient		2		2	Funding enables the organization of the Floods Project			5	5
Regulations differ across countries		1		1	Funding structures provide stability to the project	1			1
There are no specific rules for what good TD implementation is		1		1	**Proposal enables changes in accordance with unexpected progress**		**6**		**6**
Lack of internal rules and regulations	**9**		**2**	**11**	Proposal was broad enough to provide sufficient flexibility to adapt to changes in the progress of the project		6		6
Consortium wide rules and regulations are lacking	1			1	**Rules and regulations are agreed upon**	**1**	**2**		**3**
Insufficient agreements on data sharing within the project	3			3	The internal project structure is limited but sufficiently defined		1		1
Specific, program wide rules and responsibilities are not sufficiently formalized	5		2	7	The internal project structure is sufficiently defined		1		1
Rules and regulations limiting the process	**1**	**7**	**12**	**20**	Workpackage rules and regulations are agreed upon	1			1
Complying with regulations takes a lot of effort		2		2	**Rules and regulations benefit the process**	**1**			**1**
Rules and regulations do not legitimise the project			1	1	The project is allowed flexibility by university rules and regulations	1			1
Rules and regulations in practice limit the flexibility of the project	1			1					
Strict regulations limit the flexibility of the project		5		5					
The Floods Project is limited by the university rules and regulations			1	1					
The project is limited by university rules and regulations			8	8					
The project is organized informally			2	2					
Integration (Req)	**4**	**9**	**2**	**15**	**Integration (Req)**	**6**	**4**	**5**	**15**
Difficulty integrating perspectives	**2**	**6**		**8**	**Different perspectives are assimilated and combined**		**3**	**5**	**8**
Stakeholders exchange rather than integrate their results	1			1	Exchange of results is facilitated and happens informally			2	2
Stakeholders have difficulty integrating expertise across disciplines		3		3	Perspectives are shared and integrated by exchanging why and how things are done		3	1	4
Workpackages are related but work mostly individually	1	3		4	Stakeholders are involved in and engaged with stakeholders from practice			1	1

Difficulty integrating results	**2**	**3**	**2**	**7**	Stakeholders integrate their terminology to create a common language			1	1
Results are too case-specific to combine across cases		2		2	**Elements contributing to integration**	**6**	**1**		**7**
Stakeholders exchange rather than integrate their results	2	1	2	5	A shared vision facilitates integration between stakeholders	2			2
					Data sharing infrastructures facilitate integration	1			1
					Integration is achieved through synergy between all stakeholders	2	1		3
					Stakeholders closely work together to facilitate integration	1			1
Learning (Req)	**4**		**1**	**5**	**Learning (Req)**		**8**	**3**	**11**
Lack of focus on learning	**4**		**1**	**5**	**Different backgrounds and methods benefit learning**		**3**	**1**	**4**
Expertise is not assessed based on what the stakeholder could learn from the collaboration			1	1	Stakeholders learn from the different regulations across countries		1		1
Learning and teaching are not formalized in the project activities	3			3	Stakeholders learn new things from the perspectives of other stakeholders		2	1	3
Learning is not set as a goal in the project	1			1	**Learning is promoted in the project**		**2**		**2**
					Emphasis is placed on facilitating learning		1		1
					Stakeholders learn new things from the knowledge that is created		1		1
					Stakeholders learn from each other		**3**	**2**	**5**
					Learning between stakeholders is actively facilitated			2	2
					Stakeholders learn to better and more efficiently interact with each other		3		3
Logistical (Ini cond)	**11**	**11**	**15**	**37**	**Logistical (Ini cond)**	**3**	**5**	**2**	**10**
Difficulty planning			**5**	**5**	**Distance between stakeholders is not an issue**	**3**			**3**
Planning of stakeholders is difficult to align			5	5	Distance between stakeholders is expected and does not pose a problem for stakeholders	3			3
Distance between stakeholders inthibits the process	**7**	**5**	**1**	**13**	**Planning is on schedule**		**4**		**4**
Stakeholders are too far apart	6		1	7	Proper management of the planning keeps the project on schedule		3		3
Travel times are not equally distributed	1			1	The timeline is properly designed and feasible		1		1
Working across continents and time-zones is difficult		5		5	**Resources are available**		**1**	**2**	**3**
Lack of resources	**2**	**6**	**2**	**10**	Stakeholders made time and resources available		1		1
Compromise has to be made due to limited resources	1	1	1	3	The location of the Floods Project is good			2	2
Internet connections were insufficient for online meetings		1		1					
Not all positions have been filled	1			1					
Not all stakeholders place sufficient priority on the project		3		3					
Research site was not sufficiently accessible for stakeholders		1		1					
The Floods Project does not have sufficient legitimacy to receive more resources			1	1					
Lack of time	**2**		**7**	**9**					
Coordinators have too little time for organization			2	2					
Stakeholders have too little time to prioritize project activities	2		5	7					
Reflexivity (Req)	**2**	**1**		**3**	**Reflexivity (Req)**	**4**	**9**	**8**	**21**
Imbalance in providing and receiving feedback		**1**		**1**	**Decisions and activities are continuously scrutinized**	**1**	**1**		**2**
Difficulty finding a balance in providing and receiving advice		1		1	Progress and expectations are continuously scrutinized and adapted	1	1		2
Lack of explicit reflection by stakeholders	**2**			**2**	**Feedback is collected**	**3**	**1**	**6**	**10**
Stakeholders focus on reflecting on results rather than the process	2			2	Stakeholders are continuously provided with opportunities to give feedback	2	1	6	9

					Stakeholders were asked regularly to provide feedback on texts written for the proposal	1			1
					Reflexivity is essential in TD projects		**1**		**1**
					Reflexivity is one of the cornerstones of TD		1		1
					Stakeholders implement the reflections on the process		**1**	**2**	**3**
					Reflections are used to improve the organization of the Floods Project			1	1
					Stakeholders are open to reflection and improving their process		1	1	2
					Stakeholders reflect on the process		**5**		**5**
					Feedback between workpackages is encouraged and provided		1		1
					Reflection on the process is encouraged among stakeholders		3		3
					Writing weekly updates encourages reflexivity		1		1
Satisfaction (Succ criteria)	**0**	**0**	**0**	**0**	**Satisfaction (Succ criteria)**	**3**	**1**	**5**	**9**
					Stakeholders are satisfied with how the project is going	**3**	**1**	**5**	**9**
					Stakeholders are mostly satisfied with how the process is going	2		1	3
					Stakeholders are satisfied with the achieved goals	1	1	2	4
					Stakeholders are satisfied with the achieved goals but realise a lack of transdisciplinary activities			1	1
					Stakeholders are satisfied with the achieved goals but realise more needs to be done			1	1
Usability (Req)	**5**	**7**	**2**	**14**	**Usability (Req)**	**5**	**4**	**4**	**13**
Lack of practical relevance of results	**4**	**4**	**1**	**9**	**Activities are relevant for as many stakeholders as possible**		**1**		**1**
Academic goals are not aligning with practical needs	4		1	5	Focussing on ensuring that the discussed case studies are relevant for as many stakeholders as possible		1		1
Difficulty reflecting on whether the produced knowledge is relevant in practice		4		4	**Different backgrounds benefit the usability**		**1**		**1**
Uncertainty whether created results will be practically relevant	**1**	**3**	**1**	**5**	Focus on ensuring that the results are relevant for as many different stakeholders as possible		1		1
Breaking down academic knowledge into practically applicable knowledge takes time and effort		1		1	**Results are relevant for stakeholders**	**3**	**2**		**5**
Not all results can be generalized		2		2	Ensuring a generalizability of the results increases the usability in different contexts		1		1
Uncertainty whether the developed technology will be available for users in time	1			1	Stakeholders and others outside the project are interested in the created knowledge	1	1		2
Unclear when the impact of the project results in a proven success			1	1	Stakeholders and others outside the project are using the created knowledge	1			1
					The Water Authority translates the scientific knowledge to practical knowledge	1			1
					Stakeholders reflect on the usability	**2**		**4**	**6**
					Stakeholders reflect on whether the knowledge that is created is relevant to stakeholders from practice	2		4	6
Grand Total	**107**	**75**	**92**	**274**	**Grand Total**	**61**	**108**	**101**	**270**