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Opportunities, balancing acts, and challenges - doing PhDs in transdisciplinary research projects

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ABSTRACT

Doing a PhD in a transdisciplinary research (TDR) project allows early-career scientists (ECSs) to study innovative topics in socioecological systems and to apply methods involving the co-design and co-production of knowledge with practitioners. However, a series of interviews and a group discussion with ECSs involved in TDR projects revealed not only the benefits for career development but also a number of challenges and even risks related to working on such projects. We discuss the vital role of ECSs in sustainability science and the professionalization of TDR processes. To ensure fair conditions for these researchers, experienced supervisors who assume responsibility for ECSs in TDR projects are required, as is the acknowledgement of the twofold efforts of ECSs in TDR projects and support from scientific networks (e.g., Future Earth) to transform the academic system and build the careers of ECSs in sustainability science. Finally, it has been shown that the scientific discourse on TDR and sustainability science must pay more attention to the specific roles of ECSs and work conditions.

1. Introduction

In recent years, transdisciplinary research (TDR) that seeks to contribute solutions to environmental problems has become a promising approach in sustainability science. The attention to and application of TDR is often justified by its ability to grasp the complexity of real-world problems, integrate different viewpoints, enable mutual learning processes, provide socially robust orientations and thereby legitimize solutions for urgent sustainability challenges (e.g., Jahn et al., 2012; Lang et al., 2012; Pohl and Hirsch-Hadorn, 2008; Scholz and Binder, 2011). TDR is conducted in a variety of applied fields, including quite prominently, in the environmental sciences (Zscheischler and Rogga, 2015).

In academia, early-career scientists (ECSs), including postdoctoral scientists and PhD candidates, comprise a significant share of the workforce. With the increase in TDR projects, a rising number of PhD students seeks to complete the requirements for their scientific qualifications in these projects (see Lange and Fuest, 2016; Rothen and Parker, 2004). Working on a TDR project during a PhD allows ECSs to study innovative topics in socioecological systems and to apply methods involving the co-design and co-production of knowledge with practitioners.

However, empirical studies have shown that successful TDR processes are demanding and require a multitude of transdisciplinary skills and knowledge (e.g., Mitchell et al., 2015; Zscheischler et al., 2017). TDR is also associated with additional time costs related to involving both scientists and practitioners to acquire the reflexivity needed to facilitate mutual learning processes and to enhance knowledge integration (e.g., Fry et al., 2006; Wada et al., 2020; Zscheischler et al., 2014). Furthermore, in TDR projects, it is challenging to balance practical and scientific benefits (e.g., Zierhofer and Burger, 2007; Zscheischler et al., 2018).

These factors are likely particularly burdensome for ECSs who are developing their scientific reputation, learning how to do scientific work, and focusing on their scientific qualifications. As they often lack TDR experience when entering the qualification phase (see Schrot et al., 2020), the extent to which ECSs can adopt the transdisciplinary research approach remains an open question. On this basis, we argue that there is a need for the professionalization of transdisciplinary (research) processes, with a special focus on the situations and qualifications of ECSs within these projects.

To date, the conditions of ECSs in TDR projects are weakly reflected in the scientific literature. (Felt et al., 2013; Schönenberg et al., 2017). While the general body of knowledge on transdisciplinary research is rapidly growing, few empirical studies evaluate the challenges for ECSs

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doing their qualifications in TDR projects. In sustainability science, a small number of multiple-case studies have been published over the last few years that focus on the specific situation of ECSs in TDR projects (Holden et al., 2019; Jaeger-Erben et al., 2018; Patterson et al., 2013; Ruppert-Winkel et al., 2015). In addition, some articles discuss the challenges of ECSs in TDR projects as secondary aspects but not as the central topic (e.g., Klein and Falk-Krzesinski, 2017; Lange and Fuest, 2016; Newig et al., 2019). Other scholars have investigated the socialisation of ECSs in transdisciplinary projects (Felt et al., 2013) or developed a framework that supports PhD candidates when dealing with the challenges of doing "undisciplined" research (Haider et al., 2018).

The few available studies indicate that earning a scientific qualification in the context of a TDR project may present major challenges for ECSs (Jaeger-Erben et al., 2018; Moore et al., 2018; Patterson et al., 2013). They must qualify in an academic discipline while doing their research in project environments that are often considered "undisciplined" (Haider et al., 2018). Dilemmas exist between the demand for scientific excellence and practical relevance (Ruppert-Winkel et al., 2015), between practicality in the project and keeping time resources available for scientific work, and between heterogeneous topics and the desire to pursue one's own research interests (Fry et al., 2006; Lange and Fuest, 2016). In addition, there is evidence that ECSs who conduct their PhDs within TDR settings face competitive disadvantages in the current academic system (Felt et al., 2013; Klein and Falk-Krzesinski, 2017; Newig et al., 2019; Ruppert-Winkel et al., 2015), but the consequences of that development have not been examined.

These studies show multiple challenges for ECSs in TDR projects, but they have several limitations. Most of the studies are self-reflective and based on a subjective view (Holden et al., 2019; Jaeger-Erben et al., 2018; Patterson et al., 2013; Ruppert-Winkel et al., 2015). These studies focus on rather general challenges for ECSs in TDR projects and are partly characterised by specific conditions, such as the junior research groups from Germany, where TDR is usually an additional process but not the central approach. To date, there is no systematic study that involves diverse actor group perceptions and focuses on career implications.

The aim of this article is to narrow this gap and to systematically consider the role of ECSs in TDR projects and to present and reflect upon the experiences of PhD students, co-ordinators, and supervisors. Therefore, we focus on the conditions in third-party funded research projects in which ECSs appeared both in coordinating functions and as doctoral candidates. With this study, we seek to provide empirical evidence on the qualification conditions and the perceived career implications of ECSs who participate in large-scale collaborative research projects.

We wanted to know i) what the specific challenges, difficulties and benefits of doing a PhD in a TDR project are, ii) which strategies have proven successful for dealing with these challenges, and iii) what, in general, can be learned from these experiences or recommended to future PhD students doing their doctoral thesis in TDR projects.

2. Research design and methods

2.1. Case selection and access

To analyse the conditions faced by ECSs in TDR projects, we collected data from 22 transdisciplinary joint research projects. These projects were funded within the two German funding programmes "Sustainable Land Management" (2010–2015) and "Innovation Groups for Sustainable Land Management" (2014–2019). Both aimed to develop sustainability solutions for land use challenges in Germany. Project objectives included the development of innovative value creation networks for sustainable regional development, new instruments and resource efficiency concepts for settlement development, decentralised systems of renewable energies, and new technologies supporting sustainable land use systems. Each project was set to last between three and five years.

Application of the TDR approach was a prerequisite for funding, with the call for proposals explicitly referencing a TD concept to integrate knowledge from different disciplines (especially the integration of knowledge from "natural scientific-technological and economic-social scientific disciplines") and involving practitioners such as decision-makers and key actors.

The authors were members of an associated scientific coordination project (SCP) that accompanied these 22 joint research projects over a period of nine years. The SCP encouraged interaction and mutual learning among the members of these research projects and supported the identification and examination of cross-cutting themes. As one topic of focus was transdisciplinarity, the SCP initiated discussions and workshops addressing this issue. The SCP had no direct influence on the adoption of the TDR approach but presented the researchers with possibilities for reflecting TDR processes in their projects. The SCP also initiated and observed communication processes among project members regarding TDR. Hence, the conditions provided particularly valuable access to the field, and numerous informal discussions were complemented by insights from documents and multiple meetings. Hence, the case selection was strongly driven by the access provided via the SCP.

2.2. Research design

The research is based on a two-step research strategy that consists of (1) semi-structured interviews and (2) a group discussion with ECSs and senior scientists. We combined deductive and inductive research approaches, which means that both interviews and group discussion were structured and deductively analysed by considering theoretical pre-assumptions derived from a literature review and inductively analysed by formulating new categories and themes from the material.

2.2.1. Step 1: semi-structured interviews

Based on a set of 15 interviews, it was inductively determined that doctoral students encounter particular difficulties in TDR projects. Originally, we were interested in general difficulties and benefits when implementing TDR projects. We started by assuming that TDR is a social innovation in science and thus developed an analytical framework derived by reviewing the literature on the key principles of TDR and the factors that are important for the adoption and implementation of social innovations (see also Zscheischler et al., 2017).

This framework deductively guided data collection and analysis in the first step. We conducted semi-structured interviews with co-ordinators, doctoral supervisors and ECSs at the end of the first 13 TDR projects (within the Sustainable Land Management funding programme from 2010 to 2015). The interviews took place between September 2015 and November 2015 and focused on the practices and difficulties of implementing TDR in projects. We chose this point in time at the end of the projects to gain a comprehensive view of the experiences. Interviews focused on the following themes: definition of transdisciplinary research; design and implementation of transdisciplinary processes; benefits and difficulties of working on TDR projects; and general attitude towards the approach and impact assessment.

All interviews were fully transcribed and evaluated and interpreted according to the guide of qualitative content analysis from Kuckartz (2014). Data processing was performed using MaxQDA software. The analysis is based on an iterative deductive-inductive research strategy. In the first step, we coded the data deductively by applying categories derived from the literature (see above). In the second step, additional inductive categories were derived from the material. We thus refined the category system for the material via coding (preferentially using in vivo codes) and paraphrasing. Further themes were derived through an iterative rereading process, following the recommendations of Ryan and Bernard (2003) (cit. after Bryman, 2016). We iteratively generalised and reduced the analysis corpus by using the case summary technique

(Kuckartz, 2014).

The analysis revealed that the challenges faced by PhD students were important issues in TDR projects. The results of the interviews are supported by direct quotes (Q n) from interviewees (ECS, coordinators, supervisors) and projects (Pn). Illustrative and concise quotes were selected (see results in section 3.1).

2.2.2. Step 2: group discussion

In the second step, informed by the analysis of the interviews, we organised a group discussion within a two-day conference to deepen our insight into the working conditions and challenges of ECSs in TDR projects. Group discussions are used to observe communication and negotiation processes, as well as conflicts and consensuses within social groups. They enable access to collective experiences and orientations that depict commonly shared and implicit knowledge (Bohnsack, 2004). However, we chose this method, not only to collect data, but also because group discussions enable mutual learning and reflection.

The group discussion took place in February 2019 at the end of a five-year funding period for nine TDR projects of the second funding programme "Innovation Groups for Sustainable Land Management" (2014–2019). As with the previous interviews, we chose this point of time so that the projects and experiences could be comprehensively considered.

Approximately 30 PhD candidates and supervisors participated in the group discussion, which was deductively structured along a set of key questions on (1) perceived tasks and responsibilities, (2) resulting competencies, capacities, and skills, (3) benefits, and (4) difficulties faced by PhD students in TDR projects. In addition, we asked about (5) strategies for coping with challenges and (6) recommendations for future generations of PhD students in TDR projects.

To analyse the group discussion, we used qualitative thematic analysis and restricted our analysis to the inherent meaning of arguments (Kuckartz, 2014). During the event, the main themes of the discussion were visualised and documented through an inductive procedure that involved collective coding within the group. The group discussion was transcribed by two assistants, and after the event, we coded the transcriptions to complement the results of collective coding. Finally, we summarised the results in a report that was sent to all participants via email for validation.

3. Results

3.1. Results from interviews

Besides challenges such as funding conditions, academic structures and cultures that do not integrate well with TDR projects, the interviews also revealed "career opportunities for ECSs" as a major issue. This issue was found through inductive coding in about half of the interviews.

Interviews revealed that the consequences of doing a PhD in TDR projects are ambiguous: while TDR can have advantages for a career outside of science, it is an obstacle to a career in science. Working on transdisciplinary projects was perceived as beneficial for a career in practice, as practical experience can be gained and relationships with potential future employers could also be established:

> Q1: *"My education-related practice at the university was low, and therefore, through my work on the TDR project, I have gained so much study-related practical experience that now that I am back in the application process, I am getting very good feedback from potential new employers."* (ECS_P1)

> Q2: "*Doctoral theses are still open. However, some have also gone into industry and can show that they have worked on a project with a strong focus on implementation. That also has advantages."* (Coordinator_P2)

However, transdisciplinary work has been classified as an obstacle to a career in science. One reason for this perspective is the time required for doctoral theses within TDR projects. Most of the doctoral projects were not completed after five years (see also Q2). In addition, the scientific quality of doctoral theses based on transdisciplinary projects was critically evaluated. For example, according to one supervisor, the scientific quality of the doctoral thesis of his doctoral student was just acceptable:

> Q3: "*For example, my PhD student has become an energy consultant at the county level. For her, this [TDR project] was an ideal terrain to learn from different disciplines. With the doctoral thesis, it just about worked out so well that one could accept it. However, you could also accept it because you knew that she would not proceed in science… not in hard science, at least, which leads to a university career or something similar. In addition, that is actually good. Yes, one learns to be a scientist and gets the title, and rightly so. It is tested quite normally, like all other things. However, you also see the horizon. It does not go on in science."* (Professor/Supervisor_P3)

Independently, a doctoral student from another project came to a similar conclusion:

> Q4: *"After the three years, if I had not been able to stay in the academic field now, I would have had to do papers to formally do my doctorate, and the quality of this dissertation would not have been so good then."* (ECS_P1)

The high proportion of additional activities and the high organisational effort for the implementation of practice-relevant activities in transdisciplinary projects is considered to be at the expense of scientific work, resulting in lower publication output:

> Q5: *"It was tough, specifically with the PhDs, in part. If there is simply no time left for scientific research, because organisationally it depends on the implementation, then everything else costs time."* (Coordinator_P2)
> Q6: *"People keep asking why you do not publish enough. Because you do not do enough scientific work, that is one point. You cannot publish scientifically."* (Coordinator_P4)

These findings were generated inductively and can be described as unexpected insofar as "career opportunities from ECS" in TDR projects were not part of our semi-structured interview guide. Therefore, we took the opportunity to examine the topic in depth in a group discussion with ECSs and supervisors.

3.2. Results from group discussion

Fig. 1 provides an overview of the results from the group discussion as a category tree with selected statements from attendees.

3.2.1. Tasks and responsibilities of PhD students in TDR projects

The tasks carried out by most doctoral students in the projects were broad and covered almost all facets of facilitating and organising TDR processes and results in addition to core scientific work. These included project management tasks (such as budgeting, time management, target negotiation, and publication planning) and direct cooperation with the practice partners in the TD research processes (e.g., acquisition, product development, communication). According to PhD doctorates, the amount of time required for these extra tasks varied from project to project, depending on the tasks delegated by superiors. Nevertheless, most discussion attendees claimed to carry out multiple tasks and have multiple responsibilities for the project that were not strictly connected to the content of their PhD thesis (Fig. 1, Q7).

3.2.2. Competencies, capacities, skills and further benefits

Corresponding to their extensive responsibilities, the PhD students reported gaining a broad spectrum of additional skills during the five-year project period and claimed that these skills were a major advantage associated with the TDR project. Thus, in general, discussion group

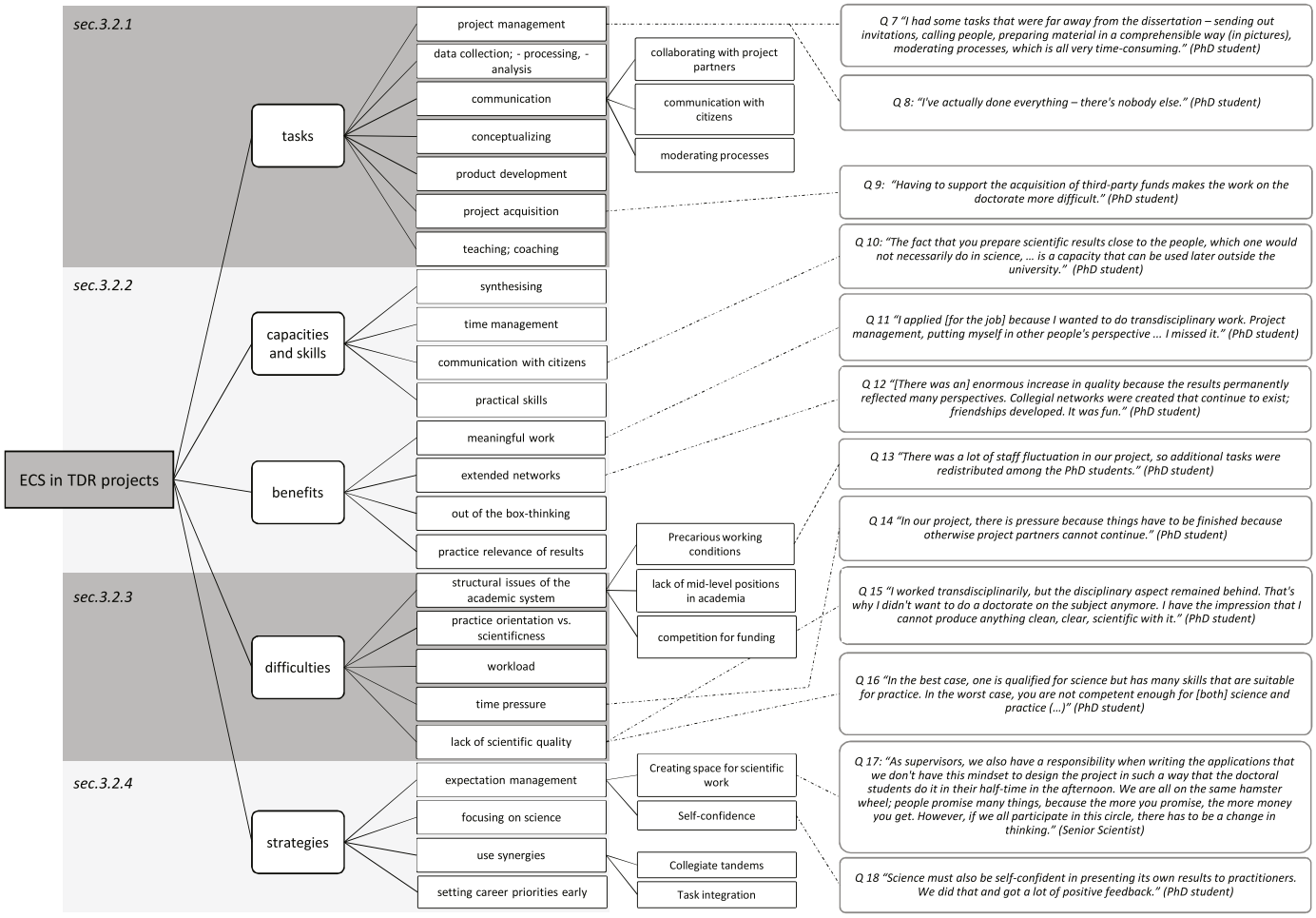

Fig. 1. Codes and selected arguments from the group discussion.

attendees had a positive perspective on their experiences with TDR projects (Fig. 1, Q12).

The attendees claimed that the added skills are often needed for innovation and transdisciplinary processes. These skills included soft skills, especially those required to communicate (with project partners and with citizens) and "translational work" (between disciplines, from science to practice and vice versa), and research result synthesis skills.

The PhD candidates reported expanding their professional networks significantly and learning how to signal their market value in the non-academic job market through collaboration with practitioners. This statement was supported by interviewees (see Q1) and group discussion attendees alike (Fig. 1, Q10). One attendee reported on fellow colleagues in the project who had been poached by project partners prior to the final project stage. The proximity to practice partners was also reported to facilitate the acquisition of interview partners and filter the relevance of early-stage ideas.

In addition, the wide range of practice-oriented activities made it possible to satisfy the individual desire of many doctoral students to advance the societal impact of their research and to broaden their disciplinary perspective.

3.2.3. Challenges and trade-offs

Many of the challenges can be summarised by three generic terms: work overload, a perceived deficit of scientific quality, and pressure to generate output.

Since the doctoral students were assigned coordinative and management-related tasks, the attendees stated that they were often unable to carry out the activities for which they were employed. Accordingly, the workload exceeded the working hours stipulated in the employment contract (Fig. 1, Q13).

The practical orientation of TDR projects, which was praised in terms of individual capacity building, appears to come with trade-offs for scientific quality from the perspective of the interviewees (Q3) and the group discussion audience (Fig. 1, Q15). In some cases, the doctoral students had to prioritise the practical tasks of the project over their research data quality requirements and their original scientific interest. Some PhD students experienced pressure to "get things done" without in-depth scientific inquiry. For some participants, this led to the production of what they perceived as low-quality research results in addition to a generally reduced publication output within TDR projects.

Even if doctoral students complete their dissertations, the hybrid nature of TDR can cause a reputation problem for those seeking to pursue academic careers (Q4). Concerns were voiced that the results were not "competent enough for science" to continue an academic career (see Fig. 1, Q16).

3.2.4. Strategies and desired future improvements

The participants discussed strategies and proposed solutions that address different aspects of the scientific system. At the individual level, attendees stressed the importance for doctoral candidates to confidently demand time to allocate toward their academic qualifications and presentations, even if this causes conflicts in the project. The importance of presenting the dissertation and scientific results to practice partners to raise awareness of and appreciation for PhD work was also mentioned (Q18).

In addition, the attendees stated that defining the topic of the

dissertation as early as possible (given the requirements of a transdisciplinary problem framing process) was crucial for success. This point underpins the importance of a productive relationship between supervisors and PhD students, which was highlighted by students and senior scientists alike during the group discussion. It was claimed that supervisors should communicate openly and early on with PhD students about the specific conditions of TDR projects to benefit both the project and the PhD student. Collaboration with postdocs and PhD students was described as supportive, as were data collection procedures that take both practical and scientific concerns into account.

It was mentioned that supervisors and project designers should initiate projects suitable for PhD research as early as the application phase. Here, the current trend of bidding competitions between scientific institutions for third-party funding was cited as counterproductive (see Fig. 1, Q17), implying that it is the responsibility of research funders (or application reviewers) to pay attention to PhD-friendly project proposals and demand adjustments if TDR projects impose unrealistic demands on doctoral students.

In summary, the results from the interviews and the group discussion showed that doing PhDs in transdisciplinary projects are viewed rather critically by both doctoral students and senior scientists with regard to academic career opportunities. However, interviewees were generally positive about the experience and rated the skills gained in the TDR projects as useful for their personal development and their professional career. Possible starting points for meeting the various challenges necessary to change the processes of the scientific system varied based on the individual PhD scientist.

4. Discussion and implications of results

4.1. The two sides of doing a PhD in a TDR project

Our results show that being part of a TDR project results in several sources of ambiguity for ECSs. First, ECSs can improve their chances in the labour market outside academia through proximity to practitioners (Lange and Fuest, 2016). While working on TDR projects, PhD candidates not only expand their professional networks but also gain valuable skills (see also Felt et al., 2013). As most PhD holders leave academia after receiving their qualification (Fry et al., 2006), this can be regarded as a vital advantage for many ECSs.

The arrangement of large, collaborative TDR projects that are constructed around real-world problems leads to broad problem-focused knowledge that stands out from disciplinary specialisation and can lead to a competitive advantage in the labour market (Lange and Fuest, 2016). In general, the results and knowledge gained are practically relevant, which is beneficial for ECSs who want to contribute to sustainable transitions and perform meaningful work (Felt et al., 2013).

However, ECSs face multiple challenges, such as the overload of demands from tasks that are not related to scientific qualification. ECSs must also confront a high degree of uncertainty due to the real-world approach and an increased dependence on external factors that might influence a TDR project. We can support the empirical findings of scholars who identified a higher risk for uncompleted PhD theses within the time frame of TDR projects compared to monodisciplinary projects (e.g., Fry et al., 2006; Newig et al., 2019). Similar results exist in studies on interdisciplinary ECSs, which provide evidence that students starting on interdisciplinary career tracks have more difficulty finding jobs within academia and publish less than students graduating in conventional, disciplinary subject areas (Bridle et al., 2013; Leahey et al., 2017; Rothen and Parker, 2004).

Thus, the increased practical relevance of TDR seems to come at the expense of scientific performance and influences reputation (Haider et al., 2018). This phenomenon cannot be reduced to ECSs only but to TD researchers in general. This struggle between societal and scientific relevance in TDR projects has been identified before (Newig et al., 2019; Zierhofer and Burger, 2007; Zscheischler et al., 2017), revealing that scholarly needs may fall to the wayside in TDR projects, as they seem to be difficult to balance, even for experienced researchers (Zscheischler et al., 2018). However, it must be acknowledged that the specific project context and conditions play important roles in how these difficulties manifest.

4.2. Fair conditions for ECSs require transparency and responsible and qualified supervision

Due to the specific conditions and observed challenges of ECSs in TDR projects, as shown in our study, supportive measures are necessary. However, these challenges were not addressed by well-tailored instruments of support. In contrast, ECSs increasingly assumed the responsibilities of lacking mid-level staff, and as low-cost labour, they often bore a significant workload of TDR projects, which they were often not credited for on their academic resume. Thus, job requirements and consequences for PhD candidates must be presented transparently. It needs to be communicated to the ECS at the start of the TDR project that participating in such projects creates interesting opportunities but invokes considerable risks to academic careers (see also Felt et al., 2013; Newig et al., 2019) as long as inter- and transdisciplinary research remains weakly institutionalized in the academic system.

Experienced supervisors and project design surely play a key role (Fry et al., 2006; Holden et al., 2019), and supervisors must assume responsibility for ECSs to create synergy and clarify the division of labour within the research team (Newig et al., 2019). To our knowledge, PhD-sensitive transdisciplinary project design has not been widely investigated (Lange and Fuest, 2016), but it should, among other issues, entail risk-minimising strategies (e.g., labour division and unwinding interconnected work packages), collaboration between experienced scientists and ECSs (preferably in the same working unit), multipurpose data collection events, and flexible individual ECS research plans. The latter should ensure that a scientific investigation by doctoral candidates is guaranteed even if the actual TDR process is endangered by external influence.

In reaction to the workload issue, Lange and Fuest (2016) suggest relieving doctoral candidates from project management-related tasks unless they choose to participate on a voluntary basis (2016:33). We think this policy could lead to inherent conflicts within TDR teams. Instead, we suggest that ECSs and their mentors should reserve fixed time slots during which a PhD candidate can work on his or her thesis, as suggested in the group discussion in this study. This strategy, however, still requires time resources for the qualification process.

Currently, the additional time demands for a doctorate in TDR projects are poorly understood. We support Lange and Fuest (2016) in their proposal to extend the time frame of TDR-related PhD projects to a "4–5 year duration" (ibid: 33), not only due to such projects' twofold practical and scientific objectives, but also to stay flexible and mitigate risks resulting from the real-world approach of TDR.

4.3. Strengthening sustainability science requires new academic structures

Sustainability science still needs to be strengthened and sustained in academic structures (Schneidewind et al., 2016). In this context, the qualification of ECSs plays a central role (Moore et al., 2018). Highly skilled and motivated leaders who are able to combine scientific excellence with transformative ambitions are required not only as practitioners but also as scientists. Currently, there are fewer permanent positions for sustainability scientists than there are positions in established disciplines. As long as reputation is predominantly based on bibliometrics and third-party funding, ECSs from TDR projects will remain uncompetitive, which essentially forces these ECSs to leave academia after completing their doctorates, resulting in a brain drain among TDR and integration experts and a permanent undermining of sustainability science and its ongoing professionalization. This is especially problematic because empirical studies have shown a lack of

professionalization and knowledge among scientists for addressing the challenging processes of TDR (Zscheischler et al., 2017).

Under the specific conditions and demands imposed on ECSs in TDR projects, one reasonable option could be to consider the introduction of a doctorate in transdisciplinary sustainability research. The academic system already differentiates between different types of doctorates, such as practice-led or professional doctorates, in addition to research doctorates following the Humboldtian model that exist in parallel (Taylor et al., 2018). TDR is widely accepted as one of the central approaches in sustainability science. In addition to a scientific qualification, the approach demands additional skills and knowledge to engage in moderation, process facilitation and knowledge integration. These efforts should be acknowledged as merits. It is conceivable that the performance of an ECS in a TDR project could compensate for a certain number of publications. As an example, a concept and/or documentation of a transdisciplinary process could be accepted as substitute.

Finally, we claim that, so far, the role of ECSs in TDR projects and in the future development of sustainability science has not gained much attention. However, this role should be a central issue for all who want to strengthen sustainability science and TDR. Scientific networks such as Future Earth should set the agenda and provide paths for this discourse.

4.4. Methodological reflection

This study combined qualitative semi-structured interviews with a group discussion. Both data collection procedures took place at the end of the projects. This timing should be considered. Most group discussion attendees were employed on a temporary, project-based contract during their final year. As Felt et al. (2013) pointed out in their study, the perception of risk among PhD candidates is most obvious toward the end of the PhD phase when the next career hurdle has to be cleared. Since studies on the motives of young researchers show that ECSs are dissatisfied with career opportunities and job security in general (Ates et al., 2011; Hauss et al., 2015), concerns about their own professional future regardless of transdisciplinary research design may have influenced our results. Therefore, further investigations should apply comparative approaches to the conditions of ECS in transdisciplinary, interdisciplinary, and monodisciplinary projects.

5. Conclusions

To date, little attention has been devoted to the specific challenges but also inherent merits of ECSs in TDR projects and the implications for career development. The results of interviews and a group discussion have shown that ECSs often play central roles in TDR projects, contributing to project management and TDR processes far beyond the typical scientific qualification of a doctorate programme. Additional tasks often result into new competencies, capacities and skills and, thus, may benefit ECSs in their career development outside academia.

However, results also revealed that doing a PhD in TDR projects invokes considerable risks for a career in academia. This is collectively perceived as a general challenge of TDR by ECSs, project coordinators and supervisors. Still, there are multiple challenges, such as demand overload, time pressure, and a potentially higher risk of failure.

These challenges have not yet resulted in significant improvements by means of tailored supporting measures for ECSs in TDR projects. In this regard, we suggest some structural adaptations such as the introduction of a transdisciplinary doctorate in sustainability science. We also sense potential for improvement in PhD sensitive project design in large-scale collaborative research projects and suggest project management instruments that facilitate working conditions of ECS.

In general, we argue that the specific conditions faced by ECSs in TDR projects are important when we want to (1) assume responsibility for ECSs in a highly competitive academic system, (2) ensure high-quality education and the professionalization of TDR processes and (3) strengthen sustainability research within academic structures. We conclude that the scientific discourse on TDR must devote more attention to the specific role and work conditions of ECSs in TDR projects.

Author contributions

Both authors contributed equally. They developed the concept and research design together, collected and analysed the data, and wrote the manuscript.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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