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*Synthesis*

# Place-based knowledge transfer in a local-to-global and knowledge-to-action context: key steps and facilitative factors

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ABSTRACT. Rapid global change threatens to outstrip global efforts to establish sustainable stewardship of social-ecological systems (SES). Place-based research can enhance effectiveness of global sustainability policies and actions by providing contextualized knowledge underpinning bottom-up solutions. However, the use and transfer of place-based knowledge remains a major challenge. In this study, we analyze place-based knowledge transfer in a local-to-global and knowledge-to-action context. We aim to provide insights on when, how, and why place-based research can inform decision making at the global scale and lead to action toward more sustainable and just futures. Our iterative and exploratory methodology involved alternating rounds of literature reviews and interviews with interdisciplinary researchers. We identified four key steps (place-based knowledge production, knowledge synthesis, knowledge use at the global scale, and knowledge revision and lessons learned) and five facilitative factors (bridging organizations, knowledge brokers, boundary organizations, institutionalized knowledge governance, and polycentric governance systems), which provide a comprehensive understanding of place-based knowledge transfer. Our conceptual framework provides suggestions on how to set up place-based knowledge transfer to be more effective, complete, and inclusive. Furthermore, our study discusses two major structural challenges that currently inhibit place-based knowledge transfer and shows ways forward for science and policy to overcome these. We argue that place-based knowledge transfer can be an effective means to undo dominant power relations and the epistemic status quo and enable a shift from short-termism in science and policy toward more long-term SES goals. Therefore, it is seminal to open up the predominant value system to more diverse knowledge systems, signifying a shift away from global decision making that is guided by neoliberal capitalist principles and over-emphasizes short-term and individual gains. Finally, it is crucial to prioritize learning over knowing to exploit the long-term value of place-based knowledge transfer.

Key Words: *knowledge-to-action; knowledge transfer; local-to-global; place-based research; science-policy interface; social-ecological systems; transdisciplinary research; upscaling*

## INTRODUCTION

The pressure of human activity on the Earth system continues to grow, endangering its stability, and thus human well-being. Rapid global change threatens to outstrip our efforts of establishing a sustainable stewardship of social-ecological systems (SES) at the global scale. Thus, action at all scales, from local to global, and science to decision making, is required (Rockström et al. 2009, Norström et al. 2017).

Recent advances in sustainability science have included social-ecological research and improved understanding of human-nature interactions and human impacts on nature's contributions to people (IPBES 2019). However, significant challenges remain with global sustainability policies and actions because they tend to apply top-down approaches, provide insufficient tools, and rely on simplifications of social-ecological models and pathways. Thus, they disregard the rich body of bottom-up approaches and place-based research (Balvanera et al. 2017a). Major gaps result from lacking cross-sectoral integration, inadequate adoption or implementation of key solutions, and insufficient incorporation of diverse knowledge systems, such as Indigenous and local knowledge (ILK) systems (Bennett et al. 2021a, IPBES 2022, Pascual et al. 2023). Knowledge systems are sets of assertations that are formally or informally followed and routinely used as truth claims. Indigenous and local knowledge systems are a cumulative set of knowledge, practices, and beliefs, "evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment" (Díaz et al. 2015:13).

Moreover, global sustainability policies and actions often fail to account for SES interconnectedness and, hence, meet the requirements of local contexts. To accelerate action toward global sustainability, it is crucial to understand how social-ecological dynamics play out across scales, and how knowledge becomes actionable (Martín-López et al. 2020, Stern et al. 2021, Andrews et al. 2024).

Place-based research can contribute to closing the aforementioned gaps by providing contextualized and actionable knowledge (Balvanera et al. 2017a). Place-based research addresses the particularities of landscapes and seascapes (Norström et al. 2017). Emphasizing place-specific characteristics, it aims to understand global sustainability from a different perspective, align global policy goals with local instrumental and relational knowledge and values, and offers "high resolution" knowledge providing more grounded cultural and epistemic legitimacy. Additionally, it complements planetary boundaries research with adequate and effective solutions that engage ILK producers and systems (Bennett et al. 2021a).

Compared to traditional forms of scientific knowledge production, place-based research emphasizes exchange across disciplinary boundaries and among different actors, including

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ILK producers (Balvanera et al. 2017a). This locates place-based research at the participatory end of the science-communication spectrum, following process-oriented, non-purposive, and open approaches (Bucchi and Trench 2021). Place-based research is often linked to meaning negotiation among different actors, making it particularly suited to providing actionable knowledge. Looking at knowledge-to-action transfer, it is critical to recognize that knowledge is not a well-defined package that can be readily exchanged. The development of actionable knowledge is rather a process of relating with different actors, which is inherently social, and a key reason why scientific evidence alone is insufficient to trigger action (Roux et al. 2006, as cited in Stern et al. 2021).

However, knowledge transfer of place-based research remains challenging. We define place-based knowledge transfer as a cyclic process that runs through several iterative key steps, namely place-based knowledge production, knowledge synthesis, knowledge use at the global scale, and knowledge revision and lessons learned, back to place-based knowledge production. Contrary to knowledge translation and knowledge exchange, knowledge transfer is a cyclic process and broader in scope. It can involve knowledge translation and is more directional than knowledge exchange (Stern et al. 2021, McEwen et al. 2022).

The above definition is an idealized conceptualization of place-based knowledge transfer and does not reflect on how place-based knowledge transfer happens nowadays. Currently, challenges arise from the aggregation of place-based knowledge to larger scales and knowledge transfer across the science-policy interface (Bennett et al. 2021a, Calderón-Contreras et al. 2022). Place-based knowledge transfer is particularly impeded by mismatches of spatial, temporal, and governance scales (Bennett et al. 2021a). For example, questions arise on (1) how place-based knowledge can be used to address global sustainability issues, (2) how legitimacy of local knowledge systems can be preserved at larger scales, and (3) how place-based knowledge can be translated into actionable knowledge for global decision making despite lacking timeliness and high complexity (Oteros-Rozas et al. 2015, Balvanera et al. 2017b, de Vos et al. 2019, Bennett et al. 2021b).

To tackle these key questions, we address two dimensions of knowledge transfer, namely local-to-global and knowledge-to-action transfer. The results of our study are theoretically and empirically grounded and provide a comprehensive and integrated understanding of place-based knowledge transfer. We provide a conceptual framework that has a normative dimension because it provides suggestions on how to set up place-based knowledge transfer to be more effective, complete, and inclusive. We also provide a summary of our results in our novel place-based knowledge transfer matrix. Our discussion subsequently compares our idealized conceptual framework to the current state of knowledge transfer, explaining existing differences. This way, we aim to provide insights on when, how, and why place-based research can complement the global scale and lead to action toward more sustainable and just futures.

## METHODS

This study's iterative and exploratory methodological approach involved alternating rounds of literature reviews (three in total) and two rounds of in-depth interviews with interdisciplinary researchers. A reflection phase followed each literature review and interview round, in which outputs were summarized and refined, and the next step was prepared (Fig. 1). The interviews complemented the literature reviews, the latter forming the basis of data collection. The interviews served to discuss gaps in the literature, clarify questions, validate findings, and exchange ideas about possible ways forward in this research. The alternating sequences of literature reviews and interviews shaped the exploratory and iterative nature of the methodology and allowed us to triangulate methods and data. We considered this triangulation to be necessary because place-based knowledge transfer in a local-to-global and knowledge-to-action context is a transdisciplinary challenge that cannot be tackled by a single method or research perspective.

### Literature reviews

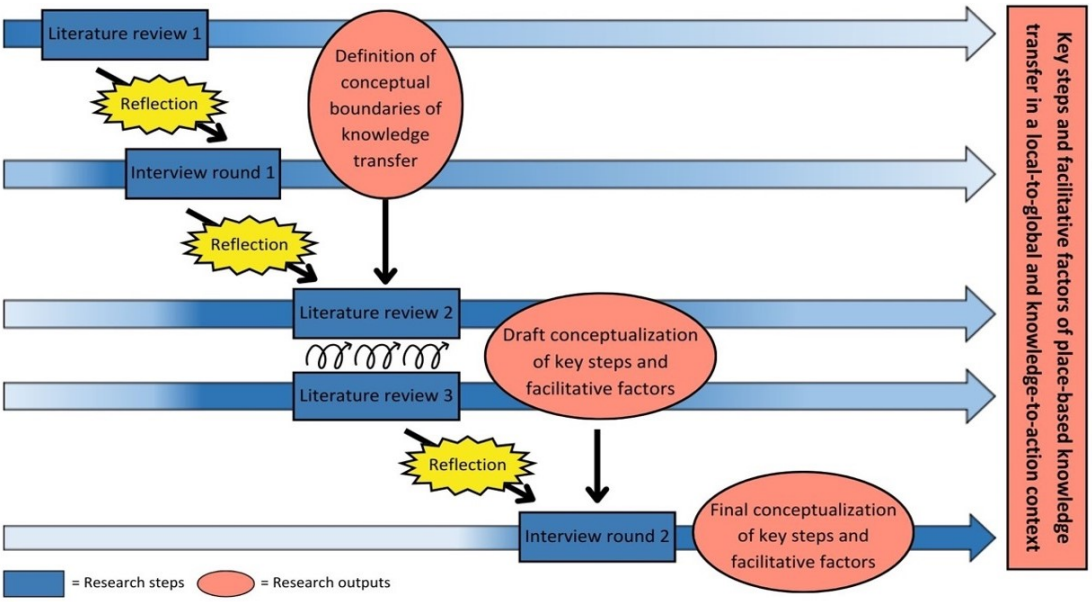
The first literature review aimed to determine the conceptual boundaries of place-based knowledge transfer in a local-to-global and knowledge-to-action context. We took a broad approach to extract well-grounded definitions, identify core elements of knowledge transfer, and assess different processes that involve knowledge transfer. We reviewed academic literature from sustainability science and social-ecological research, as well as public health, medical science, and innovation science (see Appendix 1 for databases and search terms used). We included literature from these disciplines because they offered robust methods and frameworks for examining knowledge transfer processes due to their long-standing expertise in studying knowledge dissemination, translation, and application. The first review led to a first grounding of the concept "knowledge transfer," which served as a basis for the first interview round (Fig. 1). The second review focused on social-ecological research only, to delve deeper into knowledge transfer issues in the context of SES. The third review examined transnational governance literature to shed light on knowledge transfer across scales and in the science-policy interface. The second and third reviews were conducted in parallel to account for both the particularities of place-based research and the implications of cross-scale knowledge transfer in the science-policy interface. Thus, they aimed to jointly determine key steps of place-based knowledge transfer in a local-to-global and knowledge-to-action context, and to identify facilitative factors accordingly. The second literature review served as a lens through which we explored the literature on transnational governance. This allowed us to identify key aspects of transnational governance literature that could enhance our understanding of place-based knowledge transfer. The reviews were conducted between March and July 2022, and considered literature from 2002 and upward.

We included an intermediate step to bridge the literature reviews and conceptualization of key steps and facilitative factors. We adopted the principles "coverage" and "balance" from Watts and Stenner (2012) to ensure inclusiveness of all relevant ground and a range of perspectives, as well as to avoid overlap, distortion, or bias. A more detailed description of this application can be found in Appendix 1.

### Interview rounds

We conducted two separate rounds of in-depth expert interviews. All interviews were carried out by the first author, and the outcomes discussed with the author team. The first round followed the initial literature review and involved conceptual interviews, with the aim to scope the research and provide

**Fig. 1.** Illustration of the iterative and exploratory methodological approach presenting research steps and outputs from top to bottom and left to right. The color gradient of the arrows denotes the relative significance of a research step and output and underscores their continuous influence on the research process. Both the recurring reflection phases and intermediate research outputs prepare subsequent research steps, form their basis, and feed into them.




conceptual clarification on the boundaries of knowledge transfer (Brinkmann and Kvale 2018). Interviewees were selected according to their professional experience with knowledge transfer, accessibility, and availability, as well as considerations made toward regional and gender diversity. Among the 10 interviewees, we interviewed 7 female and 3 male researchers from Europe, North America, Mexico, India, South Africa, and Australia (see Appendix 1 for a more detailed description of interviewees).

In the first interview round, we conducted three interviews (IDs 1, 2, 3). Interviews were conducted online in March 2022, lasted about 60 minutes, and were summarized afterward. We developed an interview guide for this interview round with open-ended questions (see Appendix 1), based on Magnusson and Marecek (2015).

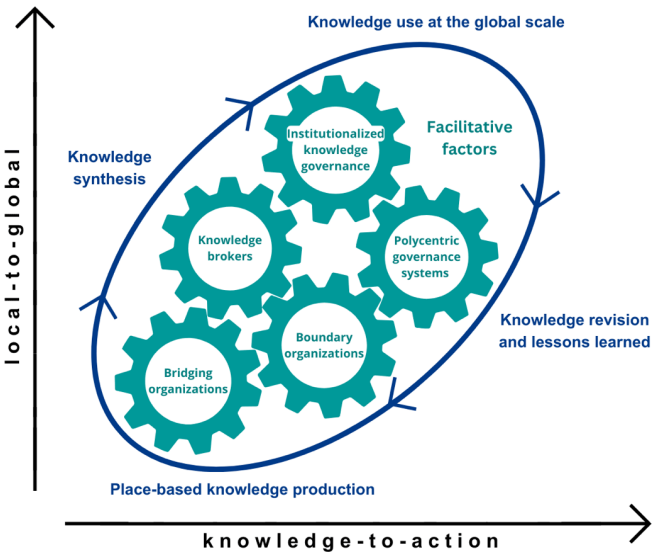
For the second round, we conducted in-depth interviews with researchers of different academic backgrounds, who study knowledge transfer issues from different perspectives. For example, we interviewed researchers with a background in place-based and social-ecological research, who are also involved in the Programme on Ecosystem Change and Society (PECS), as well as researchers working on global environmental governance, scientific advocacy, and the science-policy interface. We aimed to include a broad range of understandings and notions of knowledge transfer that offer a new perspective and an opportunity to expand on. In this second round, we conducted seven interviews (IDs 4–10), with the aim to refine and validate the draft conceptualizations of key steps and facilitative factors resulting from previous research phases. Therefore, we provided the interviewees with the latest draft conceptualization version prior to the scheduled interview and adapted interview guides accordingly. Consequently, different drafts were sent to different interviewees. This approach shaped the iterative and exploratory nature of our methodology and allowed us to reflect on, refine, and solidify the scientific basis of our outputs.

To account for the iterative interview approach, we used "immanent questions," a question technique used in narrative interviews (Przyborski and Wohlrab-Sahr 2013; see Appendix 1 for a more detailed explanation). This ensured triangulation and cross-validation of information between interviewees. Adopting such an iterative interviewing approach likely generated different outcomes. For example, during the interview rounds, the number of key steps was reduced from 6 to 4, and 15 facilitative factors were merged into 5 more overarching ones. This enhanced the overall relevance of our results, as effectiveness was increased while exhaustiveness was maintained. Second round interviews lasted between 45–90 minutes, but more typically 60 minutes. We conducted all interviews online in May 2022.

**Interview analysis**

We used a mixed inductive-deductive approach to analyze the interview summaries and transcripts of each round. Throughout all interviews, the stable entity to be analyzed was place-based knowledge transfer in a local-to-global and knowledge-to-action context. This constituted our inductive dimension. We followed a dynamic strategy and let thematic analysis codes emerge while assessing the interview summaries and transcripts. The deductive analysis dimension resulted from the preceding literature reviews, which gave us a good understanding of the interview topic. This allowed us to deductively derive categories to be examined. Because the interview analysis focused on the meaning making of language used, we chose meaning condensation as the mode of analysis. Compared to the narrower meaning coding and more

**Fig. 2.** Key steps and facilitative factors of place-based knowledge transfer in a local-to-global and knowledge-to-action context. All facilitative factors influence all key steps and no hierarchy or relative importance can be deduced from their position. The key steps and facilitative factors are the result of the iterative and exploratory methodology applied, including alternating rounds of three literature reviews and two interview rounds.




quantitative content analysis, meaning condensation focusses on reducing long statements into central themes (Brinkmann and Kvale 2018). The mixed inductive-deductive approach for meaning condensation entailed that we deductively prepared code categories for the identification of central themes. At the same time, the inductive dimension created room for a dynamic analysis to capture emerging themes.

## RESULTS: TOWARD A CONCEPTUAL FRAMEWORK FOR PLACE-BASED KNOWLEDGE TRANSFER

### The four key steps of place-based knowledge transfer

1. Place-based knowledge production refers to the interaction of actors, discourses, institutions, and capacities involved in place-based knowledge production (Fig. 2; Hegger and Dieperink 2014, Balvanera et al. 2017a).

2. Knowledge synthesis is the process of shaping and tailoring place-based knowledge for a specific purpose, for example, to make it actionable for decision making at the global scale. Synthesis activities can be carried out at various scales by individuals or multiple actors using collaborative approaches for co-produced synthesis. The context of knowledge synthesis matters, and results in different implications for the perceived credibility, salience, and legitimacy of synthesized knowledge (Tengö et al. 2017; ID 1, 2). Credibility relates to the perceived scientific adequacy of knowledge, salience to the relevance for decision makers, and legitimacy to whether knowledge has been produced in an unbiased and fair way, respectful of disparate value sets (Cash et al. 2003).

3. Knowledge use at the global scale describes the uptake and application of place-based knowledge at the global level. It is subject to power struggles and highly contested, as is the case for sub-global levels as well (Bulkeley 2005, Biermann and Pattberg 2012, Tengö et al. 2017; ID 4). Particularly when analyzed at the global scale, historic and current drivers and impacts of social-ecological change are unevenly distributed, creating global inequalities and exacerbating issues of (in) justice (Clark et al. 2016, Lam et al. 2020, Dryzek and Tanasoca 2021; ID 4, 5).

4. Finally, in the knowledge revision and lessons learned step, actors reflect on the use (and non use) of knowledge, aiming to record lessons learned (Clark et al. 2016, Rushmer et al. 2019; ID 6). Hence, the step also focuses on new knowledge that essentially may emerge from previous steps, based on experiences, empirical values, and feedback (Cvitanovic et al. 2015, Rose et al. 2020). Knowledge revision activities can be carried out at different scales by individuals or multiple actors using collaborative approaches, affecting the perceived credibility, salience, and legitimacy of the lessons learned (ID 6).

### The five facilitative factors of place-based knowledge transfer

1. Bridging organizations are designed to facilitate collaboration by bringing together a broad range of actors (e.g., researchers, practitioners, local communities, non-governmental organizations, and decision makers) and knowledge systems (e.g., western scientific, Indigenous, local, and practitioners' knowledge; Fig. 2). These organizations provide space for knowledge exchange, trust building, and coordination, thus playing a crucial role in ensuring inclusiveness (Crona and Parker 2012, Kowalski and Jenkins 2015).

2. Knowledge brokers are the "human force" behind knowledge transfer. They perform similar activities to bridging organizations but are commonly defined as individuals (Rushmer et al. 2019, Neal et al. 2023). Key qualities of knowledge brokers include networking abilities, clear communication, expertise in research and policy, knowledge of change processes, perseverance, and agility (ID 2). These skills enable them to strategically facilitate relationships, disseminate evidence, find alignment, build capacity, and advise decisions at different levels (Neal et al. 2023).

3. Boundary organizations are formal institutions working between research communities and decision makers at the science-policy interface (Cash et al. 2003, Cvitanovic et al. 2018). Compared to bridging organizations, boundary organizations include a narrower scope of actors and have an explicit focus on representing both sides of the science-policy interface, while holding dual accountability and maintaining credibility through independence. The role of boundary organizations is to translate and mediate between science and policy realms, complementing the purpose of bridging organizations, which aim to ensure inclusiveness and representation of diverse perspectives (Berkes 2009, Kowalski and Jenkins 2015, Cvitanovic et al. 2015).

4. The fourth factor is institutionalized knowledge governance. Knowledge governance encompasses the "formal and informal rules that govern knowledge processes, including production, sharing, access, and use" (Clark et al. 2016:4575).

Institutionalized means that knowledge governance is established as a systematic and sustained part of the science-policy interface. Therefore, institutionalized knowledge governance has gradually become over time a deliberate, legitimate, and routine practice (Kuchenmüller et al. 2022). This way, it provides a more long-term perspective for knowledge transfer activities and a permanent space to build and strengthen capacities to address complexity (Delina and Sovacool 2018).

5. The last facilitative factor of place-based knowledge transfer involves polycentric governance systems. Polycentricity refers to a complex governance system comprising multiple, overlapping decision-making centers that are nested at different scales (e.g., local, regional, national, international; Ostrom 2009, Carlisle and Gruby 2019, Lubell and Morrison 2021). The multi-scale configuration and institutional diversity of decision-making centers creates connectivity among groups (e.g., researchers and decision makers), fosters cooperation, and enhances cross-scale knowledge transfer (Schoon et al. 2015).

**How can place-based knowledge production be facilitated?**

Place-based knowledge production takes place in a complex patchwork of knowledge systems and institutions (e.g., Indigenous, local, traditional, or Western scientific; Table 1). Bridging organizations can facilitate weaving, bringing together, and bridging different world views, agendas, identities, practices, and value sets (Tengö et al. 2017, Chambers et al. 2022). They also foster inclusion of marginalized actors in knowledge production, ensure equal representation, and navigate power struggles and conflicts, especially when ILK producers are involved (ID 4, 7). For example, bridging organizations can set the institutional context and establish rules of conduct and transparent decision criteria (Berkes 2009, Chambers et al. 2022; ID 8, 9, 10). Due to a colonial history of suppressing voices and denigrating cultural expressions and ILK producers, this has particular importance for place-based knowledge production (Bennett et al. 2021a).

Knowledge brokers promote cooperation and facilitate interaction among a diverse set of actors involved in knowledge production (Wyborn 2015; ID 1, 2). They can help find active and open modes of communication, using a language that can be understood by all actors (Bennett et al. 2021a; ID 6). Knowledge brokers support disadvantaged and vulnerable actors in participating in knowledge production by providing space for capacity building, teaching, mentoring, and mediating different perspectives (Neal et al. 2023). Thus, knowledge brokers are vital to balance the power dynamics in knowledge production (Wittmayer and Schäpke 2014; ID 8, 9).

Boundary organizations are vital for making place-based knowledge actionable for decision making (Clark et al. 2016). Because they hold dual accountability, they can provide a forum to develop boundary objects (co-produced and agreed upon outputs) that are robust enough to ensure connectivity among different actors (Cash et al. 2003, Tengö et al. 2017; ID 5). One example mentioned in the interviews is the Arizona State University Decision Theater: "This boundary organization brings in different partners, particularly decision makers, and produces transdisciplinary boundary objects, such as visualizations and models, together with them to better understand consequences and trade-offs of decisions before making them" (ID 8). Finally, by explicitly focusing on the science-policy interface, boundary organizations can bridge social and cultural divides in knowledge production, link diverging time scales, and generate stakeholder buy-in (Crona and Parker 2012, Chambers et al. 2022; ID 10).

Institutionalized knowledge governance can foster long-term stakeholder engagement and help build on existing relationships and mutual trust (Bennett et al. 2021a; ID 3, 4). It provides the opportunity to address complexity and conflict, reshape rigid structures, and include emergent groups in knowledge production (Cuppen 2018, Ostrom 2005; ID 4).

Polycentric governance systems can enhance bottom-up agility in knowledge production (Biggs et al. 2012; ID 4, 5). Such governance systems can support disadvantaged actors in developing a basic level of agency, enhancing their ability and willingness to engage in knowledge production and develop common ideas, strategies, and actions (Neelakantan et al. 2021; ID 9). By enhancing bottom-up agility and agency of disadvantaged actors in knowledge production, polycentric governance helps elevate marginalized agendas, question dominant agendas, navigate conflicting agendas, and explore diverse agendas (Chambers et al. 2022).

**How can place-based knowledge synthesis be facilitated?**

Bridging organizations are instrumental in (co-)synthesizing place-based knowledge because they involve a wide range of actors, representing diverse knowledge systems (Berkes 2009, Kowalski and Jenkins 2015; ID 1, 2, 8; Table 1). By adopting an inclusive approach, bridging organizations can ensure transparency of the synthesis process and outcomes, and allow knowledge producers to retain interpretive sovereignty, enhancing legitimacy.

Knowledge brokers are key to translating, tailoring, and communicating place-based knowledge to decision makers at the global scale, thus playing a crucial role for knowledge synthesis (Neal et al. 2023). They can mediate differences, enhance mutual understanding among actors, and create common ground (Hegger and Dieperink 2014, Young et al. 2014). Knowledge brokers can take a leading role in the joint production of boundary objects and therefore establish forms of cooperation that are perceived as legitimate, particularly in spaces with large power differentials (ID 8).

By explicitly targeting the science-policy interface and promoting cross-boundary cooperation, boundary organizations can synthesize place-based knowledge in a way that it is perceived as credible, salient, and legitimate (Crona and Parker 2012, Cvitanovic et al. 2018; ID 7). They help knowledge producers identify preferred ways of knowledge acquisition by decision makers at the global scale and adapt types and means of dissemination accordingly (ID 7). Boundary organizations connect the legitimacy of knowledge producers to global decision-making spheres and therefore knowledge to action. Thus, they are seminal to ensure that actions are not undermining or perceived as offensive (ID 8, 9).

For knowledge synthesis, institutionalized knowledge governance allows space for navigating credibility, salience, and legitimacy of knowledge in different social, political, and cultural contexts. It

**Table 1.** Novel place-based knowledge transfer matrix: charting the course from local knowledge to global impact. Note: ILK = Indigenous and local knowledge.

| | Place-based knowledge production | Knowledge synthesis | Knowledge use at the global scale | Knowledge revision and lessons learned |
|---|---|---|---|---|
| Bridging organizations | Weave diverse knowledge systems;<br>Foster inclusion of marginalized actors;<br>Navigate power struggles and conflicts. | Involve a wide range of actors representing diverse knowledge systems;<br>Ensure transparency of the synthesis process and outcomes;<br>Allow knowledge producers to retain interpretative sovereignty. | Mobilize ILK systems and introduce them to global decision making;<br>Support more equal representation at the global scale and provide reflection on power dynamics;<br>Provide leadership, coordination, and more comprehensive visions and goals. | Provide an arena for sense making and learning;<br>Create space for deliberation, promote learning, and foster implementation of lessons learned;<br>Connect actors from local to global scales to jointly derive lessons learned. |
| Knowledge brokers | Promote cooperation and facilitate interaction;<br>Enable active, open, and accessible communication;<br>Support disadvantaged actors through capacity building, teaching, mentoring, and mediating different perspectives. | Translate, tailor, and communicate place-based knowledge to decision makers;<br>Mediate differences, enhance mutual understanding, and create common ground;<br>Take a leading role in the joint production of boundary objects and establish forms of cooperation that are perceived as legitimate. | Create decision maker buy-in at the global scale through building strong relationships and powerful networks;<br>Advise decisions by using place-based research to directly inform global decision making;<br>Promote a culture that values the use of place-based research for global decision making. | Facilitate learning through scale-spanning activities, built networks, and relationships;<br>Facilitate workshops and deliberative dialogues to jointly identify lessons learned;<br>Reflect on the use (and non-use) of knowledge and promote transformative debate. |
| Boundary organizations | Make place-based knowledge actionable for decision making;<br>Provide a forum to jointly develop boundary objects;<br>Bridge social and cultural divides, link diverging time scales, and generate stakeholder buy-in. | Promote cross-boundary cooperation in the science-policy interface;<br>Help to identify preferences of decision makers for knowledge dissemination and uptake;<br>Connect the legitimacy of knowledge producers to decision-making spheres to prevent undermining or offensive actions. | Monitor dynamic and non-linear flows of knowledge in the science-policy interface and trends in global decision making;<br>Help understand when, how, and why an issue receives attention and identify effective frames. | Promote communication and collaboration between knowledge producers and users to jointly identify and retain lessons learned;<br>Develop learning networks, enabling dynamic interaction among actors to reflect on experiences. |
| Institutionalized knowledge governance | Fosters long-term stakeholder engagement and builds on existing relationships and mutual trust;<br>Provides space to address complexity and conflict;<br>Allows to reshape rigid structures and include emergent groups. | Navigates credibility, salience, and legitimacy of knowledge in different contexts;<br>Balances relevance for global users and legitimacy of local knowledge producers;<br>Connects diverging time scales of place-based research and decision making. | Creates awareness of and addresses structural barriers to knowledge use at the global scale;<br>Sustains and essentially bakes-in knowledge transfer activities to the science-policy interface;<br>Allows for continuous adaptation to complexity and knowledge use in different contexts. | Establishes reflection and learning as a systematic and legitimate part of knowledge transfer;<br>Provides permanent space for capacity building and contributes to the long-term value of recording lessons learned;<br>Increases transparency and helps actors develop skills to assess knowledge and criteria for the joint identification of lessons learned. |
| Polycentric governance systems | Enhance bottom-up agility;<br>Support disadvantaged actors in developing a basic level of agency;<br>Elevate marginalized agendas, question dominant agendas, navigate conflicting agendas, and explore diverse agendas. | Facilitate (co)-synthesis activities of different actors at various scales;<br>Deal swiftly with changing perceptions of credibility, salience, and legitimacy;<br>Link local and global perspectives and navigate complexity and cross-scale interaction, enhancing traceability and transparency. | Increase connectivity between scales and actors;<br>Provide functional redundancy and institutional diversity, creating institutional fit and more adequate responses;<br>Emphasize the need to diversify knowledge systems used in global decision making. | Allow capitalization on scale-specific knowledge and include lessons learned from different perspectives;<br>Foster deliberation and learning by facilitating cross-scale exchange of knowledge and experiences. |

can create permanent space for capacity building and synthesis activities, helping to balance relevance for global knowledge users and legitimacy of local knowledge producers (ID 6). By providing a long-term perspective on knowledge synthesis, institutionalized knowledge governance can connect diverging time scales of place-based research and decision making, hence addressing complexity (Reyers et al. 2015; ID 4).

Polycentric governance systems can facilitate knowledge synthesis activities of different actors at various scales and deal swiftly with changing perceptions of credibility, salience, and legitimacy (Biggs et al. 2012, Carlisle and Gruby 2019; ID 6). The multiple, nested decision-making centers of a polycentric governance system enable the linking of local and global perspectives, navigation of complexity and cross-scale interaction, and the enhancement of traceability and transparency (ID 6).

**How can place-based knowledge use at the global scale be facilitated?**

Bridging organizations are crucial for mobilizing ILK systems and for their introduction to global decision making (ID 9). Bridging organizations of the Majority World especially can support equal representation of stakes and values at the global scale and can provide reflection on ideologies and agendas likely to be strengthened or threatened at the global scale (ID 4; Table 1). We refer to "Majority World" instead of "Global South" (and "Minority World" instead of "Global North") to remind the

presumably mostly Western science-related readership that we are but a small minority on the globe. By linking a diversity of networks, knowledge systems, and values, bridging organizations can provide leadership, coordination, and more comprehensive visions and goals (Berkes 2009).

Knowledge brokers remove barriers to knowledge uptake and create decision maker buy-in at the global scale through building strong relationships and powerful networks (Cvitanovic et al. 2015; ID 3). Knowledge brokers can advise global decision making by using place-based research and promoting a culture that values and emphasizes its complementary role and promotes balanced perspectives (Cvitanovic et al. 2015, Neal et al. 2023; ID 6). One example of a knowledge broker acting at the global scale is a researcher in environmental law and policy who is also Ambassador for Climate Change and Environment for the government of Tuvalu: "His brokering work involves the effective representation of Small Island Developing States in global climate negotiations and creating momentum for their interests on a global stage" (ID 4).

Boundary organizations help monitor dynamic and non-linear flows of knowledge in the science-policy interface and trends in global decision making (Young et al. 2014, Gustafsson and Lidskog 2018; ID 6, 7). They can help to better understand when, how, and why an issue receives attention and create buy-in at the global scale (Jones 2005, Rose et al. 2020; ID 2, 4). For example, boundary organizations can identify effective frames, such as "fit within," radical or innovative frames, to open up attention pathways for decision makers (Lakoff 2010, Clark et al. 2016; ID 4).

Institutionalized knowledge governance at the global scale creates awareness of and addresses systemic barriers to knowledge use. It can sustain and essentially bake-in knowledge transfer activities to the science-policy interface, which accelerates action at the global scale (ID 3). Institutionalized knowledge governance allows for continuous adaptation to complexity and knowledge use in different social, political, and cultural contexts. Thus, it can stimulate systematic use of place-based knowledge in the complex patchwork of global decision making.

The presence of multiple, local to global, nested decision-making centers in a polycentric governance system increases connectivity between scales and actors. It can result in a set of institutions (as opposed to individual ones) to collectively structure knowledge use (Carlisle and Gruby 2019). The resulting functional redundancy of diverse institutions can mitigate the risk of institutional failure and lack of social legitimacy. This way, functional redundancy positively contributes to creating institutional fit and enhances the adaptive capacity of institutions (Schoon et al. 2015, Lubell and Morrison 2021). Finally, polycentric governance systems emphasize the need for diversifying knowledge systems used in global decision making (Bulkeley 2005, Stone 2019; ID 5, 6).

**How can place-based knowledge revision and lessons learned be facilitated?**

Bridging organizations bring together different knowledge systems and provide an arena for sense making and learning (Berkes 2009; Table 1). By creating and maintaining space for deliberation, bridging organizations can connect actors from local to global scales and promote learning and implementation of lessons learned (Clark et al. 2016; ID 7).

Learning is facilitated by the scale-spanning activities of knowledge brokers, as well as their ability to build networks and relationships (ID 8). Knowledge brokers can facilitate workshops and deliberative dialogues to jointly identify and formulate lessons learned and bring together knowledge systems from different scales. These brokers play a key role in reflecting on the use (and non-use) of knowledge in global decision making and in promoting transformative debate (Rushmer et al. 2019; ID 9).

Boundary organizations promote communication and collaboration between global knowledge users and local knowledge producers to get together and jointly identify and retain lessons learned (Crona and Parker 2012, Clark et al. 2016). They can support the development of learning networks across the science-policy interface and scales, enabling dynamic interaction among actors to share and reflect on experiences (Gustafsson and Lidskog 2018, Rushmer et al. 2019; ID 8).

Institutionalized knowledge governance establishes reflection and learning as a systematic and legitimate part of knowledge transfer instead of making it an add-on activity or afterthought. It can provide permanent space for capacity building and a more long-term perspective to revising knowledge use. Thus, institutionalized knowledge governance can augment the long-term value of learning and enable knowledge transfer as a cyclic process (Clark et al. 2016; ID 6, 9). This increases transparency and helps different actors to develop skills for assessing knowledge and establishing criteria for the joint identification of lessons learned (ID 6, 9).

Functional redundancy resulting from the presence of multiple, local to global, nested decision-making centers in a polycentric governance system provides multiple opportunities for learning. Polycentricity allows capitalization on scale-specific knowledge for feedback, thus including experiences and lessons learned from different perspectives (Biggs et al. 2012, Shipan and Volden 2012). For example, a polycentric governance system can account for feedback of government implementation agencies, providing insights on local preferences, feedback dynamics, and strategic decisions (Polman and Alons 2021).

## DISCUSSION

The iterative and exploratory methodology of our study enhanced the flexibility and openness of our approach and allowed us to capture narratives that emerged throughout the different lines of questioning. By triangulating data and methods, we could take a more critical perspective, reassess relevance of emerging topics from different perspectives, and embed interview information in the broader context of the literature reviews. Eventually, this helped us to develop further thoughts and explore novel and transdisciplinary perspectives.

Although this approach allowed for continuous reflection on the research process and the refinement of intermediate outputs, it comes with limitations. Our methodology made the research direction and outcomes dependent on the choice and order of interviewees, and their inputs. We recognized a pattern of reoccurring topics and saturation of information throughout the interviews. However, researchers interviewed in the initial stage were more likely to have a directional influence, while lacking the opportunity to provide feedback at a later stage.

The most notable shortcoming of this study relates to the absence of ILK producers, as well as the underrepresentation of knowledge systems of the Majority World in the interviews. In many place-based cases, knowledge transfer inevitably includes transfer of ILK systems. However, we only interviewed experts on ILK, rather than ILK producers. Although available time and resources did not allow otherwise, it skews the perspective and implies a drawback for the integrity of ILK systems (Tengö et al. 2017, Hill et al. 2020). The inclusion of ILK producers in the study would have led to different outcomes, for example, by featuring first-hand experiences and culturally rooted perspectives on place-based knowledge, and also by shedding light on the nuances and intricacies of transferring such knowledge, which may be overlooked or underestimated by experts on ILK alone. Likewise, our paper calls for greater integration of and emphasis on knowledge systems of the Majority World at the global scale. Regrettably, with most interviewees coming from the Minority World, the research does not do justice to its own claim. We hope that future research building on our findings can rectify this shortcoming and critically reflect on our study's findings and implications.

Reflecting on our novel place-based knowledge transfer matrix (Table 1), the level of abstractness increases as one moves from left to right and top to bottom. Although the first two steps are the most concrete and backed up with data, the third and fourth steps become vaguer and more diluted. This is because science and decision making are currently paying more attention to knowledge production and knowledge synthesis, and they tend to neglect knowledge use and knowledge revision and lessons learned in discourse and practice. Similarly, the first three facilitative factors are fairly precise and tangible, whereas the last two are more abstract and difficult to implement. The reason is that bridging organizations, knowledge brokers and boundary organizations are more easily integrated into existing systems of science and decision making, while institutionalized knowledge governance and polycentric governance systems may require more fundamental system changes.

A gradient becomes apparent, as abstractness and complexity increase with each step and factor, but so does their leverage potential. This has important implications for the implementation of our conceptual framework because it is highly context dependent. Our five proposed factors target different levels (e.g., individual, team/group, organizational, institutional), time scales (e.g., short-term, medium-term, long-term), and intervention areas (e.g., policy or research design vs. implementation). As a result, their effectiveness depends on contextual conditions. For example, it may be more useful to include a bridging organization in an ongoing knowledge co-creation process to foster cooperation between actors and create trust. However, when writing a grant proposal to a funding agency, it may be more powerful to make institutionalized knowledge governance an explicit part of the proposal, to establish learning as a systematic part of research and contribute to the long-term value of knowledge transfer. In addition to the complexities highlighted, the five factors are likely to interact and partly overlap in practice, underscoring the need for nuanced understanding of their interplay and deliberate, context-dependent decisions about their application, embracing the intricate nature of place-based knowledge transfer.

Consequently, the first steps and factors are not of higher quality or importance, our place-based knowledge transfer matrix rather hints to the structural challenges when aiming to upscale and generate action of knowledge transfer. These challenges are multi-faceted and involve different aspects related to actors, institutions, power dynamics, logistics, and spatial and temporal scales (see for example Ramsey et al. 2019, Bennett et al. 2021b). We therefore discuss two major challenges that we found to be persistent when looking at place-based knowledge transfer in a local-to-global and knowledge-to-action context. These challenges are both policy-related and significant research questions. Related to each challenge, we provide some preliminary ideas and reflections about ways forward.

**Challenge #1: how to undo dominant power relations and the epistemic status quo?**

Place-based research contributes to a better understanding of global social-ecological dynamics by providing complementary knowledge and by accounting for local contexts. It explores solutions that engage ILK producers and systems. These solutions often require making choices in relation to temporal, spatial, and social trade-offs, and different groups of actors will have different visions about and interests in these.

However, stakeholder groups might lack access to decision-making processes, and knowledge systems may not be equally acknowledged or considered part of knowledge use at the global scale. Hence, place-based research often explicitly addresses power struggles and justice issues in place-based knowledge production and synthesis (Chambers et al. 2022). Therefore, place-based knowledge transfer might be seen as undesirable by certain actors who may thrive in the current system and whose position could be threatened (Clark et al. 2016; ID 4).

Degrading knowledge transfer to a one-way process, instead of acknowledging its iterative and cyclic character, may help maintain the epistemic status quo (ID 3). The same effect can occur with regard to the overrepresentation of Minority World knowledge systems in global decision making (Lam et al. 2020). Maintaining the status quo, and thus the dominance of these knowledge systems, may be in the interest of many decision makers, especially those in the Minority World (Latulippe and Klenk 2020), and connected to their socioeconomic and political interests (Biermann 2021). Hence, there might be low incentive to foster transfer of knowledge from diverse contexts, which may problematize and challenge the dominance of knowledge systems from the Minority World.

**Ways forward #1: opening up global decision making to more diverse knowledge systems**

The transfer of place-based research is a powerful means to introduce a diversity of knowledge systems to global decision making. It makes decision making more inclusive, more representative, and aligned with issues of justice, power, and equity. Therefore, it is seminal to acknowledge the complementary function of place-based knowledge for global environmental governance (Balvenara et al. 2017a, Martín-López et al. 2020). Especially in contexts of pronounced power asymmetries, structural inequalities, marginalization, and exclusion as well as unequitable distribution of benefits and burdens, structural integration of diverse knowledge systems can have particular leverage.

Place-based knowledge offers different perspectives to understanding global sustainability, especially to tackle wicked problems and persistent lock-ins to socially and environmentally damaging pathways. It brings the urgency of complex global challenges and possible ways forward to a level in which solutions can be concrete and implemented. This way, place-based knowledge transfer can play a central role in opening up transformative pathways toward more sustainable and just futures (Norström et al. 2017, Bennett et al. 2021b).

Our conceptual framework shows that place-based knowledge transfer involves many potential pitfalls, if not considered carefully, for example, related to the limited scalability and context dependency of knowledge. To address these potential pitfalls, research networks and purpose-built case study networks are important for connecting different knowledge systems, identifying commonalities, maintaining their integrity across scales, and jointly drawing lessons (Horlings et al. 2020). Particularly when aiming to upscale place-based knowledge, intergovernmental organizations and bodies, such as IPBES, provide a useful platform to create leverage for and promote knowledge transfer across scales that does not undermine or harm ILK systems. To apply ILK systems at global scales in ways that are culturally appropriate and maintain integrity, it is crucial to use methods that are based on deeply respectful and trusted relationships. This entails not only the information of and communication with ILK producers, but their active involvement in discussions on how their knowledge is to be applied and in the actual implementation processes (Hill et al. 2020).

Furthermore, we note that marginalizing or excluding knowledge systems from global decision making often leads to social-environmental injustices (e.g., Biermann 2021, Fletcher et al. 2021, Ottinger 2023). Entrenched conflicts leave a legacy of resentment and mistrust that can easily turn into protest or sabotage (c.f. IPBES Values Assessment 2022, Pascual et al. 2023).

Place-based knowledge transfer is a crucial means to align global policy goals with local instrumental and relational knowledge and values, thus helping to address conflicts and injustices. Opening global decision making up to more diverse knowledge systems enhances distributional and procedural justice. This creates a sense of co-ownership and legitimizes decisions and their impacts. Legitimacy must be "actively sought and earned" (Matson 2016:116). Together with conflict resolution and the complementary function of place-based knowledge, increased legitimacy forms crucial motivation for actors to account for a diversity of knowledge systems.

The IPBES Values Assessment (2022) proposes governance structures that give voice to and act upon diverse knowledge systems, for example, through citizen engagement and public deliberation. Institutions can be stimulated to allow for place-based knowledge transfer by creating societal pressure and emphasizing the interconnectedness of people and nature, sustainability and justice, and present and future generations. Future research can dive deeper into these questions and illuminate which institutional reconfigurations, at multiple governance levels, would support epistemic diversity and justice-informed knowledge transfer.

Local to global change in institutional arrangements and shifts in societal goals and norms are needed to integrate diverse place-based knowledge into global decision making. Ultimately, this strengthens the values of democracy and justice in global SES governance.

**Challenge #2: how to transform short-termism in science and policy?**

Our results suggest that the added value of knowledge transfer requires long-term orientation and commitment. It builds up gradually and becomes evident over time. However, long-term commitment clashes with predominant procedures and accountability mechanisms within science and policy, focused on short-term gains and immediate impacts. Hence, the long-term value of knowledge transfer is not fully acknowledged and exploited.

Researchers face the pressure to publish cross-cutting results as often and quickly as possible to maintain their position or advance their career (ID 8, 10). Although the increasing prominence of place-based research is an opposing trend, most efforts to enhance knowledge transfer are limited to knowledge production and synthesis, rather than considering knowledge use, revision, or lessons learned. Hence, the institutional setting, research design, and funding criteria of science hamper efforts to explicitly account for knowledge transfer (ID 5, 6, 8).

Decision makers tend to focus on short-term, more visible gains to legitimize their own actions and impact in the present (Povitkina 2018, Martin et al. 2020; ID 4). Particularly in the Minority World, decision making is guided by employing "useful" scientific knowledge and neoliberal capitalist principles, thereby placing great value on short-term productivity and extractivist growth paradigms (Sjöblom et al. 2012). This so-called "short-termism" is in deep conflict with the place-based knowledge transfer, which aims to cultivate and share existing research, foster ongoing mutual learning, and follow collective interests.

The temporal delay of benefits resulting from knowledge transfer poses a dilemma for both researchers and decision makers (Martin et al. 2020, O'Mahony 2021, Winkler et al. 2021; ID 5, 10). Given the non-linear characteristic of place-based knowledge transfer, it is unlikely that those bearing the costs of establishing effective and durable knowledge transfer will also be recognized and credited for the positive outcomes occuring years later. As a result, the incentive to take responsibility for such a complex and costly endeavor is low (Chambers et al. 2022). One could argue that knowledge transfer is a tragedy of the commons for actors of the science-policy interface.

**Ways forward #2: prioritizing learning over knowing**

Currently, knowledge transfer in science and policy is frequently considered implicit or additional. However, it is imperative to embed knowledge transfer structurally and prioritize it as a social learning goal to make it an established part of the science-policy interface. Therefore, a paradigm shift toward learning over knowing, i.e., recognizing the long-term value of knowledge transfer, is urgently required. In the domain of global social-ecological sustainability, short-termism (in science, economics, and policy) seems to have caused multiple crises, making long-term thinking and commitments especially pertinent (Krznaric 2021).

For science, this would mean a shift in institutional environment, providing the structure and coordination needed for meaningful knowledge transfer (Balvanera et al. 2017a, Bennett et al. 2021a). Institutional norms, incentives, and funding mechanisms need to be established to account for knowledge transfer in research design from the onset. Time, funding, and personnel must be allocated to knowledge production and synthesis but also to knowledge use, revision, and lessons learned (ID 5, 7). This requires the establishment of novel procedures and practices at different scales, the cultivation of reflection and revision activities, and the systematic recording of lessons learned (ID 5).

Additionally, transdisciplinary research teams, communities of practice, and case study and research networks, such as PECS, can help sustain knowledge transfer activities (Bennett et al. 2021a, Calderón-Contreras et al. 2022). By providing a platform for coordination and deliberation, research networks have significant opportunities for knowledge sharing and transfer in the science-policy interface (Martín-López et al. 2020, Neelakantan et al. 2021).

Realizing deep-rooted structural changes in academic institutions can have leverage for scientific disciplines that address complexity and lock-ins to socially and environmentally damaging pathways, e.g., complex systems science, transformative change research, institutional analysis, or resilience studies.

For policy and decision making, the short-term orientation of institutional legitimacy and accountability needs to be addressed if a paradigm shift toward learning over knowing is to be achieved. Temporal delay effects resulting from knowledge transfer need to be bridged in policy frames that value relevant knowledge and impact. It is important to underline the interconnectedness of the knowable present and the uncertain future. Both responsiveness and adaptability are important to address temporalities in policymaking (Convery and Wagner 2015) and the utter contingency of short-term knowledge. This also applies to other wicked problems with low visibility, which require a complex mix of instruments and multi-pronged institutions (Povitkina 2018). Enabling structural institutional change could be most effective in policymaking spheres that imply long-lasting impacts on SES, such as urban and infrastructure planning, natural resource management, as well as fiscal and macroeconomic policies.

Environmental psychology studies show that reduced temporal discounting, i.e., higher future valuation, fosters the adoption of long-term decision-making strategies and behaviors (Griskevicius et al. 2012, van der Wal et al. 2013, de Leeuw et al. 2015). Thus, improved academic understandings of these temporal dynamics and future discounting can help to promote the long-term value of knowledge transfer.

To bridge delay effects of knowledge transfer and account for temporal mismatches between research and decision making, perceived legitimacy of decision makers and their actions needs to be disentangled from the temporal dimension. Therefore, it is seminal to increase transparency and traceability of knowledge and actions used and inform on the temporality of giving credit to actors or holding them accountable. Similarly, mechanisms that systematically ensure accountability and the maintenance of credits are promising (Lidskog and Elander 2009, Stone et al. 2020). For example, organizational mentioning, or logbook systems can incentivize decision makers to commit to knowledge transfer in the long run. Also, inclusive knowledge sharing and transfer platforms can be valuable and relatively easy to access, for example, regarding ILK systems (Shawoo and Thornton 2019).

Finally, and in line with the IPBES Values Assessment (2022), a broader shift away from the predominant value system of decision making is required, from one that over-emphasizes short-term policy thinking and neoliberal capitalist principles. This entails opening up and redefining key concepts such as development and well-being and aligning societal goals more strongly to values like social-environmental justice, stewardship, and responsibility. Place-based knowledge transfer is enhanced by challenging dominant values and agendas and elevating marginalized knowledge systems, particularly of the Majority World, as well as ILK systems.

**Author Contributions:**

*Eva Sievers: conceptualization, methodology, analysis, writing - original draft, writing - review and editing, visualization, project administration Marja Spierenburg: conceptualization, writing - review and editing Shivant Jhagroe: writing - review and editing, supervision Alexander van Oudenhoven: conceptualization, methodology, writing - review and editing, supervision*

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**Data Availability:**

*Data available on request because of privacy/ethical restrictions. The data that support the findings of this study are available on request from the corresponding author (E.S.). None of the data are publicly available because they contain information that could compromise the privacy of research participants.*

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APPENDIX – METHODS

This paper applied an exploratory and iterative methodology that involved a combined approach of alternating rounds of academic literature reviews and in-depth interviews with researchers of different disciplines.

**Literature reviews**

For the literature search we used the SCOPUS database and the catalogue of Leiden University Libraries. For the first literature review we took a broad approach in the beginning, thus used broad search terms, which we gradually narrowed down by using the "Advanced Document Search" function and combining different search terms (see below). As this literature review had the aim to scope the research and get a state-of-the-art overview, we selected articles by filtering publications by "Cited by (highest)" and "Date (newest)". The approach of the second literature review was already narrower, focusing on social-ecological literature only. Based on the search results using the search terms below, we compiled a pool of research papers that were most relevant to the research objective of the study. Ultimately, we selected two key publications: First, we selected the paper of Balvanera et al. (2017a), as it is the most cited paper dealing with place-based knowledge transfer in a local-to-global context. Second, we opted for the paper of Bennett et al. (2021a), as it is one of the most recent publications that addresses general challenges of place-based knowledge transfer. To yield further literature, we used a snowballing approach to the key publications' listed references and recommended readings. The third literature review examined transnational governance literature. We first reviewed literature that addresses climate action, as this is the most developed research area for transnational governance. We further specified the search by adding more targeted search terms (see below).

| Round | Search terms |
|---|---|
| Literature review 1 | "Knowledge AND Transfer"; "Knowledge AND Transferability"; "Knowledge AND Translation"; "Knowledge AND Synthesis"; "Knowledge AND Transfer AND Sustainability"; "Knowledge AND Transferability"; "Knowledge AND Transfer AND Natural AND Resource"; "Knowledge AND Transfer AND Environmental AND Sustainability"; "Knowledge AND Transfer AND Social-ecological AND System"*; "Knowledge AND Transfer AND Place-based AND Research"* |
| Literature review 2 | "Knowledge AND Transfer AND Social-ecological AND System"*; "Knowledge AND Transfer AND Place-based AND Research"*; "Knowledge AND Transfer AND Upscaling"; "Place-based AND Research AND Interconnectedness"; "Place-based AND Research AND Global AND Sustainability"; "Place-based AND Research AND Action"; "Place-based AND Research AND Decision AND Scale"; "Place-based AND Research AND Cross-scale AND Transfer"; "Place-based AND Research AND Governance AND Local AND Global" |
| Literature review 3 | "Knowledge AND Transfer AND Transnational AND Governance"; "Knowledge AND Translation AND Transnational AND Governance"; "Transnational AND Governance AND Policy AND Translation"; "Transnational AND Governance AND Natural AND Resource"; "Transnational AND Climate AND Governance"; "Transnational AND Environmental AND Governance" |

**Principles "coverage" and "balance"**

We used the two principles "coverage" and "balance" from Watts and Stenner (2012) to bridge literature reviews and conceptualization of key steps and facilitative factors and ensure inclusiveness of all relevant ground and a range of perspectives, as well as avoid overlap, distortion or bias. To achieve this, it was useful to think of each potential key step and facilitative factor as an individual carpet tile. Each "tile" making its own contribution, the totality represents a neat surface without gaps or redundant overlaps (Watts, 2008). For example, the literature on knowledge transfer often mentions both "knowledge synthesis" and "usable knowledge". Instead of including both in our conceptualization, we followed the coverage principle and found that "usable knowledge" has overlaps with both "knowledge synthesis" and "knowledge use". Therefore, we did not include it as an additional key step in our conceptualization. Applying this strategy allowed us to step- by-step essentialize the information extracted from the three literature reviews, until the key steps and facilitative factors represented all relevant ground without gaps, overlaps or ambivalence. This intermediate step resulted in draft conceptualizations of key steps and facilitative factors of place-based knowledge transfer, which served as a basis for the final interview round.

**Interview rounds**

A brief description of the interviewees' expertise and research field can be found in the table below. To account for the iterative nature of interviews, we used immanent questions, a strategy frequently used in narrative interviews, for the second interview round. Immanent questions directly relate to what has just been said and pick up on previous statements or information given. Although they bring forward topics of the interviewee, immanent questions should always be anchored in the interviewer's broader narrative of the interview guide. This way we connected topics brought forward by the interviewee with pieces of information from previous

interviews to see whether something new emerged from it. We used immanent questions for requesting more details, filling gaps, furthering thoughts and clarifying statements (Przyborski and Wohlrab-Sahr 2013).

| ID | Brief description of interviewees |
|---|---|
| ID 1 | The first interviewee works as researcher with an applied focus on knowledge valorization, policy and governance. In this context, they deal with issues such as knowledge translation, transfer, uptake and research evaluation. |
| ID 2 | The work of interviewee 2 is divided between research and practical application of engagement, knowledge transfer, learning theories and science communication. Currently, s is involved in a project by building knowledge systems for resilience across governance levels. |
| ID 3 | The research of interviewee 3 centers around the effective management of multiple ecosystem services, investigating interactions, benefits and trade-offs among them. Additionally, the interviewee is involved in the Programme on Ecosystem Change and Society, a research network comparing place-based, long-term social-ecological cases. |
| ID 4 | Interviewee 4 is involved in global and transnational environmental governance research. The interviewee particularly focusses on governance issues at the global scale, such as global justice and democratization, climate change and global governance and deliberative governance. |
| ID 5 | The research of interviewee 5 is mainly concerned with ecosystem services and related questions of equity in access, and drivers and consequences of social-ecological interactions and implications for sustainability. Additionally, the interviewee is involved |

| | |
|---|---|
| | in the Programme on Ecosystem Change and Society, a research network comparing place-based, long-term social-ecological cases. |
| ID 6 | Interviewee 6 is involved in research on the transferability of place-based knowledge across scales, and the tensions between local stakeholder engagement and global decision-making. They work at the science-policy interface, also at the global level. Additionally, the interviewee is involved in the Programme on Ecosystem Change and Society, a research network comparing place-based, long-term social-ecological cases. |
| ID 7 | The work of interviewee 7 is embedded in social-ecological resilience and biosphere-based sustainability science. The interviewee is engaged in place-based research and questions of global stewardship towards sustainability. Additionally, the interviewee is involved in the Programme on Ecosystem Change and Society, a research network comparing place-based, long-term social-ecological cases. |
| ID 8 | Interviewee 8 has expertise on environmental governance, networks, social-ecological systems and resilience, regional collaborative governance for sustainability, and the science-policy interface. Additionally, the interviewee is involved in the Programme on Ecosystem Change and Society, a research network comparing place-based, long-term social-ecological cases. |
| ID 9 | Interviewee 9 is a conservation scientist working as coordinator of a multidisciplinary network that aims to develop visions for social-ecological systems in a human-dominated conservation landscape. Additionally, the interviewee is involved in the Programme on Ecosystem Change and Society, a research network comparing place-based, long-term social-ecological cases. |

| | |
|---|---|
| ID 10 | Interviewee 10 is in the administrative lead of a large network monitoring, modelling and managing ecosystem services for sustainability and resilience. Their work involves community-engaged research to identify paths for sustainable landscape management. Additionally, the interviewee is involved in the Programme on Ecosystem Change and Society, a research network comparing place-based, long-term social- ecological cases. |

**Interview guide**

The conducted interviews are part of an iterative methodology approach. This means questions evolved throughout the interviews and were adapted depending on the interviewees' background and topics emerging. Therefore, the interview guide merely served as a basis, providing general orientation, rather than being prescriptive in nature. The interviews were conducted with high flexibility, sometimes more resembling a discussion-style format than a semi-structured interview. Hence, the list below provides a summary of general interview questions that were posed, not posed, or modified, depending on the interview dynamic.

*First interview round (scoping purpose):*

- How do you define knowledge transfer?
- Do different scientific disciplines use knowledge transfer differently?
- How do you distinguish knowledge transfer from other processes that involve knowledge transfer (e.g., generalizing, upscaling, mainstreaming, aggregating, comparing, synthesizing or integrating knowledge)?
- From your perspective, does knowledge transfer cover both a horizontal and vertical dimension? Or is there either a stronger horizontal or vertical focus?
- What are processes overarching knowledge transfer? What are subordinate processes?

- What are specific characteristics of place-based knowledge transfer? What are similarities to transfer processes of other knowledge types? What are differences?
- What implications result from knowledge transfer in a local-to-global dimension?
- What implications result from knowledge transfer in a knowledge-to-action dimension?
- What are key elements of knowledge transfer that you would highlight as particularly important?
- What are key steps of knowledge transfer that need to be considered?

*Second interview round (draft conceptualizations served as basis for interviews)*

- When looking at the draft conceptualization, are any important elements missing? Would you like to add anything to it?
- Do you think the conceptualization is appropriate to analyze the process of knowledge transfer? Do you think it is suitable to conceptualize it as a closed loop?
- What is important when place-based knowledge is transferred across scales, for example, from local to global?
- Why it is useful to transfer place-based knowledge to the global scale? What are the main benefits?
- What governance aspects and challenges arise from local-to-global knowledge transfer, and how can they be addressed? What are risks?
- What are characteristics of local or place-based research that are important to be maintained when knowledge is transferred across scales? And how can integrity then be ensured?
- How can mismatches (e.g., scalar, temporal or governance) be avoided or addressed?
- What needs to be taken into account so knowledge is perceived as credible, salient and legitimate by decision-makers?

- What factors enhance perceived credibility, salience and legitimacy of knowledge?
- What governance aspects and challenges arise from knowledge-to-action transfer, and how can they be addressed?
- From a social-ecological perspective, what elements related to knowledge transfer would you highlight as particularly important?
- From a transnational governance perspective, what elements related to knowledge transfer would you highlight as particularly important?
- From an attention politics/framing perspective, what elements related to knowledge transfer would you highlight as particularly important?
- From a politics of scale perspective, what elements related to knowledge transfer would you highlight as particularly important?
- What are your experiences with knowledge uptake? Do you have ideas on how it can be directed or enhanced?
- How can knowledge use be traced back in order to record lessons learned?
- How can you assess knowledge use at the global scale? What aspects could be added to this step to make it more comprehensive and tangible?
- What are factors that facilitate the transferability of place-based knowledge?
- How would you assess the impact of the following factors?
    - Regional collaborations and networks?
    - Research networks and communities of practice?
    - Bridging organizations?
    - Boundary organizations and boundary objects?
    - Active, iterative and inclusive communication?
    - Knowledge brokers?
    - Institutionalized and active knowledge governance?

    - Co-creation approaches?
    - Trusted relationships?
    - Inclusiveness, equity and integrity of knowledge systems?
    - Training, capacity building?
    - Bridging scales, embeddedness in larger system?
    - Involvement of transnational and non-state actors?
    - Adoption of both bottom-up and top-down approaches?
- What role do research networks such as PECS (Programme on Ecosystem Change and Society) play for knowledge transfer? And how can they foster the process?
- Is there an example of a PECS project that explicitly incorporates knowledge transfer activities?
- Can you give an example of a PECS project that addresses local-to-global or knowledge-to-action transfer?
- What are general challenges and opportunities PECS-related research has encountered throughout the process of knowledge transfer in a local-to-global and knowledge-to action context?

**Narrative interview elements**

Immanent questions directly relate to what has just been said and pick up on previous statements or information given. Although the focus is on bringing forward topics of the interviewee, immanent questions should always be anchored in the interviewer's broader narrative of the interview guide. This way, we connected topics brought forward by the interviewee with pieces of information from previous interviews to see whether something new emerged from it. We used immanent questions for requesting more details, filling gaps, furthering thoughts and clarifying statements (Przyborski and Wohlrab-Sahr 2013). Using

immanent questions to guide interviews places different demands on the interviewer. Despite the preparation of an interview guide, the interviewer has to settle in an immersive interview situation, requiring spontaneous interaction, creativity and openness to new opportunities and learning.

**Interview analysis**

The table below presents the codes used for the interview analysis. The codes were derived using a mixed inductive-deductive approach for meaning condensation. To reduce long statements into central themes, we determined natural meaning units first. Subsequently, we rephrased the natural meaning units as simple as possible to identify the central theme, which we then assigned to a broader code category (Brinkmann and Kvale 2018).

| **Key steps** |
|---|
| 1. Place-based knowledge production |
| 2. Synthesis/usable knowledge (credibility, salience, legitimacy) |
| 3. Knowledge use by decision-makers at the global scale |
| 4. Revision of knowledge use/lessons learned |
| **Facilitative factors** |
| a) Bridging organizations |
| b) Knowledge brokers |
| c) Boundary organizations |
| d) Institutionalized knowledge governance |
| e) Polycentric governance approach |