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Why context matters: understanding transdisciplinary research through the lens of nine context factors

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Transdisciplinary research (TDR) integrates academic and non-academic expertise to co-produce actionable knowledge that contributes to societal impact in addressing sustainability challenges. While context is widely acknowledged as important, the role and definition of context factors shaping TDR remain underexplored. This study develops an integrative understanding of context by synthesising theoretical literature and analysing 17 semi-structured interviews from international TDR case studies. We identify nine key context factors across three categories: outer factors

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(outside projects), inner factors (within projects), and temporal/ spatial dimensions (project boundaries). These context factors influence collaborative research processes in different ways across projects, requiring ongoing reflexivity and adaptation. Positionality awareness and ethics are central in shaping power dynamics, stakeholder engagement, and knowledge-co-production, highlighting the need for context-sensitive approaches. To support this in a structured way, we present a framework linking context with research design, process, methods and outcomes. Additionally, we provide a set of reflective questions for researchers and practitioners to identify, assess, and respond to contextual influences that shape stainability transformations. By advancing a more systematic understanding of context, this study contributes to building reflexive and inclusive approaches to transdisciplinary collaboration.

Keywords: Reflexivity; power dynamics; knowledge co-production; sustainability transformation; collaborative research methods; positionality; research framework

1. Introduction

The need for transdisciplinary research (TDR) to adequately address globally relevant sustainability problems (such as climate change, biodiversity loss, poverty, and social injustice) and respond to the complex nature of such problems is highlighted by national to international actors, such as the Intergovernmental Panel on Climate Change (IPCC) and Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). In the light of these challenges and anticipated further crises, there is an increasing urgency for impactful TDR that creates transformative changes (Nölting et al. 2022). That is, TDR should contribute to problem-oriented research and solution options through action-oriented knowledge for specific contexts to address grand and interconnected global challenges more effectively and impactfully (Bergmann, Klein, and Faust 2012; Jahn, Bergmann, and Keil 2012; Norström et al. 2020; Renn 2021). TDR within and beyond sustainability science is a research practice focusing on real-world problems by means of involving actors from different scientific disciplines and relevant societal domains who seek to collaboratively define the problem and goals, and produce solution- and action-oriented knowledge (Caniglia et al. 2021; Lang et al. 2012; Lawrence et al. 2022). Different scholars have developed ideal-typical models with three overlapping phases: (1) team building and problem framing, (2) co-creation of solution-oriented transferable knowledge, (3) re-integration and application of created knowledge (e.g. Jahn 2008; Jahn 2008; Jahn and Keil 2015; Lang et al. 2012; Pohl and Hadorn 2007). Complementing this, Horcea-Milcu, Leventon, and Lang (2022) emphasise the relevance of an initiating phase that establishes a transdisciplinary collaboration based on an in-depth understanding of the case study context and on building trustful relationships with actors, which they consequently named phase 0. These phases provide a useful structure for understanding how TDR projects are influenced at different stages.

Although context is relevant for every research project, understanding context factors is particularly important in TDR projects, especially for mobilising and integrating relevant knowledge in the field (Schneider et al. 2022). Context is defined by the research object and processes, and how they are embedded in the (local) context determines, for example, the selection of stakeholders, choice and adaptation of collaborative formats (e.g. real-world laboratories) and methods (e.g. workshops), or the emergence of societal and scientific impacts (Lam et al. 2021; Nagy et al. 2020). Given the complexity of these contextual factors, it follows that project-specific factors such as teamwork dynamics and the overall functioning of the academic system can significantly

influence TDR projects' design and development, further emphasising the critical role of context in shaping TDR.

TDR projects are fundamentally shaped by a complex interplay of factors (Cockburn et al. 2020), encompassing the political landscape and, for instance, associated power dynamics (Fritz and Binder 2020). Another aspect is the social and economic environment influencing stakeholder engagement and collaborative approaches (Blicharska et al. 2011; Mollenhorst 2008).

Despite the fundamental role of context for TDR, the theoretical and empirical understanding of context in this field remains underdeveloped, and the literature lacks synthesis (Schneider et al. 2022). Recent work is starting to address this gap. For example, Wuelser et al. (2021) show that understanding the impact of context factors on TDR supports the transfer of knowledge across TDR projects. Pärli et al. (2024) further emphasise this point, demonstrating in their comparative study of TDR projects in the Democratic Republic of Congo and Rwanda how dramatically different local realities shape project design, implementation, and outcomes.

Further recent studies raise other important aspects to take into consideration when thinking of context, shedding light on single aspects within that broader issue, but at the same time emphasising the need to bring these aspects together in an approach to more comprehensively and coherently grasp the potential influence of context factors within TDR. Some studies increasingly emphasise cultural worldviews, knowledge systems, and values (Chambers et al. 2021; Schneider et al. 2022), including the critical consideration of perspectives that are not from the Global North, and call for the decolonisation of research practices. This requires researchers to reflect on their onto-epistemological positionality in relation to a broader spectrum of knowledge generation, and unlearn extractive research mechanisms as well as non-inclusive behaviour to foster inclusive and just joint knowledge production, particularly in North–South research projects. (Chambers et al. 2021; Chilisa 2017, 2020; Manuel-Navarrete, Buzinde, and Swanson 2021)

Additionally, studies describe the physical and environmental setting that frames the context of the research – and the overall success and quality of collaborations between diverse actors (Cockburn et al. 2020; Schneider et al. 2022; Schoon et al. 2021). Understanding existing relationships and building new ones (i.e. team dynamics) (Mollenhorst 2008) can influence the success of stakeholder involvement, e.g. in environmental assessments (Blicharska et al. 2011). Moreover, reflexivity regarding one's positionality is crucial, as it can shape the research process and outcomes. Studies focusing especially on North–South collaborations or the involvement of Indigenous people show that context-sensitive TDR can avoid perpetuating colonial structures (Barnes et al. 2021; Bourke 2014; Chilisa 2017; Manuel-Navarrete, Buzinde, and Swanson 2021; Sellberg et al. 2021). While these studies provide valuable insights, they often focus on specific contexts, a limited set of factors, or only deliver vague understandings of what context factors matter in TDR and what relationships exist between TDR and context.

Adding to all this, a tension remains between needing context specificity to co-generate knowledge in local contexts and the need for scientific generalisability and transferability of context specific results to other contexts (Adler et al. 2018). As context is most often not approached in a systematic manner in research design and practice as well as in the reporting about TDR projects, it also limits the possibilities to reflect upon their relevance and identify potentials to replicate and transfer findings.

Our study builds upon this emerging body of work by providing a more systematic and integrative understanding of context in TDR. Through a synthesis of theoretical literature and empirical analysis of 17 international case studies, we identify and disentangle nine key context factors, offering a more comprehensive framework for context-sensitive TDR practice.

In this study, we seek to provide a theoretically and empirically grounded, integrative understanding of context in TDR and its implications for TDR processes by exploring the following research questions:

(1) Which context factors influence the design, processes, methods, and outcomes[1] of TDR projects?
(2) What are the mechanisms that link context factors and the design, processes, methods and outcomes of TDR?
(3) What are the implications of these insights for context-sensitive TDR practice considering relevant context factors?

While the broader question of transferability – how context-specific findings from TDR projects can be applied or adapted to other contexts – is a critical concern, this paper focuses primarily on understanding and addressing context factors within the design and execution of individual TDR projects. We aim to provide a framework for conducting context-sensitive research, thereby laying a foundation for future research that puts an explicit focus on the challenge of transferability.

This is an initial attempt to collect various ways how context can shape TDR and thus, systematise the current understanding of context in TDR and synthesise a set of context factors that should be consciously and deliberately considered. The focus of this paper is to suggest ways to engage with the complexities of how context shapes TDR projects. We investigate how researchers and TDR teams strive to become aware of how specific context factors shape TDR, and understand, reflect and include these contextual complexities in their TDR projects.

In the following sections, we outline our methodological approach for synthesising and conceptualising context factors. In the results section, we first answer research questions 1 and 2 by disentangling 9 context factors and providing a synthesised model. We further illustrate how context factors influence the design, process, methods and outcomes of TDR projects through examples from three case studies. Finally, we explore the implications of these new understandings for context-sensitive TDR (research question 3). In the discussion, we suggest how TDR can integrate the insights of this paper based on four ideal-typical TDR phases (Horcea-Milcu, Leventon, and Lang 2022; Lang et al. 2012), and introduce reflective questions for actors applying TDR.

2. Methods

This study triangulates findings on context in TDR from a theoretical literature review and empirical insights from interviews with researchers involved in 17 case studies. These insights were used as separate data sources to validate the results. Interviewed researchers are co-authors of this study to reduce exploitation, avoid reinforcement of stereotypical representation of cases, foster research collaboration and validate results through investigator triangulation (Chilisa 2017; Edwards and Brannelly 2017; Kimchi, Polivka, and Stevenson 1991; Robbins 2006; Said 1978; Smith 2012).

2.1. *Data collection*

2.1.1 *Literature review*

We conducted a systematic exploratory literature review to analyse how context is understood in TDR. We conducted the literature review based on an adapted approach of Luederitz et al. (2016): (1) Definition of selection criteria, (2) Data Gathering, (3) Data Screening, (4) Data Cleaning, (5) Data Scoping, and (6) Full Text Review (Figure 1).

We used the following inclusion criteria to select articles. Included articles (1) covered TDR, participatory research, or stakeholder involvement as the main research mode, in which science and actors from other societal domains collaborated beyond one-way communication, e.g. through the joint formulation of research questions and problems; (2) were peer-reviewed and published between 1999 and January 2021, and in English language; (3) included information related to how explicit and implicit context factors play out in TDR projects, and how these context factors influence process, methodological choices and/or outcomes; and (4) had been cited at least once per year since 2017 (to reduce data and represent the current discourse).

In January 2021, we applied a search query in Scopus using the search string displayed in Figure 1 to gather articles. We retrieved a total of 7705 articles from the search. After removing duplicates and excluding articles due to low citation frequency, two researchers screened 5901 articles' titles and abstracts to check if they met the inclusion criteria. We divided the remaining 280 papers into two categories: (a) empirical studies (n = 250) and (b) conceptual papers and reviews (n = 30). In order to align with the aim of conceptualising and synthesising pre-existing theoretical knowledge on context factors and due to limited resources, we decided to focus on the conceptual papers for a full-text review. Out of these, we excluded 3 publications that did not match the inclusion criteria. The final sample (Appendix B) consisted of 27 conceptual papers, which one experienced

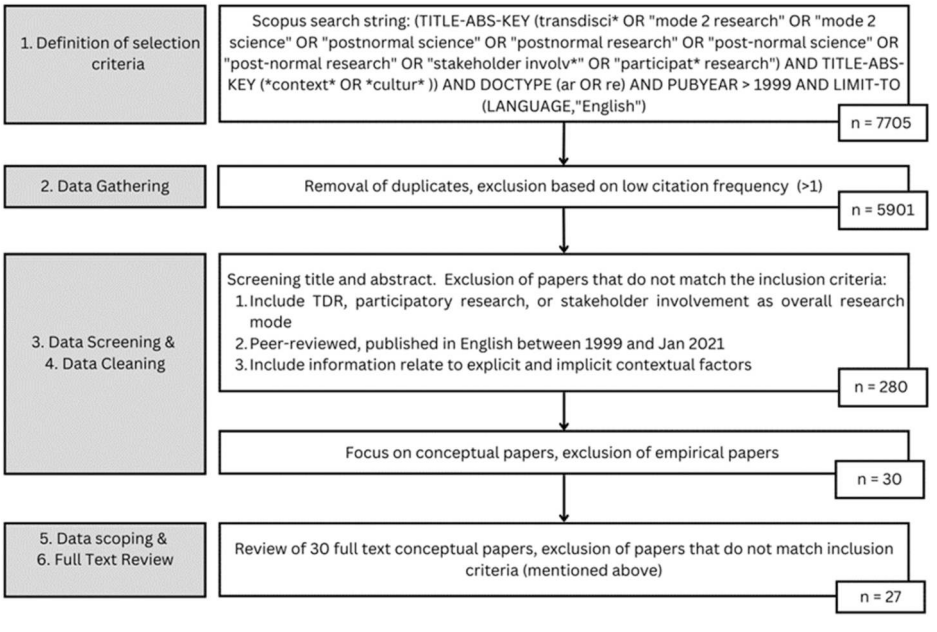

Figure 1. Selection criteria for literature review, based on Luederitz et al. (2016).

researcher coded according to the coding scheme (Appendix E) and three researchers analysed the coded segments.

2.1.2 *Exploratory case study analysis*

We additionally analysed 17 case studies (Yin 2009) in 23 different countries (Appendix A) to empirically understand context and context dependencies in TDR, i.e. how context factors impacted the process and outcomes in each case. When selecting the case studies, we strived for geographic and thematic variety.

We applied a purposeful sampling strategy to identify a small sample of 'information-rich' cases (Patton 1990, 182) which can provide deeper insights into the topic of interest (Miles and Huberman 1994; Palinkas et al. 2015; Patton 2002). As case studies, we selected projects that: (a) followed a TDR approach as defined by Lang et al. (2012); (b) had a thematic focus on sustainability and related to at least one of the three dimensions of economy, ecology, and society (Harrington 2016); and (c) were completed or, in the case of long-term projects, the first sub-project had gone through all three phases of a TDR process (Lang et al. 2012).

We identified suitable projects through online searches on scientific platforms (ResearchGate, Scopus), blogs (e.g. i2 insights), and research institutions conducting transdisciplinary research between November 2021 and February 2022. We also published a call for participation (January 2022) through the tdAcademy network and website, which had a wide reach of researchers interested in and dealing with transdisciplinarity globally.

This process resulted in a total of 18 international cases, of which one case study needed to be excluded after the interview as it did not involve stakeholders as expected. For the final sample of 17 cases, we conducted semi-structured expert interviews with researchers directly involved in the cases. The interview questions were partly adapted from the questionnaire of a comparative quantitative analysis by Newig et al. (2019) that investigated the relationship between research mode and outcome in sustainability-related projects. These categories from Newig et al. (2019) specifically included the aspects such as involvement of non-academic actors, academic research outcomes, knowledge creation methods, societal project outcomes, funding context or goal achievement. Their work provided a valuable framework for analysing sustainability-oriented research projects, which aligns with our focus on context factors in TDR. We chose to build upon their questionnaire because it offered a validated approach to examining research processes and outcomes in sustainability contexts and supplemented it both based on desk research of context factors, and based on our research interests. The final interview guide included open questions about the context of the project, researchers' role, TDR approach and processes, project outcomes, and which context factors had influenced the latter (Appendix C). Six researchers conducted interviews online between February and June 2022. They lasted 90 min on average, and were video recorded via Zoom and transcribed with consent from interviewees.

2.2. *Data analysis – qualitative content analysis*

For the analysis of both the literature review and case study analysis, we applied qualitative content analysis (Mayring 2015) using MAXQDA software 2022. The parallel analysis of the literature review and the case studies was grounded on two code books (Appendix D and E), which we developed iteratively, starting with broad deductive categories from our desk research (e.g. political influences, funding, team collaboration, power), categories partly adapted from Newig et al. (2019), and categories of interest

(e.g. explicit or implicit definition of context, effects of the context on the process, methodological choice or outcomes). We supplemented these with inductive categories (e.g. academic system, changes during the project, legal conditions, historical background) during the coding process.

The synthesis of insights from both analyses provided the basis for the structured overview of context factors in section 3 and resulting implications for context-sensitive TDR. To better understand which context factors were most present in the discourse, we counted how many articles mentioned each factor. We used the synthesised data of mentioned influences to build overarching categories of context factors. In addition, we also included codes related to the different phases of TDR to explore how context factors manifest across project stages. However, as the interview data contained limited explicit references to these phases, they were not a central focus of the final analysis.

We ensured validity of the analysis through several approaches to triangulation: method triangulation (semi-structured interviews and an exploratory literature review as data collection methods), data source triangulation (journal articles and interviews with 17 different experts), and investigator triangulation (3 different researchers involved in the literature review; 5 different researchers involved in the exploratory case study analysis; interviewees validated results as co-authors through two iterations) (Schwandt 1997; Marshall and Rossman 1999; Denzin and Lincoln 2017; Mayring 2015). The coding process was conducted by multiple researchers with expertise in qualitative content analysis and TDR. The researchers met at regular intervals, presenting and explaining newly derived codes, and discussing uncertainties in the spirit of collegial validation (Mayring 2015). To ensure realiability, we implemented an intercoder reliability test (similar code occurrences) for the case studies, where two different researchers coded two identical interviews, resulting ina reliability value of 89.72%.

The conceptualisation of context into three dimensions (inner, outer, and spatial/temporal) – which will be presented in depth in the next chapter – emerged inductively from our analysis of both literature and interviews. While not directly asked about these dimensions, interviewees were prompted to consider context broadly: ‘What comes to mind when you think of context regarding the project(s) you were part of? By context we mean local circumstances where the project takes place, as well as aspects of the project itself (such as team structures)’.

This inductive process of clustering context factors into three dimensions aimed to provide a comprehensive yet comprehensible framework for understanding the multifaceted nature of context in TDR. The discussion of how these three dimensions relate to existing literature will be addressed in the results section, acknowledging the inductive nature of this categorisation while situating it within the broader discourse on context in TDR.

3. Results

3.1. *Systematising context factors for TDR*

Results from the literature review and case study analysis confirm the complex, multidimensional and dynamic nature of ‘context’ in transdisciplinary research. The results show that context has not been consistently conceptualised in TDR literature, indicating a scattered understanding of context. Although all conceptual papers mention at least one context factor, only 8 out of 27 papers provide an explicit definition of the term ‘context’. In the remaining 19 papers, there were only vague explanations of what was meant by context. while three papers did not provide any information on what they understood as context. Within the exploratory case study analysis, interviewees reflected that

definitions of context itself underlie context-dependencies and therefore differ depending on 'different organisational logics' (C05) and one's own perspective:

> So I think one thing is to be aware of certain contextual factors. The other thing is also, I guess to be aware that […] the fact that they carried this, or that the research carries these contextual factors re-influences their research in the sense of that people might answer the questions raised because they expect the person to expect this. And that they also needed to reflect on what their role [is] and what the context to research, how that influences their research results […] (C09)

Thus, we raise awareness that context in TDR is a subjective and relational concept (Tolksdorf et al. 2023). Its relevance evolves and changes throughout the TDR process and its scope and descriptions can differ drastically depending on how it is defined by different actors.

The following definition and framework on context in TDR summarise the main results of the inductive analysis and synthesis of literature and case studies. It further elaborates how the identified context factors influence the design, processes, methods, and outcomes of TDR projects, structured by the TDR phases, including the team

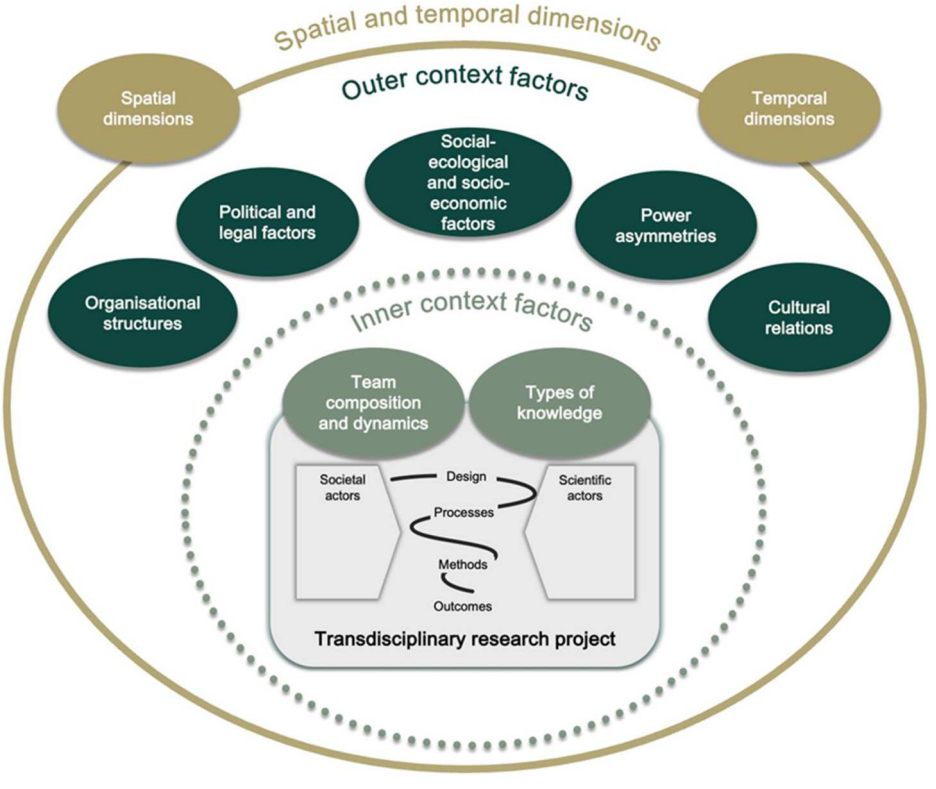

Figure 2. Context factors in a transdisciplinary research (TDR) project (grey box: figure based on Lang et al. 2012). Context factors are organised considering their condition according to the dimensions: outer context factors (external to the TDR project), inner context factors (related to the TDR project design, process, methods and outcomes), and underlying spatial and temporal dimensions, which illustrate that context factors are dynamic (they have a history and change over time and space). Context factors can be interdependent and can influence each other.

building and problem framing, co-creation, and re-integration introduced by Lang et al. (2012).

Context in TDR can be defined as a combination of circumstances that interact with and influence a TDR project along three dimensions (Figure 2): Outer context factors are external to TDR projects and represent the wider environment and systems in which a TDR project is situated. We found five outer factors, including political and legal factors, social-ecological and socio-economic factors, cultural relations, as well as prevailing power asymmetries and organisational structures. Outer context factors can only be intentionally influenced by the design and processes of the specific TDRproject to a limited extent. For example, outer factors, such as political and legal factors, cannot easily and directly be influenced by a TDR project design. These outer factors influence inner context factors that include types of knowledge held by both scientific and societal actors, as well as the team composition and dynamics. When referring to the team, we include researchers and practitioners. Inner context factors have a hybrid character, meaning their close relation to the processes and outcomes of the TDR project allow them to be partly influenced by TDR design. However, inner factors also characterise aspects strongly tied to the individual background of different team members, e.g. one's availability of skills or beliefs, which result in unique team dynamics that are only limitedly controllable by TDR design. Temporal and spatial dimensions underlie and relate to all inner and outer factors. They include spatial dimensions (global, national, local) and associated multi-scale dynamics. The temporal dimensions determine which other context factors might be present in a certain place and moment, how they evolve over time, and include the historical context the project is embedded in as well as other time-related issues relevant to the project, also related to inner context factors (e.g. different temporal logics of scientists and non-scientists). Defining these last two dimensions as context factors highlights that context in TDR is shaped by and relies on boundary-setting strongly defined by time and space. Despite the tripartite division, some factors, such as power asymmetries (outer context factor) and time (temporal dimensions), can be ranked among inner factors too.

As described above, TDR is a subjective and relational concept which can be approached through the three-dimensional framework that we are suggesting. Its relevance evolves and changes throughout the TDR process, and its scope and descriptions can differ drastically depending on how it is defined by different actors. Our analysis suggests that context can be understood as the dynamic interplay of inner, outer, and spatial/temporal factors that shape TDR projects.

The factors that were present in most case studies and papers were 'Types of knowledge' and 'Social-ecological and socio-economic factors' (100% of interviewees and 85% of papers). In general, inner factors were mentioned most frequently, followed by outer factors. The temporal and spatial contexts were mentioned less often, as seen in Figure 3.

In the following, we describe the context factors identified in the literature review and case study analysis, organised according to the three main dimensions (Figure 2). Some of the context factors are large, abstract concepts such as power. We are aware that we are not able to describe all concepts in their full richness, including tensions and contestations of their meaning. However, we make initial steps of identifying their importance and show, albeit briefly, how these concepts are being related to discussions of context in TDR. Table 1 provides an overview of the context factors, their definitions, and implications for designing context-sensitive TDR, as derived from our content analysis.

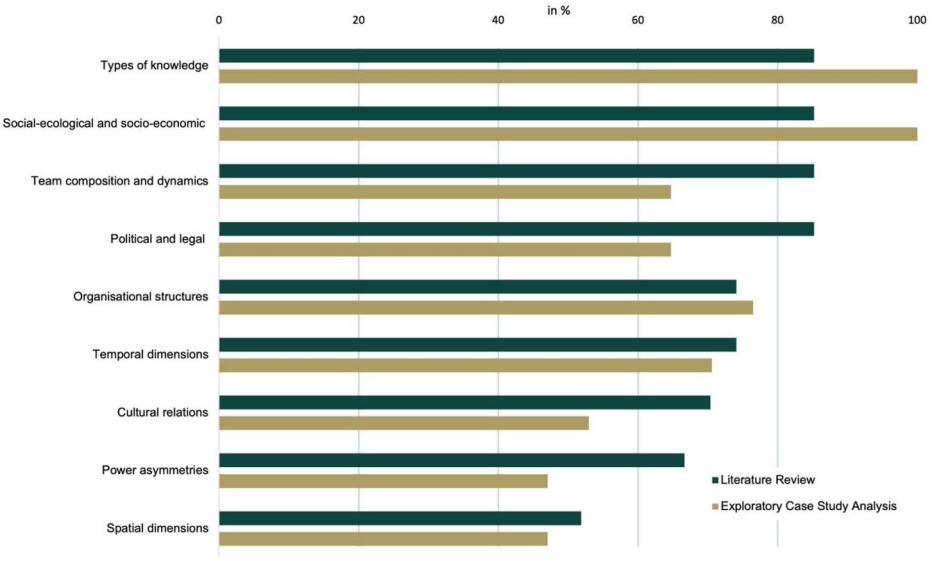

Figure 3. Frequencies of identified context factors in TDR (in percentages, counted once per paper or case study) within the literature review of conceptual papers (n = 27) and exploratory case study analysis (n = 17). The context factors were identified from the literature review and their relevance was then reviewed within the case studies.

In the following sections 3.1.1–3.1.3, we will describe each of the nine context factors in detail, drawing on insights from both the literature review and case study analysis. After presenting these detailed descriptions, we illustrate some influencing mechanisms of context factors on TDR processes and outcomes through three exemplary case studies in section 3.2.

3.1.1 *Outer context factors*

3.1.1.1 *Political and legal factors*. Political and legal factors involve the current and past political system, governmental policies and legal frameworks related to the research object as well as hierarchies and relations within these, including stakeholders' attitudes and trust towards the government.

Research is often subject to political interests that can support or create obstacles (Adler and Shani 2001; Rincón-Ruiz et al. 2019; Spangenberg, Görg, and Settele 2015). Depending on which stakeholders are involved, a change in government may also mean a change of stakeholders (C11), and new laws may disturb achieving project outcomes (C04 and Figure 4). Collaboration between diverse stakeholders can be complicated by hierarchies, political alliances, or corruption (C01; C11), which if mismanaged, can lead to conflict (Chouinard and Milley 2016). In one case study, difficult relations with the local government and their unwillingness to collaborate hindered carrying out the planned participatory approach (C04 and Figure 4). Political and legal factors also play a decisive role in shaping other context factors, such as socio-economic factors (e.g. social emergency law Argentina, C04), power asymmetries (e.g. centralised governments may be unwilling to cede power, complicating decentralisation efforts (Chouinard and Milley 2016)), and organisational structures (e.g. research regulations and funding conditions).

Table 1. Short descriptions of 9 context factors relevant for transdisciplinary research divided into three dimensions (inner, outer and temporal and spatial dimensions) and implications for the design of context-sensitive TDR. Synthesised context factor descriptions and specific implications are derived from the data from the literature review and the case studies.

Context factor	Sub-Factors	Implications for the design of context-sensitive TDR
Outer context factors		
Political and legal factors	Current and past political system, governmental policies and the legal framework related to research object Hierarchies, relations within governmental structures Stakeholders' attitudes and trust towards the government	Including local stakeholders who know the legal context and non-governmental structures well (Spangenberg, Görg, and Settele 2015) Considering the influence and inclusion of local communities on decision-making at higher political levels (e.g. regional and national) (Rincón-Ruiz et al. 2019; Spangenberg, Görg, and Settele 2015) Being flexible to politically unstable conditions was reported as helpful for project success (Brooks, Waylen, and Borhergoff Mulder 2012; Rincón-Ruiz et al. 2019; C11).
Power asymmetries	Discursive, instrumental and structural power implicitly or explicitly observed in and around the TDR process (Fritz and Binder 2020). Hierarchies may exist on political, historical, organisational levels Reproduction of power asymmetries due to bias	A transparent dialogue can help to shift power imbalances (Minkler 2004) Considering inequalities and hierarchies within project settings (Chouinard and Milley 2016) Self-reflection on team members' own positionality (Klodawsky 2007; C01; C09; C16) Genuine collaboration and shared ownership at every phase of a TDR project were considered helpful to reduce the reproduction of power asymmetries in TDR (Minkler 2004; Thomas, Weber, and Bradbury-Jones 2020)
Social-ecological and socio – economic factors	Resource dependency, resource availability and biophysical processes Natural and technological hazards Ecological, economic and social crises	Adapt research design, process, methods and transformation strategies to local socio-ecological and socio-economic circumstances (Brooks, Waylen, and Borhergoff Mulder 2012; Spangenberg, Görg, and Settele 2015; Thomas, Weber, and Bradbury-Jones 2020).

(*Continued*)

Table 1. Continued.

Context factor	Sub-Factors	Implications for the design of context-sensitive TDR
Cultural relations	Cultural traditions, beliefs, values, norms and practices within and around the project setting, among the stakeholders and team Societal norms, interactions between people, as well as demographic distributions related to gender, race, religion, wealth and health Collaboration of people with different societal norms Cultural domination	Team members with a socio-cultural background in the TDR project setting can help mediate this context factor (Brooks, Waylen, and Borhergoff Mulder 2012; Spangenberg, Görg, and Settele 2015; C01; C09; C11) Respecting societal norms is important, whilst acknowledging that societal norms can reinforce social exclusion, e.g. based on gender (Thomas, Weber, and Bradbury-Jones 2020). Sufficient time should be allocated to community entry and mutual familiarisation with local cultural particularities (Holkup et al. 2004). Engagement with stakeholders with high contextual cultural knowledge already early in the process is crucial (C01) Involving local leaders can increase the likelihood of effective participation, and thus lead to project success (Brooks, Waylen, and Borhergoff Mulder 2012). Collaborative, participatory research may help bridge cultural differences and build trust, especially when adapted to the project's cultural settings (Holkup et al. 2004; Minkler 2004; Spangenberg, Görg, and Settele 2015; C16). Acknowledging indigenous or local knowledge, reflecting potential domination, as well as regular updates and monitoring of the research process with the local community (Chouinard and Milley 2016; Thomas, Weber, and Bradbury-Jones 2020).

(*Continued*)

Table 1. Continued.

Context factor	Sub-Factors	Implications for the design of context-sensitive TDR
Organisational structures	Work cultures, compliance and flexibility of different organisational structures Academic system Requirements and performance standards for researchers; Recognition of TDR in academic landscapes Ethical protocols in different national contexts Funding system Availability of funds (to allow for implementing principles of TDR) Unequal payment	Consider flexibility options and context characteristics when writing project proposals (C13; C16) Choose the higher ethical standards when facing different ethical protocols (Thomas, Weber, and Bradbury-Jones 2020) Competitive funding under clearly communicated rules can positively influence motivation and success of TDR (Pregernig, Rhodius, and Winkel 2018; C18)
Inner factors (Project-specific factors)		
Team composition and dynamics	Understanding of team as consisting of researchers and practitioners Team composition in terms of gender, cultural and disciplinary diversity, background, skills, (academic) position Diversity of different understandings and logics in the team Availability of resources to individual team members	Building teams with complementary skill sets and perspectives (C09) Addressing misunderstandings and conflicts based on multiple backgrounds, interests and capacities of team members (Chouinard and Milley 2016; C17) Sensitivity to power and decision-making hierarchies (Thomas, Weber, and Bradbury-Jones 2020) Building trustful relationships (Adler and Shani 2001, C09; C06; C17) Practising reflexivity (self-reflexivity, interpersonal and collective reflexivity) (Klodawsky 2007; Pregernig, Rhodius, and Winkel 2018; Thomas, Weber, and Bradbury-Jones 2020) Transfer of ownership to practitioners (Minkler 2004; Spangenberg, Görg, and Settele 2015) Keeping motivation and (continuous) engagement of stakeholders high (C07; C08; C09; C11; C13). Relevance of research topic to stakeholders can positively influence participatory process (C08; C09)

(*Continued*)

Table 1. Continued.

Context factor	Sub-Factors	Implications for the design of context-sensitive TDR
Types of knowledge	Involvement of different knowledge systems, their epistemologies, worldviews, methods and frameworks	Reflecting on one's potential epistemic privileges to prevent imposing own perspective on others and respecting different knowledge types as well as language levels (Thomas, Weber, and Bradbury-Jones 2020) Choosing appropriate methods for a trustful co-production process (Chouinard and Milley 2016; Pade-Khene et al. 2013; Thomas, Weber, and Bradbury-Jones 2020) Learning from other TDR projects about incorporation of different knowledge types and perspectives in similar context conditions (C04; C18)
Temporal and spatial dimensions		
Temporal dimension	Different time logics and perceptions Availability of time for building relationships and trust, to participate in project activities Length of project Linkages of history to present conditions	Projects may be more successful when they run longer (Brooks, Waylen, and Borhergoff Mulder 2012) Sufficient time for team building, problem-framing phase (C05; C07; C10) Understanding the research location through historic linkages (e.g. through post-colonial politics, critical race theory, decolonisation) (Atallah 2016; Thomas, Weber, and Bradbury-Jones 2020) and address historical power differences by disrupting historical exploitative research mode (Meyer and Vilsmaier 2020) Consideration of prior research in the region (Thomas, Weber, and Bradbury-Jones 2020)
Spatial dimension	Scale and size of research setting (global/national/local; small/large; urban/rural) Climatic conditions Physical Infrastructure Multi-scale dynamics (Effects of sudden changes at upper or lower scales, e.g. pandemic, war)	Gaining an overall systemic context understanding (overview of available resources, tensions) informs defining an adequate and manageable scope for the research project (C16; C17) Choosing location for activities considering equitable participation opportunities (infrastructure, accessibility) (Pade-Khene et al. 2013; C03; C09; C11; C17)

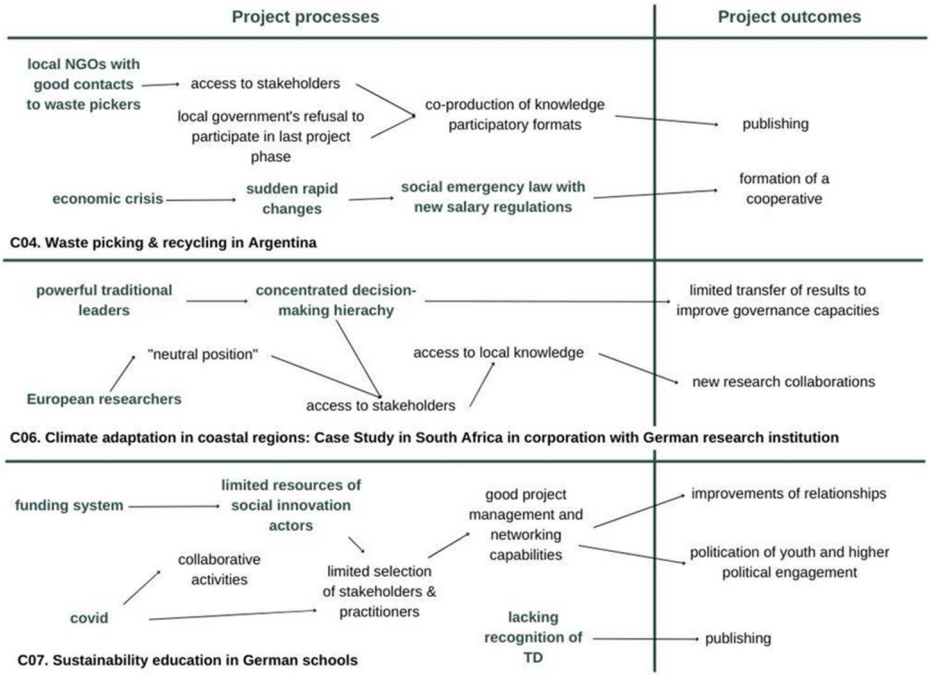

Figure 4. Influence mechanisms of context factors on TDR processes and outcomes within three exemplary case studies. Context factors are marked in bold letters.

Brooks, Waylen, and Borhergoff Mulder (2012) found that well-designed projects can compensate for less conducive political environments. It is important that appropriate and relevant political and legal stakeholders, even if they are not collaboration partners, have been informed about the project during all stages of the project and support it in order to enable project continuity and outcomes (Spangenberg, Görg, and Settele 2015; C01).

3.1.1.2 *Power asymmetries*. Power asymmetries are best understood through an integrated understanding of power, including discursive, instrumental and structural power implicitly or explicitly observed in and around TDR processes (Fritz and Binder 2020). Power asymmetries underlie many other outer factors such as politics, history, social structures, or organisational structures, and influence inner context factors.

Within the investigated TDR projects, power imbalances were caused due to misuse of authority of a team member (C11), colonial history (C10), dependencies on local authorities and political hierarchies (C04; C07; C10; C12), as well as unequal funding conditions (C09; C11). Power asymmetries also evolve and are reproduced and influenced by inner factors. For example, relationships and collaborations are shaped by the perspectives that are included and excluded within projects (Chouinard and Milley 2016; Pade-Khene et al. 2013; Rincón-Ruiz et al. 2019; C07). Powerful actors can limit and provide stakeholders' access, as local political rulers did in a German-South African research project (C06). Researchers may be biased towards engaging with better organised and powerful actors who may be more skilled negotiators and communicators (Pade-Khene et al. 2013; Spangenberg, Görg, and Settele 2015) in spite of the valuable input

offered by others. Likewise, a lack of appropriate flow of information and opposed powerful interests can also frustrate actors in TD projects (Fischer et al. 2021).

Besides creating a balanced team composition and context-sensitive and fair role distribution of all relevant stakeholders (C09), a transparent dialogue on inequalities during the research process, as well as an awareness of one's own positionality and engagement in continuous evaluation are helpful for dealing with power inequalities and for establishing quality relationships (Minkler 2004), especially when insider-outsider tensions are expected.

3.1.1.3 *Social-ecological and socio-economic factors*. Social-ecological and socio-economic factors are social factors that are intertwined with environmental and economic factors (Folke et al. 2016) and relate e.g. to resource dependency and availability as well as biophysical processes impacting the TDR setting. They are strongly connected to the temporal and spatial dimensions (e.g. the local history and geographical research scope shapes potential land use conflicts), power asymmetries (e.g. contribute to economic inequalities), and influence inner context factors (e.g. inclusion and exclusion of stakeholders based on resource availability).

Some reviewed papers (Atallah 2016; Balvanera et al. 2017; Fischer et al. 2021; Rincón-Ruiz et al. 2019) took a social-ecological systems approach which highlights the complex interactions and feedbacks between the human and natural dimension of systems. For example, considering overlapping hazards such as natural hazards (e.g. hurricanes), technological hazards (e.g. oil spills) and social crises (e.g. poverty) and their interactions can inform the choice of suitable research methods in a TDR project (Atallah 2016). For example, in one project in Argentina a new law regulating the salary of waste pickers was implemented as a result of an economic crisis, strongly affecting the participatory processes (C04).

The socio-economic factors mentioned mainly include distributive economic inequalities, for instance the unequal allocation of resources that can lead to different starting positions and power of stakeholders involved in TDR projects (Atallah 2016; Rincón-Ruiz et al. 2019; C04). Researchers' false assumptions on e.g. the resource availability at the research location might cause inaccurate interpretations of data (C05). The varying vulnerabilities, coping and adaptation strategies to social-ecological and socio-economic conditions should be carefully observed by TDR researchers. This was emphasised in one project on climate adaptation, where poor economic conditions required a shift in the research topic.

> You are reaching the limits with your questions about adaptation to climate change, because other things are much more important to them. Like: How will I feed my family tomorrow? They are very different scales […] so in the end we changed our research and did more research on vulnerability [to climate change]. (translated, C06)

3.1.1.4 *Cultural relations*. Factors related to cultural relations include cultural traditions, beliefs, values, norms and practices within and around the project setting that influence interactions among the stakeholders and team. Factors related to cultural relations named in the literature included societal norms, interactions between people, as well as demographic distributions related to gender, race and religion (Atallah 2016; Bharadwaj 2014; Meppem 2000; Minkler 2004; Pahl-Wostl et al. 2020; Spangenberg et al. 2015; Thomas, Weber, and Bradbury-Jones 2020). Cultural relations closely interrelate with history, scale, communication, education, participation, and power asymmetries

(Brooks, Waylen, and Borhergoff Mulder 2012; Chouinard and Milley 2016; Rincón-Ruiz et al. 2019; Spangenberg, Görg, and Settele 2015). For example, stakeholder involvement with farmers about agroecological practices has shown that men traditionally represented families and would speak up first, although women held valuable knowledge on agroecological practices (C10).

Stakeholders' trust towards the research team and process is impacted by the ways in which research teams deal with cultural differences (Holkup et al. 2004; C10). Insensitivity to cultural factors may lead to misinterpretation of data because of different cultural backgrounds, racism, misrepresentation of communities, unfulfilled expectations, or unintentional exclusion by researchers (Holkup et al. 2004; Minkler 2004; Pade-Khene et al. 2013). For example, when working with Indigenous communities, using mainly methods and approaches developed in the Global North with their embedded cultural values, epistemologies, and normative assumptions may be part of a broader system of cultural domination (Chouinard and Milley 2016). Respecting Indigenous cultures was especially relevant for 10 of the analysed papers and one case study.

A multiplicity of groups with differing socio-cultural backgrounds in the project area (Holkup et al. 2004) as well as heterogeneity within groups (Pade-Khene et al. 2013) might complicate understanding the complex web of cultural relations. Understanding cultural relations is crucial as it impacts how people give meaning to objects, places or events (Meppem 2000) and how they make judgements (Spangenberg, Görg, and Settele 2015). It is difficult for outsider researchers to fully familiarise themselves with local cultural factors (Holkup et al. 2004; C10). Therefore, a balance of local research partners and outsider researchers in the team, as well as sufficient time to build relationships with local people and context, support the prevention of confusion, misunderstanding and conflicts within a TDR project.

3.1.1.5 *Organisational structures*. Organisational structures refer to the processes, complexity and work cultures amongst academic and non-academic, formal and informal organisations that have an influence on TDR practice (Holkup et al. 2004; Margules et al. 2020), as well as the underlying academic and funding systems determining these. Thus, they underlie political and legal factors, the spatial and temporal dimensions, cultural relations and can shape the possibilities to compose a team.

It is often a challenge to bridge different organisational structures, cultures and aims with varying administrative support, time and resources (Chouinard and Milley 2016; Pade-Khene et al. 2013; Pregernig, Rhodius, and Winkel 2018). Low flexibility in organisational structures may clash with evolving and adaptive TDR processes with the need to make changes along the way (Holkup et al. 2004). Lengthy and complicated application procedures can deprive local stakeholders from decision-making in initial stages of the project (Thomas, Weber, and Bradbury-Jones 2020). For example, specific policies for engaging with indigenous people in research led to limited involvement of these groups due to conflicting timelines in one case. TDR projects in multi-country settings (e.g. North–South) also bear the challenge of navigating ethical protocols of different national academic systems (Pade-Khene et al. 2013). The complexity of organisational structures can strongly relate to the spatial dimension of a research area. One case demonstrated that the given island setting allowed easy access to stakeholders and decision-making levels.

Organisational structures in academic institutions underlie the academic system that shapes the range of possibilities towards the implementation of TDR (Balvanera et al. 2017; Pregernig, Rhodius, and Winkel 2018). Additionally, the outcomes achieved and skill sets required to conduct TDR often do not match the criteria according to which

the performance of researchers is assessed (Margules et al. 2020; Pregernig, Rhodius, and Winkel 2018). This might be displayed in terms of lacking recognition of TDR results in compartmentalised academic landscapes (C07; C16), and discourages the pursuit of TDR agendas or hinder the funding options.

The academic system is conditioned by the openness of funding bodies towards TDR (Balvanera et al. 2017; Margules et al. 2020). The availability, allowances and requirements of funding structures determine the implementation of principles of TDR. Funding is often limited and short-term, which is prohibitive for projects with the goal of making change in practice (Margules et al. 2020). Donor expectations and scarcity of funds were reported to clash with internal success criteria (Pregernig, Rhodius, and Winkel 2018; Spangenberg, Görg, and Settele 2015), e.g. the need to make changes during the TDR process in response to all types of context factors is subject to the approval of the donors (Pregernig, Rhodius, and Winkel 2018; C07). Publishing scientific results can create additional pressure on researchers, particularly in the light of limited human resources and an overload of work within TDR projects (C01; C02; C06; C10).

Challenges also include low and insufficient compensation of practitioners, which often causes frustration or even excludes some from taking part in TDR (Minkler 2004). Researchers may face the burden of unpaid overtime, as well as funding structures that request for specific academic titles, which are not accessible in the same way in different countries (C11). Further, some funding structures did not allow for equal payment conditions of researchers from the Global North and Global South,[2] reinforcing hierarchies within the research team. One interviewee referred to a research project where researchers from the Global South could only be subcontractors without budget authority.

> The funding being acquired in [country in Global North], [is] being paid out exclusively to the [University in Global North] and then distributed further on to other researchers, which of course by definition, leads to large power imbalances just in terms of project structure. (C09)

3.1.2 *Inner context factors*

3.1.2.1 *Team dynamics*. Team dynamics are project-specific context factors at the core of TDR projects, inseparable from and bound to the outer context factors, making them unique in every project. The composition of teams relates to the diversity of skills and perspectives within a team, resulting team dynamics relate to the team's ability to deal with this diversity, including collaboration mechanisms, decision-making power asymmetries, trust and respect levels as well as communication, reflexivity, positionality, ownership and knowledge co-production processes. Furthermore, each team will also lack some skills and competencies and have to deal with this.

The team composition and dynamics (including researchers and practitioners) majorly shape the project and its outcomes. Our review highlights several examples of specific elements influencing the team composition, including gender, cultural backgrounds (Chouinard and Milley 2016; Thomas, Weber, and Bradbury-Jones 2020), complementary skill sets (Margules et al. 2020), complementary communication skills (Chouinard and Milley 2016), involved disciplines and their respective research traditions, assumptions and methodologies (Adler and Shani 2001; Pregernig, Rhodius, and Winkel 2018). Beneficial traits within teams include epistemological agility – the ability to work with persons from different disciplines and knowledge systems (Margules et al. 2020), openness to other perspectives and sensitivity to and reflection on positionality (Chouinard and Milley 2016; Holkup et al. 2004; Margules et al. 2020).

In most case studies (11 out of 17), the access to stakeholders was determined by one or few team members that acted as gatekeeper, providing crucial contextual and local knowledge as well as contacts. This can impact TDR processes in terms of changing response rates from stakeholders depending on the practitioner establishing the contact (C12). However, practitioners often represent key decision makers, traditional leaders, as well as wealthy, powerful or politically well-connected people (Spangenberg, Görg, and Settele 2015). Emerging change agents and decision makers, as well as people with language barriers or a lack of participation skills are often hard to identify and frequently excluded (Pade-Khene et al. 2013; Spangenberg, Görg, and Settele 2015).

TDR benefits from diverse teams with complementary skill sets (C09). However, dealing with multiple backgrounds and interests can lead to misunderstandings and conflicts (Chouinard and Milley 2016; Pade-Khene et al. 2013). For example, C17 identified differences in time capacities, competences and the availability of resources between team members (both from science and society) as important elements to be considered and reflected on during the research process (see also context factors temporal dimension and organisational structures), giving special attention to compensation for practitioners (C07). Scarcity of resources for transdisciplinary processes for practitioners can impact participation continuity (C04; C07; C12).

Within team dynamics, the quality of relationships is considered particularly important for TDR (C09; C16; C17), as it influences the level of openness, degree of involvement, and readiness for mutual learning among team members (Adler and Shani 2001). For a fruitful collaboration, sensitivity to power and decision-making hierarchies were reported to be crucial (8 out of 17 case studies; Thomas, Weber, and Bradbury-Jones 2020).

3.1.2.2 *Types of knowledge*. Types of knowledge include the different knowledge systems with corresponding ontologies, worldviews, methods and frameworks that interact during TDR (Van Opstal and Hugé 2013). This factor is closely related to team dynamics as well as other factors such as socio-ecological and socio-economic factors and cultural relations that shape individual and collective knowledge types. Types of knowledge as a context factor does not refer to the knowledge to be co-created during the project (e.g. action-oriented, transformative knowledge), but to the knowledge types team members and stakeholders of TDR projects bring into the project from their individual context.

Valuing multiple knowledge types and exploring different understandings of epistemological and cultural assumptions by various actors/stakeholders are both aims and challenges in TD knowledge co-production processes (Meppem 2000; Saunders et al. 2016; Stepanova, Polk, and Saldert 2020; Van Opstal and Hugé 2013; C02).

> So this dynamic of going there to learn something that is considered as an unknown because it's not codified in scientific terms is kind of, of course, very arrogant. And I understand that, you know, it's not the same. Oral culture is not the same as written culture. […] But you and I know there should also be a value attributed to the other way of knowing, that perhaps it does things. […] It doesn't promote a way of relating with nature that is meaningful. It's an instrumental way. And then so yeah, all these power dynamics are playing there constantly. (C02)

In TDR, dominant forms of knowledge (e.g. Euro-American) may be perpetuated while others (e.g. local, Indigenous, emotional) are ignored (Pade-Khene et al. 2013). Thus, a reflection of dominant knowledge systems, such as the epistemic privilege of researchers from the Global

North is considered necessary to ensure an equal valuation of knowledge systems whilst actors can maintain ownership of their knowledge (Stepanova, Polk, and Saldert 2020).

3.1.3 *Temporal and spatial dimensions*

3.1.3.1 *Temporal dimensions*. The temporal dimension, with multiple layers and perceptions of time (Winter 2019), underlies all other context factors and encompasses the time-related issues relevant to the implementation of TDR projects.

Time can be seen as an influencing factor to outer context factors, since the present conditions are linked to their history and perceptions of the future (Winter 2019). The political history of the project location as well as the history of interactions between stakeholders (e.g. donor-funds recipient) impacts current TD project developments, e.g. in relation to inequalities and the dominance of certain voices in participation processes (Bharadwaj 2014; Chouinard and Milley 2016; Pade-Khene et al. 2013; Saunders et al. 2016) or historically grown mindsets, as the following case demonstrates:

> [T]his legacy of 40 years socialism […] created a kind of a mindset in people, so they are just waiting for decisions [to be made on their behalf] which had implications on the outputs of TDR as they don't know what to do with all these […] reports [generated by the projects]. (C03)

Furthermore, prior interactions between local stakeholders and scientists and prior research approaches impact the management of expectation and willingness of practitioners to participate in TDR (C05; C16).

Time can also be seen as an operationalisable element in the inner context sphere. Project length can, for instance, present paradoxes. Problems identified in projects demand a quick resolution as short-term funded projects is the common practice, but on the other hand, deep system change often requires long-term commitment (Margules et al. 2020; Tribaldos, Oberlack, and Schneider 2020). Institutionally set time frames in the project may lead to further time constraints, reducing the capacity of participants to engage in the respective project, as illustrated in a TDR project on sustainability education with students:

> The project team realised that the teachers are [the students'] central reference persons and they have ultimately dictated the time windows for the TD project. Regulatory power came very centrally from the schools, the non-school actors also said this again and again in the interviews. It actually manifests itself in the factor of time. Time for extracurricular activities and time that can be taken away from the core lessons. That's one power relationship. (C07, translated)

Time frames also affect collaboration, as relationships take time to develop and time is needed to bridge different disciplines and backgrounds (Margules et al. 2020; Pregernig, Rhodius, and Winkel 2018). Thus, building formal and informal research agreements is time-consuming and can also lead to insider-outsider tensions due to different timetables, resources, and priorities of stakeholders (Minkler 2004). Sufficient time in the preparatory phase to set realistic conditions and establish stable relationships with partners can be key to the success of a TDR project (C10, C07).

3.1.3.2 *Spatial dimensions*. The spatial dimensions encompass the scale (global, national, regional, local) at which the project is implemented and its implications, for example, geographical boundaries and distances. These dimensions shape the scope

and setting of TDR projects (specific country, Global North/Global South, small/large, urban/rural) (Kumar et al. 2020; Rincón-Ruiz et al. 2019) and are strongly connected to cultural relations and political factors (Chouinard and Milley 2016; Rincón-Ruiz et al. 2019).

The size of the research area and its location determines whether researchers can be physically present at the research site (Krütli, Pohl, and Stauffacher 2018; C03). On the other hand, large distances to research locations can create barriers to stakeholder participation (for example, if rural stakeholders are invited to participate in a workshop held in an urban area) or physical infrastructure is lacking (C03; C11; C17). Sudden changes at a broader scale, such as conflicts, pandemics, and natural disasters, can impact projects. For example, five cases mentioned severe negative impacts to research activities and collaborative actions due to COVID-19 (C11; C07; C06; C10; C12). Further, the extent to which stakeholders are affected by a problem and their capacities, can differ within a research location. For example, stakeholders of a case on flood planning had different consternations of flooding based on their location in the basin (C11).

It is crucial to choose the spatial boundaries of a research project adequately to the available resources and project approach to engage appropriately with targeted communities and prevent a scalar misfit (e.g. multinational projects with one project approach for differing contexts (C2)).

3.2. *Exemplary influence mechanisms of context and TDR*

To better understand how the described context factors can be embedded within and affect both TDR processes and outcomes, we provide three case study examples (Figure 4). The selection of cases was based on their ability to clearly illustrate direct links between context factors and research project aspects, ensuring that the interrelations were tangible and comprehensible. We aimed to include cases that reflect a variety of context factors to demonstrate the complexity and embeddedness of these influences in project processes and outcomes.

3.2.1. *Waste picking and recycling in Argentina*

Research project C04 dealt with improving the situation and visibility of waste pickers in Argentina. The initial access to waste pickers was provided by a local environmental NGO. Due to working with the informal sector of waste pickers and the local government that was not accepting the sector, co-production processes were described as messy and hard to organise properly due to inconsistent participation. The project was further pervaded by many changes in terms of contact partners and political conditions that highly affected the research processes. An economic crisis in Argentina led to a new law regulating the salary for waste pickers that had influence on the formation of the cooperative. Indeed, the new ‘social emergency law’ (N° 27345/16) recognised the workers of the ‘popular economy’, that is, those who invented their job – like waste pickers – with a complementary social salary representing half the national minimum wage. This measure, which implied the inscription of waste pickers in a national register, allowed local social referents to strengthen contact with them and better explain the opportunities a cooperative formation could have. Also, the new revenue enabled interested waste pickers to dedicate some working hours to collective tasks. Finally, once the cooperative was operating, it was an incentive to other waste pickers to join it.

3.2.2. *Climate adaptation in coastal regions: case study in South Africa in corporation with German research institution*

This case study was a research project in South Africa about climate adaptation processes in coastal regions with the aim to support local governance capacities. The project was set up in collaboration with German research institutions. In the rural region, traditional leaders have a high decision-making authority over local people, and thus, regulate the permission of which stakeholders researchers could talk to. As the leaders were interested in improving the situation for their people, they provided access to local stakeholders and knowledge, laying the basis for new research collaboration and a widened network. As an inner context factor, the team constellation played a crucial role for the intensity of collaboration. The fact that research was not conducted by white South African researchers as it often seemed the case, but by European researchers opened a more 'neutral' position to talk about sensitive topics. However, the strong social-political hierarchies limited the potential of the results to be transferred to practise as governing capacities were centred around local leaders.

3.2.3. *Sustainability education in German schools*

This case study dealt with sustainability education in German schools aiming to create long-term workshops with students, teachers, non-formal education sector actors and civil society. Precarious funding conditions for all actors hindered collaborative activities within the project. There was a small budget for them to enable participation, which could only partly compensate for the different starting conditions of the various actors involved. For example, practitioners were cooperating social innovation actors that had very limited resources to take part in activities. Funding systems (in Germany) often do not display and recognise the complexity of transdisciplinary practice in terms of the actual capacities needed for the coordination of all activities. Inner factors, such as the presence of a very competent team colleague who managed relationships, communication very well was reflected to be a success factor for good outcomes such as the politicisation of youth and higher political engagement. Further, the COVID-19 pandemic as a spatial and temporal dimensions factor affected collaboration activities, as schools closed down or dropped out of the collaboration.

4 Discussion

4.1. *Towards context-sensitive transdisciplinary research*

Dealing with and understanding context in TDR is important in the light of its ambition to address real-world problems embedded in complex systems and to foster sustainability transformations. Our results reflect that TDR projects often lack context-sensitivity, particularly in North–South research relationships. Considering the scarce resources and time TDR projects are often equipped with, adequate and easy to implement tools to better engage with and reflect on the complexity of context factors and imbalances are a relevant issue for a transformative and decolonial TDR practice.

We present a conceptualisation of context based on relevant literature and drawing from case studies globally. Our results also indicate how context factors interrelate among each other and with processes, methods and outcomes of TDR projects, emphasising the importance of context-sensitive approaches to TDR (Table 1). Thus, initiators of TDR should consider analysing relevant context factors before and during the planning and implementation of their TDR projects. Given the complex and unique nature of

Table 2. Reflective questions on context factors in transdisciplinary research for guiding TDR researchers and designing TDR projects.

Context factor	Reflective question
General	Which context factors (inner/outer/temporal and spatial) may hinder the achievement of your project outcomes?
	Which context factors (inner/outer/temporal and spatial) may support the achievement of your project outcomes?
	How may your project potentially influence the context it is embedded in?
Outer context factors	
Political and legal factors	Which political interests of different stakeholders may influence your project?
	Which legal frameworks and regulations is your project embedded in?
	Are sudden changes in the political or legal framework likely to influence your project?
Power asymmetries	Which kind of power imbalances exist in the project?
	How do power imbalances impact the project team and process?
	How and when are power imbalances within the project addressed/reflected?
Social – ecological and socio-economic factors	Which impacts do socio-economic and social-ecological factors have on your project?
	Are there trade-offs between ecosystem services and human well being present in the project area?
	Which groups of people are excluded from decision-making?
	Where do you see potential for conflict or synergies between project aims and societal norms and rules of stakeholders?
Cultural relations	How does the research team attempt to understand the local cultural context (as outsiders)?
	Which adverse effects could community entry without sufficient sensitivity have?
	Which values are present among stakeholder groups?
Organisational structures	Which different organisational structures meet in the project?
	Which possibilities and restrictions do they bring along for project processes and intended outcomes?
	How much space for changes and revisions along the research process do the organisational structures allow for?
	To which degree are the intended outcomes and products of your project supported by academic criteria?
	Which different academic cultures meet in your project? How do you deal with different protocols?
	In which way do funding structures support or hinder transdisciplinary research, specifically your project aims?
	In which way does payment of researchers (from Global North and Global South) as well as compensation of practitioners influence their contributions to the project?
Inner context factors	
Team composition and dynamics	How might the composition of the team (e.g. disciplines, positionalities, skills, ontologies) influence the project?
	To what extent does the research team include room for reflection (e.g. on processes, context, power) into the project?
	How might the team dynamics support/hinder your project aims in terms of trust, ownership, communication?

(*Continued*)

Table 2. Continued.

Context factor	Reflective question
Types of knowledge	What are the strategies and methods to include the various knowledge types of involved scientists, practitioners and stakeholders in the TDR process?
	How does the team deal with dominance of certain forms of knowledge (e.g. science in the Global North)?
Temporal and spatial dimensions	
Spatial dimensions	Which needs and interests of stakeholders are attached to the spatial scope of the project?
	How do different scales (local, regional, national, international) and multi-scale dynamics influence the project?
Temporal dimensions	Is the project time frame adequate to the project aims?
	Is enough time considered in the project design for building relationships and reflexive processes?
	How are different timetables, time resources and time handlings of actors aligned in the project?
	How does the history of both scientific research and of the local context (e.g. political context) influence the project and its actors?
	How do prior interactions between scientists and practitioners influence current relationships?

sustainability challenges and TDR projects, it is impossible to establish general cause-and-effect relationships between context factors and project processes, methods and outcomes. However, we propose a set of reflective questions to serve as a guidance for a context analysis in TDR (Table 2).

Furthermore, in the following sections we use Lang et al.'s (2012) TDR design principles, along different phases (team building and problem framing, co-creation, and re-integration), and Horcea-Milcu et al.'s (2022) addition of a phase 0 to provide insights on how different context factors manifest and influence desi TDR projects. As described above, ideal-typical processes of TDR are divided into three phases. In this paper we consider an additional phase 0 with regards to the relevance but scarcity of time and capacities to building up collaborations and initiating TDR (Cockburn et al. 2016; Horcea-Milcu, Leventon, and Lang 2022; Lawrence et al. 2022).

4.1.1 *Phase 0. Preparation phase*

Phase 0 involves choosing a case study on the basis of societal demands and other relevant criteria; building an understanding of context and various perspectives; and laying foundations for stakeholders coming together by identifying expectations and initial goals (Horcea-Milcu, Leventon, and Lang 2022).

First, in relation to the case study selection, defining the temporal and spatial characteristic of the TDR project is especially relevant, as it will determine the main traits of context borders (Pulver et al. 2018). Furthermore, the temporal and spatial context factors might be shaped by the TDR design decisions in this preparatory phase, although there might be trade-offs with societal priorities and other relevant criteria. For example, the logistical convenience of selecting a small research area (e.g. municipality level) might clash with the scale at which specific dynamics operate (e.g. vanilla value chain, ground-water governance). Second, having access to

context-dependent information is important to build an understanding of the relevance of specific context factors and gaining place-based knowledge in this phase (Horcea-Milcu, Leventon, and Lang 2022). This influences the selection of TDR case studies, and usually requires the early engagement of persons with considerable local knowledge; which in turn influences and is impacted by inner factors. Third, open discussions within the team to loosely identify different understandings of the context, define scope and aims, and share expectations of the TDR project at this stage can prevent inaccurate assumptions and shape future team dynamics (Chouinard and Milley 2016; Pade-Khene et al. 2013).

In sum, in the preparation phase context factors can interact in an iterative manner with the preliminary project design decisions. The development of this phase is highly influenced by organisational context factors, such as funding requirements or length of funding schemes and contracts of TD researchers and practitioners, which can determine the extent to which resources for the implementation of phase 0 are available.

4.1.2 *Phase A. Team building and problem framing*

This phase aims to build a collaborative research team and collaboratively design the research project, including problem framing, research objectives, methodology and success criteria.

Building a research team is tightly connected to inner context and outer context factors. While team dynamics can be shaped by design to a certain extent, we argue that there are many considerations that are beyond the design process. For example, the accessibility to TDR processes may hinder certain actors from joining the team. For example, from the researcher's side, the lack of resources (a sub-factor of organisational structure) in the initial phases of TDR projects might be a major challenge for many early career researchers to join, as high job insecurity make their time dependent on availability of project(s) money (OECD 2021; Woolston 2020). From the practitioners' side, the possibility of compensation (organisational structures factor), distance to meetings or quality of internet connection (spatial dimension) can determine whether they can participate, especially for those with low income (Fritz and Binder 2020; Krütli, Pohl, and Stauffacher 2018). Furthermore, the formal and informal rules regulating how stakeholders can be approached in TDR underlie power asymmetries, cultural relations and organisational outer factors (Schneider et al. 2022). As a result, the resulting team dynamics will be a unique constellation of elements in each TDR, which are shaped by multiple inner context factors, that can't be identically reproduced in other TDR projects, and are influenced by multiple outer factors.

Our results also show that balancing diversity (of e.g. disciplines, cultural backgrounds, gender) and complementarity of skill sets are important elements that influence team dynamics. But diversity brings collaboration challenges (Lang et al. 2012; O'Rourke et al. 2019). In this sense, trust is essential for building bridges across disciplines and backgrounds (Adler and Shani 2001; Schneider et al. 2022), and a key enabler for successful TDR projects (Chilisa 2017; Manuel-Navarrete, Buzinde, and Swanson 2021), but it requires a considerable time investment (influenced by a temporal dimension) even before the research project properly starts (Cockburn et al. 2016).

4.1.3 *Phase B. Co-creation of solution-oriented transferable knowledge*

This phase aims to co-create knowledge with different societal and scientific actors. It is the doing of TDR, where methods are designed and applied to facilitate the mobilisation of

diverse knowledge systems and their translation, negotiation and synthesis (Lang et al. 2012; Tengö et al. 2017). This phase involves identifying who will do what, using which means and to what end (Lang et al. 2012).

Developing appropriate settings for cooperation and knowledge integration is at the core of TDR, and is dependent upon the inner context factors of types of knowledge present within the team and the team dynamics. Thus, when designing TDR processes and methodologies, attention should be payed to hierarchies among knowledge holders, to avoid privileging dominant forms of knowledge (e.g. scientific or from the Global North) while undervaluing other knowledge (such as Indigenous or local) (Pade-Khene et al. 2013; Stepanova, Polk, and Saldert 2020; Van Opstal and Hugé 2013). Thus, reflection on how power privileges different types of knowledge and/or participants can support choosing and adjusting methods for collaboration and knowledge co-production (Stepanova, Polk, and Saldert 2020; Thomas, Weber, and Bradbury-Jones 2020; Van Opstal and Hugé 2013). Furthermore, team dynamics inner factors, as displayed in Table 1, will also influence the success of the TD co-creation processes (Adler and Shani 2001; Margules et al. 2020; Thomas, Weber, and Bradbury-Jones 2020).

Another challenge in this phase is clearly defining, assigning and supporting appropriate roles within practitioner and researcher teams, which relates to the team dynamics. Two main issues highlighted in our results influence this principle. First, the presence of complementary and diverse skill sets within the group are important factors to consider when assigning roles (Margules et al. 2020). However, role assignment should also mitigate power imbalances and avoid biases due to, for example, gender, cultural backgrounds or hegemonies in (academic) institutions (Fritz, Vilsmaier, and Fam 2021). For example, women frequently take on more 'non-promotable tasks', i.e. tasks that are not directly linked to the project goals, are largely invisible, and don't require specific skills (Babcock et al. 2022). Thus, shifting power asymmetries within the team is fostered by a balanced role assignment, which requires powerful actors sharing authority, responsibility, and credit for success, as well as respectfully considering different opinions and taking their fair share of 'non-promotable tasks' (Babcock et al. 2022; Holkup et al. 2004).

Second, role assignment and task development are supported by the commitment of participants with the TDR process. Transfer of ownership and relevance of the research topic to practitioners ensure strong practitioner commitment to the co-creation process (Minkler 2004; Spangenberg, Görg, and Settele 2015). We argue that such involvement is vital when distributing project tasks, as they put into practice the co-creation process, as well as any strategy, plan or action that might come from it. However, if tasks are to be shared between practitioners and researchers in the TDR team, ensuring sufficient compensation for practitioners to support a just research process seems fundamental. In this sense, rethinking funding structures within the academic system (organisational outer factors) is much needed to be discussed by decision-makers.

4.1.4 *Phase C. Re-integration and application of created knowledge*

This phase deals with the use of co-created knowledge in society and science (Lang et al. 2012). Understanding how context factors influence this phase is challenging as societal effects of TDR often appear with time delay and through complex and non-linear processes (Schäfer, Bergmann, and Theiler 2021).

On the one hand, acknowledging different types of knowledge systems as well as trust and good relationships within the TDR team (inner context factors), often support the

success and implementation of results from TDR projects (Adler and Shani 2001; Schoon et al. 2021). On the other hand, outer context factors, such as the short-termism of research projects and limited funding (organisational outer factors), restrict the range of action and scale of outcomes within a project (Margules et al. 2020). Evaluation of impact (scientific and societal) remains difficult in the light of limited resources and time.

In planning and realising intended outcomes, finding a balance between generating societal and scientific impact can be accompanied by trade-offs. Advancing scientific understanding or following the methodological design is not always compatible with stakeholders' goals, agendas or time availability (Horcea-Milcu, Leventon, and Lang 2022). In this sense, choosing which outcomes to prioritise is fundamental, and context-specific to the team's inner composition and dynamics.

Finally, targeted products and impacts of TDR can intentionally or unintentionally influence the inner and outer context on different levels and scales (Schäfer, Bergmann, and Theiler 2021). The strength and extent of effects depends on the quality and nature of the teams' dynamics, i.e. how relationships are formed and maintained or how committed stakeholders are to the process (Schäfer, Bergmann, and Theiler 2021).

4.2 *Methodological limitations and new avenues to explore*

Context can influence TDR projects in multiple ways, and the perceptions on this influence can also be multiple and operate at different scales, e.g. individual, team or stakeholders as well as funders or actors engaged in science policy. Thus, the analysis of 27 conceptual papers and 17 case studies can only present a fraction of perspectives on context in TDR. As shown in the introduction and throughout the paper, our work confirms or overlaps with other studies that are mentioning or dealing with context factors – as an example, our outer context factors generally align with how they are framed in other literature (Cockburn et al. 2020; Pärli et al. 2024; Odume et al. 2021; Schneider et al. 2022; Schoon et al. 2021). Some of the researchers from the case studies have confirmed and validated the conceptualisation of context factors as proposed in our framework, further indicating that it could be a valuable contribution to advancing a more systematic approach to context in TDR that is currently still missing in this rather comprehensive manner. We must, however, acknowledge that certain perspectives are not represented in our study:

First, perspectives on context in this study are biased toward scientific views. In this sense, we acknowledge that perspectives from practitioners or other societal actors involved in TDR projects would enrich the understanding of TDR context factors. Perspectives of practitioners are covered in a second upcoming paper of our project (Manuel-Navarrete et al. 2025). Second, the literature review's search string was developed in English, thus prioritising Anglophone science and authors, and generating a bias towards scientific knowledge from the Global North. Similar bias occurred with the selection of case studies, which was supported by Anglophone and German scientific platforms and research networks. Consequently, interviews were conducted in English and German. Future research should consider expanding the knowledge on context factors with non-Anglophone cases and literature as has been done in other research areas (e.g. Burke et al. (2023) for an example in biocultural approaches). Also, while it was intentional and purposeful for our concrete research, the fact that we strictly limited case sampling to those following a TDR approach according to Lang et al. 2012 (resulting in a rather small set of 17 cases), limited our scope of insights to a very specific set of cases.

Additionally, taking an exploratory approach to context created trade-offs. On the one hand, open-ended interview questions allowed interviewees to define in their own words what they considered context in their specific projects. On the other hand, the lack of an agreed upon common definition of context in TDR and the resulting varying perceptions on the meaning of the term, led to challenges differentiating between context factors and project process-factors.

Another crucial consideration beyond the scope of this paper is the question of transferability: how findings and approaches from one context-specific TDR project can be adapted and applied in other contexts. Our framework for context-sensitive TDR aims to provide a foundation for more effective and impactful projects; this can be used to further explore the mechanisms and conditions under which TDR results can be successfully transferred or scaled up.

Our approach sought to develop an integrative perspective on context, which can be further refined by researching on single context factors and relations between context factors. Furthermore, differences in the perceived relevance of context factors in different settings and research projects indicate that not all of them are equally important within a given project. A challenge for TD researchers is then to explore which factors are crucial to consider at which stages in their project. The analysis of the context factors in light of the ideal-typical TDR phases (Horcea-Milcu, Leventon, and Lang 2022; Lang et al. 2012) seeks to help TD researchers navigate this challenge.

5. Conclusion

Context sensitivity is vital for TDR to achieve the transformative outcomes it aims for. Context is always present, but studies show that TDR has, despite its good intentions, failed to address context sensitively (Chilisa 2020; Manuel-Navarrete, Buzinde, and Swanson 2021). To fill the gap of understanding context and mechanisms how context influences TDR (Schneider et al. 2022), we analysed which context factors influence TDR projects based on conceptual papers and empirical case studies. Especially with the empirical cases and specific questions we investigated how context is perceived and how context-sensitive research can be applied with the underlying mechanisms between context and the design, process, methods, and outcomes of the TDR projects. Our findings show that TDR often lacks sensitivity for its context due to (a) a lack of definition or synthesised basis of context for TDR, and (b) missing active reflection on how context could affect the TDR project. This holds true particularly in North–South research relationships, for example, when Indigenous or other academic approaches are involved. While this paper does not focus specifically on these differences in North–South collaborations and other types of collaborations (e.g. national collaborations), we propose a framework that highlights the importance of following a structured approach to understand context in TDR: Context-sensitive research requires consciously perceiving, understanding and reflecting context factors and their (possible) influences on a TDR project.

We therefore believe that our contribution of a systematic framework of nine context factors based on literature and empirical evidence helps to reflect on context factors that could shape the TDR process and outcomes. These factors can be closely related to the project internal dynamics and processes (inner factors) or more external factors (outer) and are also shaped by temporal and spatial dimensions. Understanding these factors, as well as their influence in the project's design, can guide TD researchers when setting up and conducting TD research that is context sensitive.

Importantly, this systematisation of context factors serves a dual purpose, functioning as both design and evaluation criteria for TDR projects. During the design phase for example, the context factors can be used as a comprehensive checklist to ensure all relevant contextual elements were considered. Similarly, these factors can serve as evaluation criteria throughout the project cycle and after its completion, allowing researchers and funders to assess how well a project has adapted to its specific context, how context factors have influenced outcomes, or where adjustments might be needed in future projects.

We shed light on the fundamental particularities of mechanisms in different TDR by providing specific examples, and believe that our proposed broader reflective questions and the discussion of how to apply context-sensitivity in different TDR phases invite the TDR team to reflect on their specific mechanisms.

We take this context-focussed approach to counteract research where solutions are being implemented given one identified attribute (e.g. establishing a new industry to encounter unemployment) but instead raising awareness to interlinked mechanisms and factors. We are aware that the nature of transdisciplinarity already involves actor analysis in its problem framing phase, but results show that a holistic understanding of place-specific factors (environment etc.) and team dynamics (seeing the researchers as part of the context) is necessary complementary to the actual focus topic of the research.

While this framework provides a valuable starting point for conducting context-sensitive TDR, future research should focus on testing its applicability across diverse case studies and exploring its potential to facilitate the transfer of knowledge and best practices between different contexts.

In the light of the limited resources many TDR projects have, we aim to support researchers to carry out context-sensitive TDR processes and to foster sustainability transformations. However, as other authors have acknowledged (e.g. Chilisa 2017), merely looking at the context factors as a checklist alone is not enough, and a continuous reflection on assumptions and practices must be an essential part of TDR. Further research should be done in investigating mechanisms of context on the design, process, methods, outcomes and impacts of TDR projects. Our approaches can be used as a basis to collect more detailed data on these mechanisms, for example by using accompanying research. Further endeavours could be developing easily applicable tools and routines that can pragmatically be implemented in TDR practice whilst acknowledging the contrasts in global contexts.

Notes

1. When referring to a project's outcomes, we include direct outputs (e.g. a product) as well as the generation of knowledge, improvements of a situation, and other learnings that can contribute to societal or scientific impacts (Mitchell, Cordell, and Fam 2015).
2. Similarly to Thomas, Weber, and Bradbury-Jones 2020, we use the terms Global South and Global North to refer to socio-economic and political inequalities and differences between the so called 'developed' countries (Global North) and countries formerly under colonisation (Global South), whilst acknowledging the diversity of realities within and among the respective countries.

Author contributions

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