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Utilization of research knowledge in sustainable development pathways: Insights from a transdisciplinary research-for-development programme



J. Jacobi^{a,b}, A. Llanque^c, S. Bieri^a, E. Birachi^d, R. Cochard^e, N. Depetris Chauvin^f, C. Diebold^a, R. Eschen^g, E. Frossard^h, T. Guillaume^{i,v}, S. Jaquet^a, F. Kämpfen^j, M. Kenis^g, D.I. Kiba^h, H. Komarudin^k, J. Madrazo^l, G. Manoli^m, S.M. Mukhoviⁿ, V.T.H. Nguyen^e, C. Pomalègni^o, S. Rügger^p, F. Schneider^a, N. TriDung^q, P. von Groote^r, M.S. Winkler^{s,t}, J.G. Zaehring^a, C. Robledo-Abad^{u,*}

^a Centre for Development and Environment, University of Bern, Switzerland

^b Institute of Geography, University of Bern, Switzerland

^c University of San Simón, Cochabamba, Bolivia

^d International Center for Tropical Agriculture (CIAT), Rwanda

^e Institute of Geography and Sustainability, University of Lausanne, Switzerland

^f HES-SO, Haute Ecole de Gestion de Genève, Switzerland

^g CABI, Switzerland

^h Group of Plant Nutrition, Institute of Agricultural Sciences, ETH Zurich, Switzerland

ⁱ École Polytechnique Fédérale de Lausanne EPFL, School of Architecture, Civil and Environmental Engineering ENAC, Laboratory of ecological systems ECOS, Switzerland

^j University of Lausanne, Switzerland

^k Center for International Forestry Research (CIFOR), Indonesia

^l Geographic Information Systems Laboratory, EPFL, Switzerland

^m Department of Civil, Environmental, and Geomatic Engineering, Institute of Environmental Engineering, ETH Zurich, Switzerland

ⁿ Department of Geography and Environmental Studies, University of Nairobi, Kenya

^o National Agricultural Research Institute of Benin (INRAB), Benin

^p Department of Humanities, Social and Political Science, ETH Zurich, Switzerland

^q Consultative and Research Center on Natural Resource Management (CORENARM), Viet Nam

^r Institute of Social and Preventive Medicine (ISPM), University of Bern, Switzerland

^s Department of Epidemiology and Public Health, Swiss Tropical and Public Health Institute, Basel, Switzerland

^t University of Basel, Switzerland

^u Transdisciplinarity Laboratory (D-USYS TdLab), Institute for Environmental Decisions, ETH Zurich, Zurich, Switzerland

^v Swiss Federal Institute for Forest, Snow and Landscape Research (WSL), Switzerland

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ABSTRACT

This study contributes to the ongoing discussion on how to attribute and evaluate the contribution of transdisciplinary research to sustainable development. As co-created knowledge is a key product of transdisciplinary research, we tested the hypothesis that the extent to which this knowledge is utilized beyond the project consortia, in different areas – from scientific methods and insights to policy decisions – and across a continuum of geographical scales can be used to identify potential impact pathways. For this purpose, we developed an analytical framework that links the transdisciplinary process to six possible utilization stages, which we used as indicators of the usability of co-created knowledge. We gathered data from 22 research projects active in 36 countries using a survey and semi-structured interviews. Our results show that even during implementation of the projects, co-created knowledge is utilized by multiple actors at different stages, in all areas and at all scales simultaneously, suggesting multiple impact pathways. Project knowledge is predominantly utilized for national-level policymaking, and research partners named *co-creation of knowledge with key stakeholders* as the most frequently used mechanism for promoting knowledge utilization. Closer analysis revealed different understandings of and approaches to knowledge co-creation. These can be linked to weaker or stronger definitions of transdisciplinarity. The analysis shows that researchers using strong transdisciplinarity approaches typically face challenges in encompassing multiple epistemologies and facilitating dialogue. Some results suggest that inclusion and collaboration in co-creating knowledge can empower actors otherwise excluded. Our research shows

* Corresponding author.

E-mail address: carmenza.robledo@usys.ethz.ch (C. Robledo-Abad).

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that although transdisciplinary projects have nonlinear impact pathways, these can be partially assessed using the proposed analytical framework. Further, our results indicate a link between usability, inclusion, and collaboration in transdisciplinary research. We conclude with the observation that transdisciplinarity and its requirements still need to be better understood by actors within and beyond the research community.

1. Introduction

The effect of research projects on sustainable development pathways is a matter of ongoing debate in the context of development cooperation (Wiek et al., 2012; Brandt et al., 2013; Miller et al., 2014; Schneider and Buser, 2018). This is partly because, during the last decades, an increasing share of so-called official development assistance has been invested in research for development. Although the debate demonstrates agreement about the urgency of understanding the effectiveness of these investments, there are multiple – and often contradictory – views on how to define, attribute, and evaluate results and outcomes of research-for-development projects (Spreckley, 2009; Belcher and Palenberg, 2018). In addition, there is a lack of contextualized studies about science-based mechanisms that facilitate positive sustainable development outcomes (Nutley et al., 2007; ESRC, 2011; Zaehring et al., 2019).

The role of science in achieving sustainable development has long become a concern for governments and public sectors, and the contribution of participatory research to transformative processes is the subject of ongoing debate (Archibald et al., 2016; Thornton et al., 2017). Transdisciplinary research is one of the answers that the scientific community provides for addressing this challenge. Transdisciplinary approaches aim at increasing the relevance, credibility, and legitimacy of scientific research by securing the active participation of non-academic actors in research (Russell et al., 2008; Archibald et al., 2016; Basche et al., 2014; Bunders et al., 2010; Basche et al., 2014; Thompson et al., 2017; Hansson and Polk, 2018). But a clear attribution of transdisciplinary projects' contributions to or impacts on development pathways is a serious challenge (Thompson et al., 2017; Belcher and Palenberg, 2018; Schneider and Buser, 2018; Matenga et al., 2019).

Aiming to contribute to this debate, we analysed the utilization of co-created knowledge by different stakeholders as a proxy for understanding the transformative capacity of co-created knowledge generated by 22 research projects implemented by transdisciplinary consortia in 35 countries in Africa, Asia, and Latin America. All projects included in the analysis are part of the Swiss Programme for Research on Global Issues for Development (r4d programme), a ten-year research programme that supports transboundary, partnership-based inter- and transdisciplinary research with a focus on low-income and middle-income countries. The projects in the r4d programme are grouped into six thematic modules: Ecosystems Management, Food Security, Public Health, Employment, Social Conflict, and an thematically open module. The question at stake is thus whether there is evidence showing how co-created knowledge is being utilized, in which areas, at what scales, and through which mechanisms.

2. Methods: analytical framework, data collection and analysis

2.1. Analytical framework

Transdisciplinary research is gaining recognition for helping to solve current sustainability challenges (Levesque et al., 2019). To achieve that aim, transdisciplinary research is problem-oriented and combines scientific cooperation between different disciplines (interdisciplinarity) with the participation of different types of actors in the creation or production of knowledge (Hirsch Hadorn et al., 2006; Wiek et al., 2012; Miller et al., 2014; Polk, 2015).

For the purpose of this analysis, we understand societal impact as long-term social, cultural, environmental, and economic returns or

benefits from research results or products of publicly funded research that lead to sustainability transformations (Bornmann, 2013). Thus, societal impacts include transformations both within the project sphere and beyond it, in the sphere of the wider social-ecological system (see Fig. 1).

Co-creation or co-production of knowledge is a key characteristic of transdisciplinary research and can be understood as a process in which the knowledge of different actors is brought together and which is designed to facilitate decision-making processes (Bunders et al., 2010). Polk (2015:111) describes transdisciplinary knowledge co-production as “a research approach targeting real life problem solving. Knowledge is co-produced through the combination of scientific perspectives with other types of relevant perspectives and experience from real world practice including policy-making, administration, business and community life”. Schneider et al. (2019) propose that transdisciplinarity is a mode of knowledge production that has an inherent potential for contributing to societal transformation. As knowledge co-creation and knowledge co-production are often defined in similar ways, we use the two terms interchangeably in this article. Knowledge co-creation involves the participation of non-academic actors in the research process – not just as mere informants but as active stakeholders, and preferably from the very outset of the project, which includes the negotiation and agreement of research questions and activities. Consequently, we understand the term “researchers” to include all academic and non-academic actors co-creating knowledge in a transdisciplinary research project. The earlier non-academic actors participate in the knowledge co-creation process, and the more empowered their participation is, the stronger is the project's understanding of transdisciplinarity; by contrast, the mere consultation of different stakeholders on conditions set by academic actors indicates weaker understandings of transdisciplinarity (see Krüti et al., 2010; Jahn et al., 2012).

Transdisciplinary approaches are often guided by a normative understanding of research (Pohl et al., 2017). Jahn et al. (2012) propose

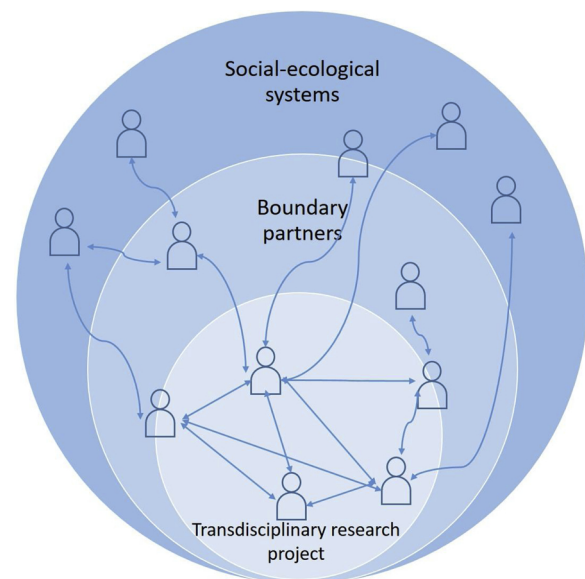


Fig. 1. Societal impacts of transdisciplinary research projects reach beyond the project sphere (based on Schuetz et al., 2017). Actors in the sphere of transdisciplinary research projects include academic and non-academic actors.

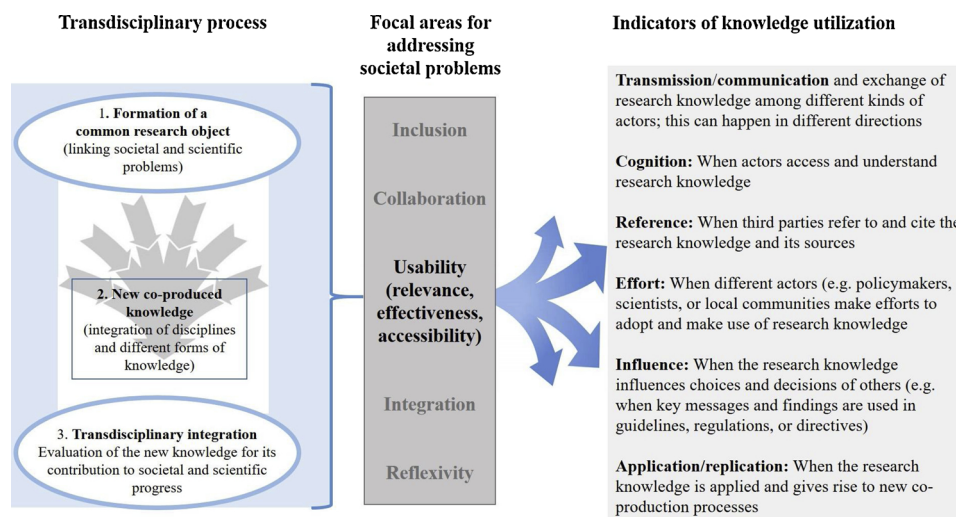


Fig. 2. Analytical framework used in this study combining a transdisciplinary process (based on Jahn et al., 2012) with focal areas (based on Polk, 2015), and indicators (“stages”) of knowledge utilization (based on Landry et al., 2001).

an ideal transdisciplinary process that combines societal views and values with scientific problems, discourse, and practice. The process includes three main phases: the formation of a common research object, production of new knowledge, and transdisciplinary integration (Fig. 2, left part).

Polk (2015) proposes five focal areas for addressing scientific and societal problems through transdisciplinary research: inclusion, collaboration, usability, integration, and reflexivity. Usability focuses on the relevance, effectiveness, and accessibility of research knowledge for participants and other user groups; and the different actors reflect on usability throughout the research process. As co-created knowledge is a key output of transdisciplinary research (Hirsch-Hadorn et al., 2006; Mobjörk, 2010; Pohl, 2008), understanding the extent to which this knowledge is later used or leads to new processes of knowledge co-creation appears to be a meaningful way of obtaining first indications of direct and indirect project impacts on transformation.

To answer the first part of our question – whether and how research knowledge from the examined projects is being utilized – we adapt the six stages of knowledge utilization proposed by Landry et al (2001): transmission, cognition, reference, effort, influence and application (Fig. 2, right side). Although initially proposed as a “ladder”, we use the six stages as a nonlinear set of indicators, since several stages may occur simultaneously depending on the context conditions. In addition, the concept of unidirectional “transmission” seems at odds with knowledge co-production processes in transdisciplinary research. For example, Rist et al. (2006) show that, beyond knowledge transmission, the actors involved must engage in a social learning process and develop a common goal and meaning in order for the co-created knowledge to contribute to societal change. However, acknowledging that “transmission” of knowledge happens in different ways within and beyond research projects, we conceptualize the transmission process as “communication and exchange of research knowledge” happening in different directions and among all kinds of actors, including beyond the transdisciplinary research consortia.

As we built up an inductive process, we did not limit the question to “scientific” or any other specific definition of knowledge, but kept the analysis open for any type of knowledge co-created during the transdisciplinary research projects. Although we share the wide definition of scientific knowledge as “part of its wider societal, cultural historical and ‘natural’ environments rather than somehow independent of them” as suggested by Schneider et al. (2019:2), we are aware that not all co-created knowledge needs to be characterized as “scientific” (Jahn et al., 2012). Nevertheless, as all co-created knowledge can potentially be used in

societal transformations we did not limit the analysis to co-created “scientific” knowledge.

In order to achieve more nuanced insights into possible impact pathways, we additionally differentiate between three potential areas and five possible scales of utilization. The potential areas of utilization were defined aligned with the objectives of the programme under study. These areas are: design or improvement of scientific methods or tools, generation of scientific insights, and informing policymaking. With regard to scale, Sheppard (2002) and Rangan and Kull (2009) have described the sociopolitical construction and the dynamic interaction of local and global scales in a spatial continuum. For practical reasons related to the projects’ design, we differentiated between five geographical scales – local, subnational, national, regional, and global – and asked respondents to describe the role of scale and how it was used in the project.

We further wanted to assess possible connections of mechanisms that the projects used to focal areas other than usability (e.g. inclusion or collaboration), to see whether they enhance knowledge utilization. Therefore, we complemented the analysis of stages of knowledge utilization as indicators of impact pathways with an assessment of the perceived usefulness of eight mechanisms for promoting knowledge utilization, identified through a portfolio analysis of the projects included in the r4d programme. These mechanisms are: personal contact/training with key agents of change; co-creation of knowledge with key stakeholders; training of key stakeholders; publishing in scientific journals; presentations at conferences; non-scientific publications such as policy briefs or reports; exchange platforms created by the projects; and other exchange platforms.

2.2. Data collection and methods of analysis

Data collection was organized in two steps. First we did a survey to obtain quantitative data on the stages of knowledge utilization, and second we conducted semi-structured interviews providing qualitative information on knowledge co-creation. At the time of our research, the r4d programme had 46 ongoing projects. The online survey was administered to all, and we obtained responses from 22 projects (one from each project). This represents 47% of the projects active within the r4d programme at the time of the survey, and 86% of the total research funds. Nineteen projects (86% of the sample) included two phases of three years each and were between the middle of phase one and starting phase two. The other three projects had only one three-year phase and were nearing completion. Using ongoing projects allowed us to identify

utilization of co-created knowledge from the moment when integration starts to happen, thus linking utilization of research knowledge to the transdisciplinary research process as proposed by Jahn et al (2012). However, given that projects were still ongoing, our results must be understood as indicative of emerging impact pathways. Respondents were principal investigators, project coordinators, or postdocs involved in the given project.

In the survey, we asked respondents to characterize any utilization of knowledge in the project sphere (see Fig. 1) according to the three areas – design or improvement of scientific methods and tools, generation of scientific insights, and inform policymaking – as well as the six stages of utilization (of which we provided definitions) and the five scales. We also asked whether utilization had been documented. Additionally, we asked respondents about the experienced usefulness of mechanisms for promoting knowledge utilization (see 2.1). The survey enabled us to identify commonalities and differences with regard to what co-created knowledge (in terms of areas) is being used at which utilization stages and at which scales, and to elicit the respondents’ perceptions regarding the usefulness of different impact mechanisms. We analysed the responses using descriptive statistics.

In order to improve understanding regarding links between the survey results and focal areas other than usability as described by Polk (2015), we conducted semi-structured written interviews with senior researchers and project coordinators of the projects that had responded to the survey. We received a total of 15 answers from all six modules (see Table S1 for a list of participating projects). We asked respondents to provide in-depth information about utilization of knowledge from the project by different stakeholders and – if applicable – at multiple scales. The interviews were organized into three parts. The first concerned the mechanisms that facilitate knowledge utilization, particularly co-creation of knowledge with key stakeholders. The second part focused on concrete examples of knowledge utilization at different scales, including a description of challenges faced. The third part was devoted to knowledge utilization in different areas; we asked to what extent the knowledge was being utilized, and what prospects the respondent saw for its future utilization. We analysed the interviews by means of qualitative content analysis (Mayring, 2007; Kaefer et al., 2015); for coding and analysis we used Nvivo 12 Pro software. Quotes are kept anonymous in order to avoid associations with specific modules or research topics, as the sample was not designed to represent those categories.

3. Utilization of knowledge produced in a North–South research programme

3.1. Survey results

The findings of the survey across all modules indicate that most projects have produced either *new or improved scientific methods and tools* (82%) and/or brought *new insights to science* (68%), although documentation is still relatively low to medium (40% and 53% of the projects, respectively). Utilization of knowledge from the projects is more frequent along all stages for *new scientific methods and tools* than for *bringing insights to science*. When it comes to *bringing insights to science*, utilization is highest at the stages of transmission, cognition, and reference. In both cases, the most relevant scales are the national and the global (Fig. 3).

Over two thirds of the projects reported utilization of knowledge from the projects in policymaking (68%), although these effects had only been documented in publications or reports in 27% of the cases (see Fig. 4). The knowledge has been utilized in policy discussions or agreements, mainly at the national and subnational levels; transmission/communication, cognition, and reference were the most frequently reported stages.

The most useful mechanism to increase utilization was the co-creation of knowledge with key stakeholders, mentioned by 63.6% of respondents (Fig. 5). Exchange platforms and presentations at conferences were considered the least useful mechanisms to promote the utilization of research knowledge.

3.2. Interview results

In the semi-structured interviews, respondents described and discussed processes of knowledge co-creation. Although the projects differ widely in terms of research topics (and thus disciplines) and questions, they all had in common that they covered different scales and areas of influence and that they included partnerships with academic and non-academic organisations. Interviewees also reflected on what knowledge co-creation actually means, and described how they used this mechanism. All respondents stated that they used co-creation of knowledge to some extent, and indicated that this mechanism offers participating actors the possibility of advancing beyond mere knowledge transmission or communication. In addition, comparative analysis of the responses reveals that the projects used different forms of knowledge co-creation, ranging from close everyday collaboration to dynamic interactive exchange at specific, less regular intervals. We coded this

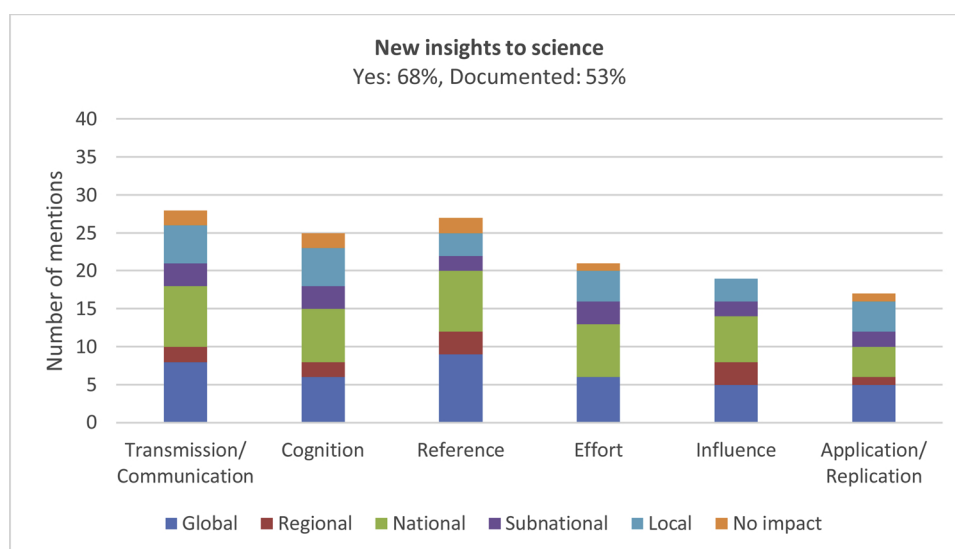


Fig. 3. Utilization of knowledge from projects in the r4d programme regarding new insights contributed to science. As each project can have multiple levels of utilization at multiple scales (e.g. when thinking of a continuum or a network), the total number of mentions per stage can be higher than the number of projects included in the survey.

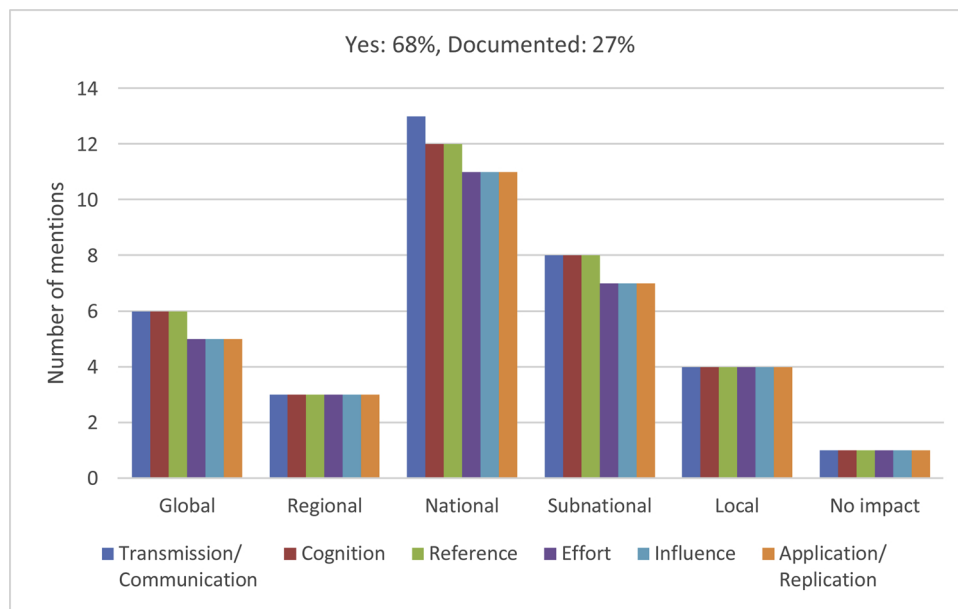


Fig. 4. Utilization of research knowledge from 22 research-for-development projects in policymaking.

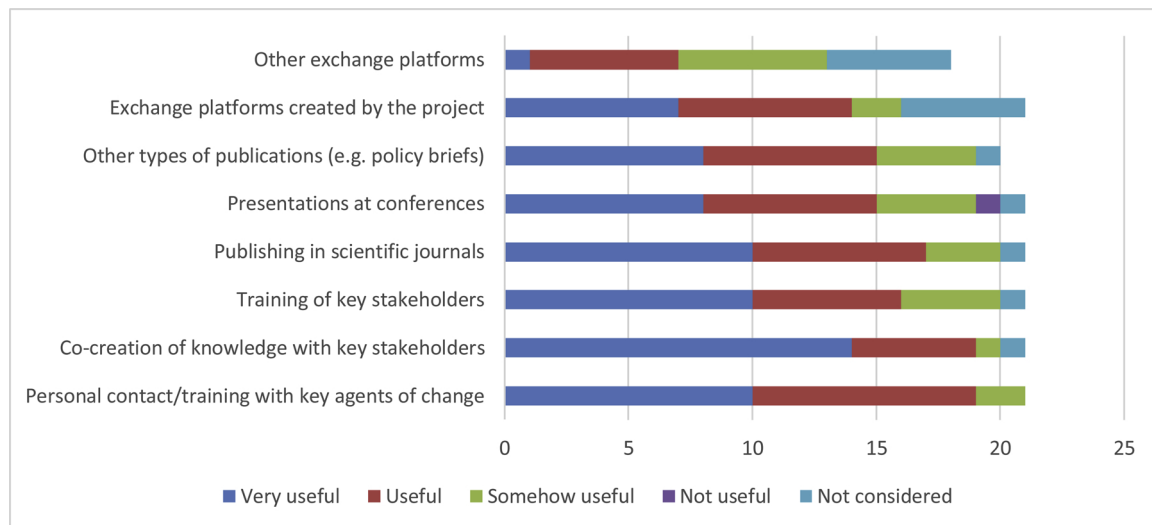


Fig. 5. Usefulness of mechanisms for promoting the utilization of knowledge as perceived by r4d researchers.

information as “understandings of co-creation” and, proceeding inductively, identified the following types: (1) obtaining information from new stakeholders (all projects); (2) providing capacity building for further use of knowledge (most projects); (3) communicating evidence in a targeted manner (all projects); (4) creating spaces for exchange and dialogue (all projects); and (5) collaborating and jointly making decisions in various phases of the project (about half of the projects). Five out of the 15 projects for which we received responses used knowledge co-creation from the project design onwards: they reported having defined the research problem or negotiated project contents jointly with different stakeholders. The remaining 10 projects started using co-creation after project funding had been secured. Thus, only a reduced number of projects fully undertook “formation of a common research object”, which represents the first phase of a transdisciplinary process as expressed by Jahn et al. (2012) (Fig. 2). In terms of formats for knowledge co-creation, respondents mentioned “inclusion” or “interaction with stakeholders” (mainly workshops), “public forums”, “roundtables”, “everyday collaboration”, “participatory mapping”, and “co-authored publications”. Several respondents highlighted their

understanding of the role of “stakeholders”. One stated that “we consider project participants also stakeholders, but not with knowledge that is superior,” pointing to a perspective that considers different realities as equally justified (Max-Neef, 2005; Schneider et al., 2019). Two projects mentioned the importance of “champions” – knowledgeable individuals who need to be identified and empowered to ensure uptake and continuity. These results show a preliminary link to the focal area of inclusion as described by Polk (2015).

Further, we asked in which areas project knowledge was utilized. Seven interviewees reported that the project had an effect on *scientific methods and tools*; interestingly, this was often mentioned in combination with local application (e.g. in a project on ecosystem services and social-ecological resilience in locally managed forest landscapes in Vietnam). Several projects reported that they had first had a local influence, which was later scaled up into national and sometimes even global policies (e.g. UNREDD in the case of a project active in Vietnam, or more restrictive policies on pesticides in the case of a project on food system sustainability).

Answers regarding scale were more complex. The most frequent

scale reported for knowledge utilization in the survey was the national (see Fig. 4). During the interviews, this result became more nuanced: While all respondents mentioned feedback into national policies, a smaller number reported that they were working on global topics at a local scale. Apart from six projects focusing predominantly on one scale (four on the national and two on the local), five described that they had first achieved an effect at the local level, which they had then scaled up to the national level. Fewer projects first took a global approach and then translated it into local project influence. Scales were thus in a way continuous and difficult to separate from each other. We identified local to global, local to national and national to local as the main vectors. Furthermore, scale was connected to project duration: More advanced projects were working at more scales or across wider continuums. Respondents' answers regarding project expectations likewise indicated that scale coverage increases with project duration.

Bringing together very different actors who would not otherwise have been in contact was mentioned by several respondents as an additional benefit from the co-creation process. This represents a link to the focal areas of inclusion and collaboration. For instance, one interviewee described the importance of a “very special” trust relationship between women villagers and women researchers; another described how the project enabled conflicting ethnic groups to work together and co-create knowledge. Yet another respondent from a project on land use change in Southeast Asia mentioned empowerment, friendship, and even “healing moments” in conflict situations as key benefits of knowledge co-creation, and stated that the focus on knowledge utilization is too narrow to characterize a transdisciplinary project's impact and influence on society. For example, influence on practice may concern worldviews and values, as the following quote illustrates:

“The project is not application-oriented. It's a lot about understanding better, having a more holistic perspective, etc., but what we create is not something that can be applied.”

The following quote is emblematic of several project interviews, because it exemplifies the importance given by researchers (academics and non-academics) to inclusion and collaboration for facilitating not only usability but also transformation:

“There might be some influences on practices, but more the deeper things (e.g. mindsets, worldviews, and values). This refers to the leverage points discussion: Normally, we just focus on the more obvious leverage points and not so much on the deep ones. On the level of these deeper things (mindsets etc.), we can maybe say that something is happening through our project, not the concrete changes in practice like introducing a new crop, but these deeper changes.”

In terms of factors enabling the utilization of research knowledge, three projects mentioned early involvement of key stakeholders in the project; two mentioned communication in local languages through local media. Both belong to the focal area of inclusion (Fig. 2). Similarly, early involvement of knowledge users was mentioned as conducive to subsequent utilization of the knowledge. The most frequently mentioned enabling factor, however, was equal empowerment of stakeholders. According to one project team, true “co-creation” can only happen when all people involved are given the same power to steer the process.

Respondents also mentioned a range of challenges. A majority of the interviewees reported third-party interest in their results, for instance from policymakers who asked to receive the research results in a form understandable to non-scientific actors, often at national or regional scales. Nevertheless, lack of political will was mentioned in seven interviews as a barrier to utilization, especially when research results were inconvenient or challenged current political agendas. As stated by an interviewee, if the project results “...question what has been advocated by influential actors”, politicians tend to stick to their previous position in public – even though they may appear convinced when research results are transferred. Several respondents mentioned that time and

resource constraints prevented them from disseminating the generated knowledge more effectively. Some mentioned that building networks takes time and is difficult, and that a lack of networks can hamper co-creation processes and uptake of research knowledge. Lastly, researchers' communication skills, as well as strategies for transmitting results (reportedly often requested by other stakeholders), were regarded as a challenge for the utilization of research knowledge outside the projects. The complexity of the social-ecological systems and the multidimensionality of the problems investigated makes it even more difficult to communicate results in a tangible way; moreover, several researchers stated that they do not like to simplify complex issues for communicative purposes.

One respondent summarized monitoring difficulties in transdisciplinary projects as follows, indicating that quantification of project impacts may fail to capture the added value of transdisciplinary work:

“Given that monitoring social change in time and space is extremely difficult, the quantification of transdisciplinary research impacts is a challenge. While top-down initiatives (e.g. new policies) are easy to document, monitoring bottom-up changes is too costly and there is a risk of over-monitoring that may affect the social process under examination.”

Regarding expected project impacts in the long term, the more temporally advanced projects were, the more concrete were their expectations, and the fewer areas and scales respondents named. However, almost all had expectations regarding utilization of project knowledge in policymaking. Further impact on science was less frequently mentioned, but was implicitly present in the interviews through mentions of scientific publications, conferences, and educational activities. Although practical application was mentioned least (by only four projects), respondents used terms such as “hope” and “long-term effects” regarding all areas. One example was the following quote: “We believe that we can influence decision-makers at the micro-level (local) and thereby pursue a bottom-up approach (...) The research outcomes will be used for the policymaking process as well as for improving the quality of forest management mechanisms (...) also in other countries which share similar contexts.”

4. Towards understanding impact

Knowledge from the analysed projects was utilized in multiple areas and at multiple stages simultaneously: For instance, projects developed scientific tools and methods while facilitating policy dialogue and co-creation with multiple social agents. Our research shows that the stages of knowledge utilization proposed by Landry et al (2001), if integrated into a broader framework and adapted to transdisciplinary research processes, offer one possibility to characterize usability as a proxy for assessing impact pathways of transdisciplinary projects (for other possibilities, see Schneider et al., this issue). An exclusively linear understanding of knowledge utilization is inadequate, because it does not correspond to the complexity of the systems under research, nor to the diversity of development pathways that a research project can use when taking inclusive and participative approaches. This finding provides further evidence regarding the multiplicity of possible impact pathways of research-for-development activities that take transdisciplinary approaches (Manners and van Etten, 2018; Jagustović et al., 2019).

While almost all projects were able to document their contributions to scientific methods and tools, utilization of co-created knowledge in other areas was far less documented. However, many respondents reported requests from policymakers and other actors to prepare their results in an accessible way to enable utilization. The interviews indicated that co-created knowledge always has components referring to different scales, even if the process of co-creation is local. The continuous scales used in most of the projects might therefore best be described as “glocal” (e.g. Haller et al., 2019). Respondents also indicated that project influence grows gradually and therefore cannot be

restricted to one project nor documented only during or shortly after its lifetime.

There are multiple possible explanations for the time it takes for impacts of scientific knowledge co-creation to unfold. For instance, Haller et al. (2015) describe the importance of local agency in institution building despite power asymmetries, and highlight the prevailing top-down nature of many development activities that do not enhance communicative action from local levels. Indeed, power relations are one of the most determining issues in transdisciplinary science (Rosendahl et al., 2015; Schmidt and Pröpper, 2017). The topic of top-down and bottom-up approaches was discussed in two interviews, indicating that top-down impacts are often easier to document and more visible in the short term, and therefore possibly more strongly pursued in projects whose performance is monitored using conventional criteria (Basche et al., 2014; Burkhardt-Holm and Zehnder, 2018; Hansson and Polk, 2018). Overall, the interviews highlighted that an outcome-oriented focus may be too narrow to understand the impacts of transdisciplinary research-for-development projects. The evaluation of such projects requires value- and process-oriented frameworks like the one described in Schneider et al. (2019) rather than a linear project management logic. This poses an interesting challenge in defining the right moment in time for promoting synthesis or evaluation activities that help to maximize impact by contextualizing and integrating research findings and procedural learnings beyond individual projects. If such work is done during the lifetime of the projects, they can profit from insights beyond their own research. However, during the lifetime of the projects it is not possible to appreciate the whole range of impacts, which is often a major interest of donors and, to a lesser extent, of policymakers in donors' countries.

With regard to mechanisms for promoting knowledge utilization, most survey respondents and all interviewees identified knowledge co-creation as the preferred one. More concretely, the interviews highlighted the importance of inclusion and collaboration in enhancing usability of the research knowledge. This may partly be predetermined by the basic characteristics of the r4d programme, which funds projects that declaredly aim to facilitate the utilization of inter- and transdisciplinary research results in policy and practice (Swiss Programme for Research on Global Issues for Development, 2016), and cannot be generalized to all transdisciplinary research projects.

Understandings of knowledge co-creation in the interviews seem to range widely, from joint project design – which may include all five focal areas described by Polk (2015) – to co-authored scientific publications that are not necessarily in line with these focal areas. The four categories established by Krütli et al. (2010) – information, consultation, collaboration and empowerment – may give some indication regarding the “strength” of projects' understandings of transdisciplinarity. If we relate their differing understandings of co-creation to these four categories, all projects in our study have overcome the phase of mere “information”, and most projects seem somewhere between “consultation” and “collaboration”. Several interviewees mentioned the importance of “empowerment” in terms of creating opportunities for different actors to decide which type of knowledge they want to use. Also, empowerment was mentioned as an important consequence of promoting the utilization of research knowledge in different areas and at different scales. This may be an important point to consider in further transdisciplinary research in north–south contexts. Chilisa (2017) shows how non-western knowledge systems are still being marginalized in transdisciplinary research because European or western paradigms and methods continue to be dominant. Such exclusion often leads to interventions that are not compatible with local populations and represents a barrier to application or replication. Indigenous groups and their epistemologies must therefore be empowered in the transdisciplinary process (Chilisa, 2017). Interviewees in our research cases described two types of empowerment: (1) empowerment of groups – for instance a group of marginalized actors such as small-scale farmers – to give them a voice; and (2) empowerment of individuals, which some

respondents named “champions” or “agents of change”. In addition, respondents highlighted the need to be aware that additional time and competences are necessary to secure the empowerment of groups or change agents, otherwise the outcomes tend to become too uncertain. We agree with other authors on the importance of empowerment as a key feature of transdisciplinary research, based on its relation to legitimacy and transformation processes (Brandt et al., 2013; Popa et al., 2015). However, our results can only be considered as indicative in this regard, as the evidence base is small.

We recognize the existence of some conceptual guidance about potential strategies for empowerment, including co-design or joint development of project goals and concepts (see Pohl et al., 2017). Researchers (e.g. Schneider et al., 2019) have highlighted that transdisciplinary approaches should not consist simply of improved communication or increased consultation, but should imply that knowledge is produced in an equitable way. In a similar sense, Max-Neef (2005) introduced the concepts of “strong” and “weak” transdisciplinarity, where “strong” transdisciplinarity includes the epistemological challenge of embracing different realities, understandings, and perspectives, while “weak” transdisciplinarity is more aligned with the pre-existing views of a specific stakeholder group and/or does not challenge traditional methods and logic. However, our study shows that there is a need to improve understanding of the extent of empowerment achieved through transdisciplinary approaches as well as the means and resources required for securing it. Some testimonies pointed out the challenges faced when new actors are included and empowered through transdisciplinary approaches, or when research results are not aligned with existing policies and predominant narratives. These testimonies are in line with other scientists' conclusions regarding the epistemological challenge inherent in strong transdisciplinarity, which, for instance, involves questioning existing power relations and the idea of “scientific neutrality” (Rosendahl et al., 2015). In order to produce reliable and “socially robust” knowledge and promote transformation towards sustainable development, transdisciplinary research-for-development projects must be inclusive, relevant, credible, and legitimate (Hansson and Polk, 2018). This implies that researchers and research programme designers need to be capable of reflecting the diversity, complexity, and dynamic nature of the complex systems under consideration. To achieve this, actors using transdisciplinary approaches will need the time and competences it takes to secure mutual learning and dialogue between scientific and non-scientific stakeholders coming from different cultures and using a potentially different value system (see Hirsch Hadorn et al., 2006). Thus, contextualized knowledge is needed in order to identify both potential risks and existing opportunities related to empowerment processes in the areas where research for development takes place.

5. Conclusions and outlook

Using an adapted framework of stages of utilization of research knowledge in various impact areas from local to global scales, we analysed how research-for-development projects co-create knowledge and how this knowledge is utilized in science and policymaking. We found that research knowledge from projects in the r4d programme is being utilized at multiple stages simultaneously, reflecting diverse and nonlinear patterns of knowledge utilization at continuous scales and in different areas at the same time – *i.e.* to improve scientific methods and tools, to generate new scientific insights, and in policymaking. Practical application was also reported by several projects. Thus, the results of this study can be understood as an approximation to understanding transformation pathways using transdisciplinary research knowledge.

We also looked at the mechanisms employed to facilitate knowledge utilization. “Co-creation” of knowledge was selected as the most frequent mechanism. Information from supplementary interviews led us to conclude that, although different understandings of “co-creation” co-exist in the r4d projects, the mechanism allows to increase inclusion

and collaboration, thus facilitating usability and promoting empowerment of new actors. This is in line with the ongoing discussion about transdisciplinary research and knowledge co-creation being a means to empower social groups otherwise marginalized, so that they can help shape deliberation processes aimed at sustainable development. This suggests that “empowerment” could be used as an additional proxy for understanding impact pathways of this type of research. Such a normative approach would involve assessing the deliberative opportunities that projects offer stakeholders, for example regarding decisions on budget allocation, project contents, and project goals.

Two limitations to our study require clarification. First, while the fact that all projects in our study belong to the same research programme ensures a certain level of comparability between projects, it also introduces an internal bias, as all projects contribute to a limited, predefined set of goals and fulfil the same selection criteria. The fact that this analysis was organized and conducted within the r4d programme may further add to this internal bias. For this reason, the results should be generalized with caution. The second limitation relates to a possible wide variety of understandings among study participants of several key concepts, including the stages of knowledge utilization. Although we used a predefined set of definitions, respondents’ individual interpretations may have influenced the answers.

Transformations towards sustainable development require behavioural and structural changes alike. Transdisciplinary research as it is pursued by the r4d programme can contribute to understanding and advancing the necessary changes based on its multi-stakeholder approach, knowledge co-creation, and possibly empowerment of other-wise marginalized actors. These characteristics of transdisciplinary research certainly increase the utilization of research knowledge along multiple impact pathways. However, variation in the questionnaire responses and the more differentiated views expressed in the interviews indicate a need for better understanding the contextual requirements for knowledge co-creation.

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Appendix A. Supplementary data

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