

About barriers and transdisciplinary literacy: Context-sensitive design of transdisciplinary research

Transdisciplinary research focuses on finding solutions to societal problems with the cooperation of both science and practice. It operates in, and is strongly influenced by, different contexts. Various barriers to collaboration shape the choice of context-sensitive formats and methods. To develop the desired solutions collaboratively, integrative processes are required. We shed a light on “transdisciplinary literacy” as one prerequisite to overcome these barriers and discuss how transdisciplinary research can be improved.

Melanie Mbah , Bettina Brohmann , Nina Maria Frölich , Christine Hobelsberger , Wiebke Rössig , Annika Weiser 

About barriers and transdisciplinary literacy: Context-sensitive design of transdisciplinary research | GAIA 35/3 (2026): 157–161

Keywords: collaboration, context, formats, methods, research design, transdisciplinarity

Transdisciplinary research needs greater recognition of the interface between context and format and methods

Transdisciplinary research (TDR) aims to develop socially robust knowledge in the form of concepts, methods, practical applications, and more, in response to a societal problem and in close cooperation between science and practice. This research mode is particularly necessary in view of the complexity of societal problems regarding sustainability transformations (Jahn et al. 2020). Here, both disciplinary and interdisciplinary research reaches its limits. In addition, strong interdisciplinarity is key to successful transdisciplinarity (Müller et al. 2025). However, practical knowledge is required to develop socially robust knowledge that integrates different forms of knowledge – system, target, and transformation knowledge – in a collaborative way (Buser and Schneider 2021, Pohl and Hirsch Hadorn 2007).

In TDR, collaboration and integration are key in developing transformation knowledge and are characterised by the TDR phases of a project – phase 0, co-design, co-production, co-evaluation, and the co-integration phase (cf. Horcea-Milcu et al. 2022, Lang et al. 2012, Lawrence et al. 2022) in which the intensity of collaboration is “functional-dynamic” (Krütli et al. 2010). Yet, what conditions need to be taken into account for an ideally collaborative setup?

In the tdAcademy Special Section *Frontiers in transdisciplinary and participatory research* in GAIA, insights into key questions of transdisciplinary and participatory research are offered. Guest editors, in collaboration with the German Society for Transdisciplinary and Participatory Research (GTPF), are Daniel Lang, Alexandra Lux, Martina Schäfer, and Melanie Mbah, representing the tdAcademy's supporting institutions. The GAIA editor responsible is Ortwin Renn.

Each Special Section explores a distinct thematic focus. Special Section #2 is dedicated to *Interfaces between context and formats and methods in transdisciplinary research*.

MORE INFORMATION:

- <https://td-academy.org/en/home>
- <https://gtpf.science>

 **tdAcademy**

 **GTPF**

Gesellschaft für transdisziplinäre und partizipative Forschung e.V.

TDR is always influenced by and adapted to the context (cf. Frölich et al. 2026). Ideally, all participants in transdisciplinary research projects act on “eye-level” without any power imbalances, which means that any perceived imbalances need to be carefully addressed within transdisciplinary formats (De La Rosa et al. 2025). Recent work (Frölich and Weiser 2025) suggests that approaching contextual factors in a structured manner is of paramount importance for TDR's process-related preparation and design. Context is understood here with reference to Tolkdorf

>

Dr. Melanie Mbah (corresponding author) | Öko-Institut e.V. | Freiburg | DE | m.mbah@oeko.de

Dr. Bettina Brohmann | Öko-Institut e.V. | Darmstadt | DE | b.brohmann@oeko.de

Nina Maria Frölich, MA | Karlsruhe Institute of Technology (KIT) | Institute for Technology Assessment and Systems Analysis (ITAS) | Karlsruhe | DE | nina.froelich@kit.edu

Dr. Christine Hobelsberger | Eberswalde University for Sustainable Development (HNEE) | Eberswalde | DE | christine.hobelsberger@hnee.de

Dr. Wiebke Rössig | Zentral- und Landesbibliothek Berlin (zlb) | Berlin | DE | wiebke.roessig@zlb.de

Dr. Annika Weiser | Karlsruhe Institute of Technology (KIT) | Institute for Technology Assessment and Systems Analysis (ITAS) | Karlsruhe | DE | annika.weiser@kit.edu

© 2026 by the authors; licensee oekom. This Open Access article is licensed under a Creative Commons Attribution 4.0 International License (CC BY).
<https://doi.org/10.14512/gaia.35.3.3>
 Received November 17, 2025; revised version accepted May 18, 2026 (double-blind peer review).

et al. (2025) as “a combination of circumstances that interact with and influence a transdisciplinary research project” (Frölich and Weiser 2025, p. 1).

The nine contextual factors identified can be found on three different dimensions: inner, outer, and the spatial-temporal dimension. Inner context factors refer to the composition, expertise, and dynamics of the research team itself; including knowledge bases, relational patterns, and role assignments within the group. The outer context factors cover political and legal environments, socio-ecological and economic conditions, organizational structures, power dynamics, and cultural relationships – each shaping the project’s possibilities and challenges. The spatial-temporal dimension encompasses questions of where, when, and for how long a project is implemented, including the political scope and the geographical region. It also incorporates historical trajectories and the timing of research within broader transformations (Tolksdorf et al. 2025).

Formats of TDR are directly linked to the context. They structure and frame the research process (Lam et al. 2021) and must be designed via methodological considerations sensitive to inner and outer context conditions, and their respective interfaces.

We define formats, such as real-world laboratories (e.g., Wanner et al. 2018) or Ten Steps (Pohl and Krütli 2017), as structural elements that describe and partly determine the intensity and forms of collaboration, the level(s) of impact, and the methodological structure. They span several phases of the research process – ideally all, but at least two (Rhodius et al. 2023).

Methods of TDR, as described in Bergmann et al. (2012), Biggs et al. (2022), Defila and Di Guilio (2018, 2019), or Laursen et al. (2024), serve to implement different approaches within the format. They range from empirical research methods, such as interviews, focus groups, and surveys, to methods of collaborative exchange and cooperation, for example visioning and scenario workshops, or design-thinking (cf. Lam et al. 2021, Rhodius et al. 2023). Typically, in TDR a combination of methods in the different research phases is used.

The distinction between formats and methods is, in practice as well as in the literature, often not so clear-cut, which is why we think the above-mentioned definitions foster a shared understanding and a common language within TDR. This thereby promotes clarity and precision for newcomers and early-career researchers alike, as well as for practitioners.

Beyond looking at context or formats and methods individually, it is essential to highlight the junctions that link these two domains (cf. Frölich et al. 2026). *Junctions* are understood as continuous orientation points where contextual conditions shape the selection and adaptation of formats and methods, and conversely, where the chosen formats and methods can re-define or transform contextual circumstances (e.g., by altering power relations or opening new inclusive participation pathways). Four cross-cutting junctions – *Adaptivity*, *Hierarchy*, *Inclusiveness*, and *Trust* – provide a practical lens for monitoring and reflecting this interplay (Frölich et al. 2026).

For navigating the different context aspects, we derive key barriers for collaboration and discuss the approach of transdisciplinary (TD) literacy as a prerequisite for successful collaboration. We believe that only by recognizing these intersections between context and format and methods can we achieve successful TDR and truly enable problem-solving.

Barriers for collaboration and how to tear them down

Collaboration of diverse actors is central in participatory and TD research, as well as in practice. However, so far collaboration has been insufficiently understood in terms of specific requirements and challenges. From the perspective of practitioners and research partners alike, numerous barriers to successful participation, collaboration, and ultimately integration of knowledge at various levels have been identified (cf. Bieluch et al. 2017, Hussain and Khuhro 2019, Gärtner et al. 2024). The barriers identified to date can relate to inner, outer, spatial and temporal context dimensions. According to our thesis, they occur in all stages of the research process and need to be examined and understood in greater detail.

Relevant, especially to the *inner context*, are barriers that refer to the team composition and knowledge types, and often touch on the individual level, regarding openness and flexibility (Kleihauer et al. 2026, in this issue). This means that researchers, in particular, have to fulfil multiple roles depending on the situation (Deutsch et al. 2025, Hoffmann et al. 2024, Studer et al. 2025). A “paternalistic role” of the project team, a “lack of coordination”, and also a “lack of resources” are well-known barriers for collaboration (Hussain and Khuhro 2019, p.1).

Integration of knowledge types, for example, stems from the knowledge bases of the team members (e.g., different disciplines), the non-scientific actors (e.g., different practical experiences), and the new – process and scientific – knowledge developed. Here, prerequisites for collaboration are often 1. finding a language that all understand and 2. agreeing on the significance of certain terms. This is often a challenging and ongoing process. Therefore, spending time and effort in jointly defining terms, the boundary object, and discussing different understandings of key concepts is key to successful collaboration (Pohl et al. 2021). Ideally, experiences from collaboration are discussed in reflection processes and carried into the respective knowledge spheres or organizations (cf. Bergmann et al. 2012, Pohl et al. 2021). Personal key competencies that allow collaboration in TDR are systematic thinking, anticipatory skills, normative and strategic, as well as interpersonal competences (Rhodius et al. 2023, Wiek et al. 2011).

Outer context barriers refer to, for example, organizational structures; meaning that there may exist different institutional target systems or that recognition for different working conditions may be lacking. Other barriers come into existence via power imbalances resulting from, for instance, a lack of adequate

integration of marginalised groups (referring to age, ethnicity, social or educational status, age, religion, etc.) and/or a lack of communication or language barriers due to specific vocabulary (De La Rosa et al. 2025). To respond to existing hierarchies or power imbalances explicating “different layers of power relations [...] and actively work[ing] on them throughout the research process” is crucial (De La Rosa et al. 2025, p. 7). Methods of reflection, as well as artistic or arts-based methods can support this (Frölich et al. 2026, Heinrichs and Hoernemann 2023). Public communication of outcomes of TDR might be another strategy to address power imbalances, as this increases their visibility and their recognition (Frölich et al. 2026).

Another frequently observed phenomenon is a lack of commitment and motivation especially in an inter- and TD research environment (see Kleihauer et al. 2026, in this issue) and over long project periods. It can be shown that targeted incentive and support structures are helpful in attracting scientists and practitioners to work on TD projects (Kleihauer et al. 2026, in this issue). However, there are several challenges to this as well, since incentives for scientists are different from incentives for practitioners. Scientists need scientific recognition in the form of, for example, high-ranked publications in international journals (cf. Guimarães et al. 2019). Practitioners are interested in solutions for practical problems, to ease or support decision making. In order to foster collaboration, conditions must be created that enable a personal connection to the project, its goals, or the institution, and that foster a sense of community with the other participants. McClure (2024) shows that the ability of researchers to adapt to the perspectives and needs of practitioners is one of the most important prerequisites for successful TD collaboration. By using the theory of expansive learning, it became clear how important it is for researchers to be able to reflect on their own position, while revealing the perspectives of others (McClure 2024). Here, capacity building of early-career researchers plays a crucial role (cf. Jaeger-Erben et al. 2018, Müller et al. 2025).

When preparing a TD project, all participants should be made aware of the specific requirements of cooperation and the development of solution options. Both practitioners and scientists should familiarize themselves with the expected process knowledge in advance and improve it through reflective steps (e.g., the Ten Steps format, Pohl et al. 2017). An approach to address this is TD literacy.

Transdisciplinary literacy: Recognizing and navigating contextual complexity

Debate and work related to competencies and mindsets in TDR have contributed to the professionalization of the field – in particular for scientists or actors at the intersection of science and practice. More recent discussions, for instance, emphasize integration expertise as a central capability for coordinating knowledge production across disciplines and societal actors (Hoffmann et al. 2024), or they elaborate how roles and competencies define

the profile of the “transformative transdisciplinary researcher” (Broerse and Zweekhorst 2024, p. 373). Less attention, however, has been given to how all actors involved interpret the contextual constellations within which they operate, and how these conditions shape the feasibility and design of their collaboration.

For example, funding criteria and project requirements define the terms of the collaboration however, they may not be obvious or self-explanatory to practitioners. Conversely, scientists may have limited knowledge of the institutional conditions, which determine the work routines of practitioners. Furthermore, both scientists and practitioners do not act solely as individuals, rather within the context of their organizational rules, hierarchies, and decision-making structures. All these factors may not only lead to different understandings of quality, benefits, and utilization of the project results, but also result in conflicts over resources, time logs, and priorities throughout the course of a project. This is particularly true when – as is often the case – the initiative for collaboration comes from scientific actors, and the concrete benefits for practitioners remain unclear.

Against this background, Hobelsberger (2024) introduced the term “transdisciplinary literacy” to grasp the capacity to recognize and interpret contextual conditions shaping TD collaboration, and to translate this understanding into the design of context-sensitive research processes. TD literacy, in this sense, is not limited to scientists. If projects aim for genuine co-design and co-production, practitioners also require a basic understanding of the characteristics and the process logic of transdisciplinary research. Shared understanding enables scientists and practitioners to jointly identify and interpret contextual conditions and negotiate appropriate forms of collaboration, thereby strengthening methodological reflexivity and more balanced science-practice relationships.

The notion of literacy emphasizes this interpretive dimension. For example, in educational and policy contexts, with regard to digitization (Pangrazio et al. 2020) and climate change (vom Orde 2024), literacy denotes not merely knowledge acquisition but the ability to understand complex environments and act within them in an informed manner. Analogously, TD literacy describes the ability to identify relevant contextual factors, interpret how formats and methods interact with these conditions, and translate this understanding into the design of context-sensitive research processes. Examples of applications at the first stage of such an integrated analysis and interpretation include the incorporation of constellation analysis (Baatz et al. 2025), actor analysis, or the delta analysis approach (Führ and Bizer 2022).

TD literacy is not intended as yet another term, or even a competing approach, but as a complement to existing work and debate on competencies and mindsets in TDR. While competencies describe what actors can do and mindsets how they position themselves, TD literacy operates at a meta-level by focusing on how actors interpret the situations in which their activities take place, and inspiring them to go beyond evaluation. Evaluations are mostly conducted formatively or ex-post, and not from the start of a project or even before. Whereas TD literacy involves rec-

>

ognizing when targeted or preferred methods no longer fit contextual conditions, when participatory formats reproduce power imbalances, or when institutional constraints limit meaningful collaboration.

Within the framework proposed in this article, TD literacy is closely linked to the four junctions structuring the interaction between context, formats, and methods: *Adaptivity*, *Hierarchy*, *Inclusiveness*, and *Trust*. Each dimension requires contextual interpretation: *Adaptivity* concerns recognizing when process designs must evolve; *Hierarchy* refers to the awareness of institutional roles and power asymmetries; *Inclusiveness* addresses whose perspectives remain marginalized; and *Trust* relates to how prior experiences and institutional relationships shape collaboration. Methods like the functional-dynamic stakeholder analysis (Krütli et al. 2010) or constellation analysis (Baatz et al. 2025) may stimulate the exchange needed to build trustful and hierarchy-sensitive relations, and to identify and reflect sensitive contextual factors in early stages of collaboration (Frölich et al. 2026).

The TD literacy approach goes far beyond methods and tools in the sense of a knowledge base, which is key for practitioners (as well as scientists) for collaboration in TDR. The specific details of this knowledge base have not yet been determined.

Summary, outlook, and open questions

Contextual factors – divided into inner, outer, and spatial-temporal dimensions – influence each research phase within TDR. Responding effectively to this complexity requires that formats and methods remain adaptive to shifting circumstances, address hierarchies and power relations, promote inclusivity of perspectives, and foster trust amongst participants. The perception and interpretation of these context aspects by the stakeholders is central to successful implementation, which means barriers to collaboration need to be identified and removed. Navigating these interpretation steps requires TD literacy.

Building on this conceptual foundation of TD literacy and translating the interface between context and format and methods into practice, can identify challenges and mechanisms that hinder equitable involvement of diverse actors. Beyond the inner context factor of strong interdisciplinarity (Müller et al. 2025), outer context conditions also shape power dynamics, communication, motivation, and accessibility for collaboration. The discussion on TD literacy expands the argument by specifying the competencies and reflexive capacities required from both scientists and practitioners to sustain integration across institutional and paradigm boundaries. It stresses the necessity of shared process knowledge, mutual appreciation, and interactive reflection.

There are still many open questions that need to be addressed, regarding barriers to collaboration, TD literacy, and also the context-sensitive selection and adaptation of formats and methods. Some examples are: What kind of knowledge do practitioners and scientists need to foster collaboration? How can mutual expec-

tations be addressed and shaped? Which junctions are most benefitted by which formats and methods? What kind of formats and methods might be supportive for managing a mutual understanding in respective contexts?

It seems as if scientific actors need to put themselves more into a listening role to better understand the demands, structural limitations, and target orientations of practitioners. But how? Spaces for further discussions include the Gesellschaft für transdisziplinäre und partizipative Forschung e.V. (GTPF) working groups¹, as well as the Global Alliance for Inter- and Transdisciplinarity (ITD Alliance) working groups².

Acknowledgements: The authors would like to thank the Gesellschaft für transdisziplinäre und partizipative Forschung e.V. (GTPF) working group *formats, methods, and context* for the fruitful discussions of barriers to participation, transdisciplinary literacy, as well as the interface between context and format and methods. Special thanks go to our colleagues, Regina Rhodius and Daniel Lang, who were involved in the research, but were unable to contribute to this article.

Funding: The work was funded by the BMFTR tdAcademy project 01UV2370C, 01UV2370D.

Competing interests: The authors declare no competing interests.

Authors' contributions: MM, BB, NF: initial research design; MM, BB, NF, CH, WR: data collection and analysis; MM, BB, NF, CH, WR, AW: manuscript drafting, writing the final manuscript.

References

- Baatz, A., K. Lange, M. Schäfer, R. Linke-Wittich. 2025. Comparing two constellation analyses: Insights from the development of weeding robots and autonomous shuttles. *TATuP – Journal for Technology Assessment in Theory and Practice* 34/2: 61–67. <https://doi.org/10.14512/tatup.7210>.
- Bergmann, M., T. Jahn, T. Knobloch, W. Krohn, C. Pohl, E. Schramm. 2012. *Methods for transdisciplinary research: A primer for practice*. Frankfurt am Main: Campus.
- Bieluch, K. H., K. P. Bell, M. F. Teisl, L. A. Lindenfeld, J. Leahy, L. Silka. 2017. Transdisciplinary research partnerships in sustainability science: An examination of stakeholder participation preferences. *Sustainability Science* 12: 87–104. <https://doi.org/10.1007/s11625-016-0360-x>.
- Biggs, R., A. de Vos, R. Preiser, H. Clements, K. Maciejewski, M. Schlüter (Eds.). 2021. *The Routledge handbook of research methods for social-ecological systems*. New York: Routledge. <https://doi.org/10.4324/9781003021339>.
- Broerse, J. E. W., M. B. M. Zweekhorst. 2024. Roles and competencies in transdisciplinary practices. In: *Transdisciplinarity for transformation*. Edited by B. J. Regeer, P. Klaassen, J. E. W. Broerse. Cham: Palgrave Macmillan. 373–390. https://doi.org/10.1007/978-3-031-60974-9_13.
- Buser, T., F. Schneider. 2021. Three types of knowledge. *Integration and Implementation Insights (i2iInsights)*. <https://i2iinsights.org/2021/02/11/three-types-of-knowledge> (accessed May 31, 2026).
- Defila, R., A. Di Giulio (Eds.). 2018. *Transdisziplinär und transformativ forschen. Eine Methodensammlung*. Wiesbaden: Springer VS. <https://doi.org/10.1007/978-3-658-21530-9>.
- Defila, R., A. Di Giulio (Eds.). 2019. *Transdisziplinär und transformativ forschen, Band 2. Eine Methodensammlung*. Wiesbaden: Springer VS. <https://doi.org/10.1007/978-3-658-27135-0>.
- De La Rosa, G., D. Ludwig, A. Nieves, C. N. El-Hani. 2025. Between confluence and disenfranchisement: The role of power dynamics in transdisciplinary research. *Current Research in Environmental Sustainability* 10: 100300. <https://doi.org/10.1016/j.crsust.2025.100300>.

1 www.gtpf.science/arbeitsgruppen.html (accessed November 13, 2025)

2 <https://itd-alliance.org/working-groups> (accessed March 15, 2026)

- Deutsch, L., et al. 2025. Herding cats: Integrative leadership strategies in inter- and transdisciplinary research programs. *Sustainability Science* 20: 95–115. <https://doi.org/10.1007/s11625-024-01585-4>.
- Frölich, N. M., R. Rhodius, L. Jauer, M. Mbah, A. Weiser, D. J. Lang. 2026. Navigating four junctions: A framework to design context- and format-sensitive transdisciplinary research. *Sustainability Science*. <https://link.springer.com/article/10.1007/s11625-026-01848-2>.
- Frölich, N. M., A. Weiser. 2025. Considering context in transdisciplinary research: A framework and reflective questions. *Integration and Implementation Insights (i2Insights)*. <https://i2insights.org/2025/08/26/context-framework-and-questions> (accessed May 31, 2026).
- Führ, M., K. Bizer. 2022. *Kompaktleitfaden "Praktisches Vorgehen in der interdisziplinären Institutionenanalyse"*. Darmstadt, Göttingen. www.sofia-darmstadt.de/fileadmin/Dokumente/Sonstige/Delta-Analyse/Kompakte_Stufenheuristik_2022-01-12_mf.pdf (accessed May 31, 2026).
- Gärtner, W., A. Kaschlik, W. Rössig. 2024. Vielfalt als Norm. Kontextsensible Gestaltung von Projekten, Formaten und Methoden. Interactive workshop at *PartWiss 2024 Conference*. Berlin, December 4–6. Abstract. www.partizipation-wissenschaft.de/interaktive-workshops-1/#2 (accessed May 31, 2026).
- Guimarães, M. H., C. Pohl, O. Bina, M. Varanda. 2019. Who is doing inter- and transdisciplinary research, and why? An empirical study of motivations, attitudes, skills, and behaviours. *Futures* 112: 102441. <https://doi.org/10.1016/j.futures.2019.102441>.
- Heinrichs, H., D. Hoernemann. 2023. Sustainable development through aesthetic expertise? Results and reflection of an experimental case study on arts-science policy intervention. *Visions for Sustainability* 19: 1–27. <https://doi.org/10.13135/2384-8677/7311>.
- Hobelsberger, C. 2024. Eine Frage der Perspektive: "Td-literacy" von Praxispartner*innen als Gelingensbedingung ko-produktiver Forschungsarbeit? Unpublished impulse presentation at *PartWiss 2024 Conference*. Berlin, December 5.
- Hoffmann, S., L. Deutsch, M. O'Rourke. 2024. Integration experts and expertise. In: *Elgar encyclopedia of interdisciplinarity and transdisciplinarity*. Edited by F. Darbellay. Cheltenham, UK: Edward Elgar. 273–276. <https://doi.org/10.4337/9781035317967.ch60>.
- Horcea-Milcu, A.-I., J. Leventon, D. J. Lang. 2022. Making transdisciplinarity happen: Phase 0, or before the beginning. *Environmental Science and Policy* 136: 187–197. <https://doi.org/10.1016/j.envsci.2022.05.019>.
- Hussain, S., R. A. Khuhro. 2019. Eleven-barriers to participation and one-root. *Journal of Sustainable Development* 12/3. <https://doi.org/10.5539/jsd.v12n3p1>.
- Jaeger-Erben, M. et al. 2018. Building capacities for transdisciplinary research: Challenges and recommendations for early-career researchers. *GAIA* 27/4: 379–386. <https://doi.org/10.14512/gaia.27.4.10>.
- Jahn, T. et al. 2020. Sozial-ökologische Gestaltung im Anthropozän. *GAIA* 29/2: 93–97. <https://doi.org/10.14512/gaia.29.2.6>.
- Kleihauser, S., B. Brohmann, H. Müller. 2026. Interdisziplinäre Integrationsprozesse in transdisziplinären Projekten. Erfahrungen aus dem Hochschulkontext. *GAIA* 35/3: 162–167. <https://doi.org/10.14512/gaia.35.3.4>.
- Krüti, P., M. Stauffacher, T. Flüeler, R. W. Scholz. 2010. Functional-dynamic public participation in technological decision-making: Site selection processes of nuclear waste repositories. *Journal of Risk Research* 13/7: 861–875. <https://doi.org/10.1080/13669871003703252>.
- Lam, D. P. M. et al. 2021. Transdisciplinary research: Towards an integrative perspective. *GAIA* 30/4: 243–249. <https://doi.org/10.14512/gaia.30.4.7>.
- Lang, D. J. et al. 2012. Transdisciplinary research in sustainability science: Practice, principles, and challenges. *Sustainability Science* 7: 25–43. <https://doi.org/10.1007/s11625-011-0149-x>.
- Laursen, B. et al. 2024. Toolkitting: An unrecognized form of expertise for overcoming fragmentation in inter- and transdisciplinarity. *Humanities and Social Sciences Communications* 11: 857. <https://doi.org/10.1057/s41599-024-03279-9>.
- Lawrence, M. G., S. Williams, P. Nanz, O. Renn. 2022. Characteristics, potentials, and challenges of transdisciplinary research. *One Earth* 5/1: 44–61. <https://doi.org/10.1016/j.oneear.2021.12.010>.
- McClure, A. 2024. Enablers of transdisciplinary collaboration for researchers working on climate risks in African cities. *Sustainability Science* 19: 259–273. <https://doi.org/10.1007/s11625-023-01426-w>.
- Müller, L., M. Czymai, P. Döll, B. Blätzel-Mink. 2025. Interdisciplinary collaboration in transdisciplinary projects: Effects on, and challenges for, early-career researchers and the project design. *GAIA* 34/4: 274–281. <https://doi.org/10.14512/gaia.34.4.5>.
- Pangrazio, L., A.-L. Godhe, A. G. L. Ledesma. 2020. What is digital literacy? A comparative review of publications across three language contexts. *E-Learning and Digital Media* 17/6: 442–459. <https://doi.org/10.1177/2042753020946291>.
- Pohl, C., P. Krüti, M. Stauffacher. 2017. Ten reflective steps for rendering research societally relevant. *GAIA* 26/1: 43–51. <https://doi.org/10.14512/gaia.26.1.10>.
- Pohl, C., J. Thompson Klein, S. Hoffmann, C. Mitchell, D. Fam. 2021. Conceptualising transdisciplinary integration as a multidimensional interactive process. *Environmental Science and Policy* 118: 18–26. <https://doi.org/10.1016/j.envsci.2020.12.005>.
- Rhodius, R., B. Brohmann, M. Mbah. 2023. Vom Reallabor bis zur künstlerischen Intervention – innovative Formate und Methoden für Transformationen. In: *Nachhaltigkeit und Nachhaltige Entwicklung*. Passauer Kontaktstudium Geographie, 17. Edited by W. Gamerith, I. Voshage, M. Wagner. Passau: Selbstverlag Fach Geographie der Universität Passau. 127–142.
- Studer, S., F. Marfurt, A. B. Zimmermann, J. Behringer. 2025. Roles of scientists in sustainability transformations: A guide for reflection and workshop facilitation. *Swiss Academies Communications* 20/2. <https://doi.org/10.5281/zenodo.15235686>.
- Tolksdorf, F. L. et al. 2025. Why context matters: Understanding transdisciplinary research through the lens of nine context factors. *Innovation: The European Journal for Social Science Research* 38/4: 1482–1518. <https://doi.org/10.1080/13511610.2025.2527104>.
- Vom Orde, H. 2024. *Climate literacy: Konzepte, Dimensionen und Bedeutsamkeit*. *TELEVIZION* 37/1: 29–30.
- Wanner, M., A. Hilger, J. Westerkowski, M. Rose, F. Stelzer, N. Schäpke. 2018. Towards a cyclical concept of real-world laboratories: A transdisciplinary research practice for sustainability transitions. *disP – The Planning Review* 54/2: 94–114. <https://doi.org/10.1080/02513625.2018.1487651>.
- Wiek, A., L. Withycombe, C. L. Redman. 2011. Key competencies in sustainability: A reference framework for academic program development. *Sustainability Science* 6: 203–218. <https://doi.org/10.1007/s11625-011-0132-6>.



Melanie Mbah

Studies in geography, political sciences, and public law. Research coordinator for transdisciplinary sustainability research at the Institute for Applied Ecology (Öko-Institut e.V.), Freiburg, DE. 2014 to 2018 postdoc at the Institute for Technology Assessment and Systems Analysis, Karlsruhe Institute of Technology, DE. Research interests: transdisciplinary and transformation research, participation and governance, space and place in infrastructural planning.