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Towards a practice framework for transdisciplinary collaboration in planetary health

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Abstract

Non-Technical Summary

Despite growing recognition of the importance of transdisciplinary research in addressing complex sustainability challenges, in practice it has been much hampered by persistent inequities, power disparities, and epistemological disconnect. Planetary health as an emerging field offers a unique lens highlighting the need for knowledge integration across the environment, health, and development (EHD) nexus. Drawing upon extensive analyses, including a meta-analysis of existing transdisciplinary frameworks, a literature review of practices in these fields, and a case study of a planetary health action research project in Indonesia and Fiji, we propose a framework to guide the design and implementation of transdisciplinary research.

Technical Summary

The proposed framework was iteratively designed, starting with existing frameworks, complemented by findings and practice recommendations from a literature review of 36 publications of recent transdisciplinary practices in the EHD fields and an in-depth case study of a planetary health research from Indonesian perspectives. The practice framework focuses on the stakeholder collaboration process, and emphasises reflexivity and co-learning throughout all research phases: initiation (co-design); implementation (adaptive co-management), and monitoring and refinement (co-monitoring). Foundational considerations for stakeholder engagement could inform process design by reflecting on stakeholder contributions, interactions, integration, and expected outcomes. As suggested by development studies, and implicitly agreed upon but insufficiently elaborated within environment and health, attention to the local context of the research, mapping of power dynamics, and the values of equity and inclusivity are pertinent if research is to produce credible, relevant, and legitimate knowledge and outcomes. A renewed focus on addressing power equities can help ensure stakeholders' perspectives and interests are equally valued and potential solutions are not inadvertently excluded as a legacy of systemic power imbalance. The practice framework is most effectively applied in the initial process co-design, by process initiators and funders assessing proposals for international transdisciplinary research in power-diverse settings or resource-poor contexts.

Social Media Summary

How can researchers across diverse fields collaborate with renewed focus on power inequities to accelerate progress towards the SDGs?

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1. Background and context

Transdisciplinary research approaches have been increasingly promoted and practised in order to co-produce knowledge and urgent action towards the 2030 Sustainable Development Goals (SDGs). In particular, the emerging field of planetary health calls for the expansion of transdisciplinary (TD) knowledge integration and collaboration amongst scientific disciplines, policy, and societal stakeholders for more significant impact and coherence, as systemic disconnect among sectors could potentially delay meaningful and lasting impact (Zeinali et al., 2020; Pongsiri et al., 2017). Planetary health also offers a unique lens highlighting the interconnections amongst the health of natural systems, human health, and socio-economic development, as evidenced by the irreversible harm to human and environmental health caused by socio-economic development systems during the Anthropocene (Whitmee et al., 2015). Previously, such interconnections were conceptualised by human ecologists as biosensitivity (Boyden, 2016, 2004) and echoed by proponents of a broader eco-epidemiological understanding of health (McMichael, 2013). Boyden (2016) also extensively underscores the importance of reducing disparities among all sections of humanity towards intergenerational equity. With the Leave No One Behind (LNOB) imperative at significant risk, collaborative efforts with greater emphasis on addressing inequalities could provide a worthwhile boost towards the SDGs (Browne et al., 2023). **Figure 1** shows the intersection of environmental sustainability, public health, and development, previously operationalised as the environment-health-development (EHD) nexus (Wardani et al., 2022).

In recent years, TD research has grown in importance and practice in the respective EHD fields; however, its practice remains undertheorised, underfunded, and underdeveloped (Brown et al., 2019; Brown et al., 2015). Theories, principles, and frameworks for TD research exist, but a number of gaps exist that merit deeper exploration. First, there has been little comparison and synthesis across these diverse yet interrelated fields in search of

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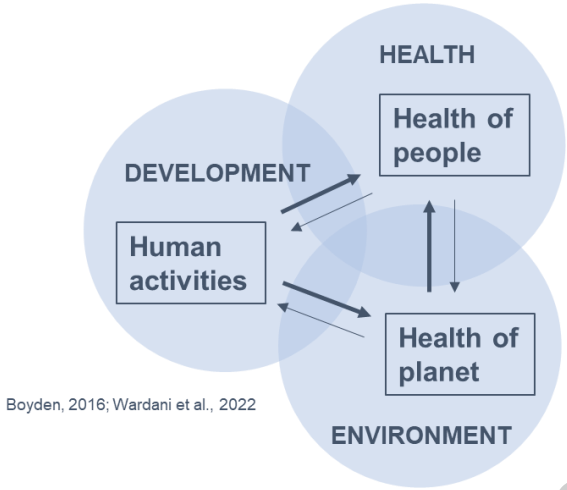
Figure 1. Biosensitivity and interconnections at the environment-health-development (EHD) nexus



common ground for collaboration. Meanwhile, increased breadth and scale of collaborations in planetary health could intensify challenges due to deep epistemological, methodological, and cultural differences among distant disciplines, sectors, and development contexts (Ely et al., 2020). Second, much TD research follows an ideal-typical, linear model of "linking knowledge to action," i.e. producing *then* applying knowledge, thereby compromising the immediacy and potential for transformative impact of an experimental approach to developing solutions (West et al., 2019). Third, the terms "collaboration" and "integration" have in many cases been used generically, but remain as black boxes without sufficient elaboration of how the process might unfold, especially in power-diverse contexts (Pohl et al., 2021). Finally, in light of widening global inequalities, TD collaboration between High-Income Countries (HIC) and Low- and Middle-Income Countries (LMIC) partners may not sufficiently consider disparities in higher education and research training and historical loss of indigenous knowledge (Jenkins et al., 2018). This is not surprising as most TD theories and frameworks have been conceived through HIC academic perspectives, e.g. Schneider and Buser (2018); Lang et al. (2012); Luederitz et al. (2017).

A brief review of transdisciplinarity across the EHD fields reveals some similarities and potential for complementarity, towards finding a common language which can help achieve common understanding and strategic alignment in addressing common risks and

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opportunities (Demaio & Rockström, 2015). TD scholarship in environment and health fields largely agree on the importance of local contexts and the value of local knowledge to ensure feasibility, relevance, and legitimacy (Luederitz et al., 2017; Peters et al., 2013). Likewise, planetary health scholars have emphasised the importance of local contexts and unique geographies, histories, economies, politics, and cultures (Capon, 2017). However, there has not been a thorough exploration into the perspectives of development studies and decolonising and indigenous knowledge scholarship and how these may be useful in understanding diverse contexts and knowledge systems (Odora Hoppers, 2011). These fields have deeply established the fallacy of universalising HIC theories without addressing the specificities and knowledge systems within LMIC contexts (Chakrabarty, 2000; Alsayyad & Roy, 2004; Roy, 2009, 2016). They have also drawn attention to differences in power and resource realities across HIC and LMIC research contexts (Littman et al., 2021). Indigenous scholars have similarly emphasised principles of holism, interconnectedness, self-determination and mutual respect, which are of major importance if indigenous and local knowledge were to contribute globally and locally relevant solutions (Smith, 2021; Kovach, 2009; Kimmerer, 2013; Archibald et al., 2019).

In bringing together diverse knowledge systems, the challenge remains how collaborations can transcend and equally value different disciplines, sectors, and cultures to produce credible, relevant and legitimate knowledge (Clark, van Kerkhoff, et al., 2016; Pineo et al., 2021). Planetary health scholars have articulated cross-cutting TD research priorities, involving diverse stakeholders in co-design and implementation, and striving for intergenerational equity (Ebi et al., 2020). However, the practice of TD research in planetary health needs more in-depth empirical exploration into recent practices, especially to understand how the process of integration and collaboration among disciplines and sectors may unfold in HIC-LMIC partnerships. As such, the literature on collaborative urban environmental governance may yield important insights, based on four decades of research and observation of collaborative practices (e.g. Innes & Booher, 2018). In addition, while

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some understanding of cross-disciplinary, team-based research have developed within public health (Hall et al., 2017), a more explicit theoretical and empirical synthesis of existing frameworks and practices among diverse fields at the EHD nexus is needed to understand the collaborative process itself, including the factors that may enable or constrain collaboration (Stokols, 2006), especially in LMIC settings.

In summary, this research seeks to address the abovementioned theoretical and practical gaps in the state of TD research, specifically the need for 1) explicit synthesis of recent TD practices and theoretical frameworks at the EHD nexus; 2) exploration of the collaborative environmental governance literature which may shed light on the collaborative process; and 3) deeper empirical understanding of the implementation of planetary health TD collaboration, especially from LMIC perspectives. The remainder of this section outlines the eventual aim of this research to develop a practice framework, while **Section 2** describes the empirical and theoretical analyses conducted to address the abovementioned gaps, and how their findings intertwine and contribute to the framework development process. The practice framework is presented in detail in **Section 3**, followed by a commentary on its application (**Section 4**) and some potential limitations of the framework in its infancy (**Section 5**).

Aim of the research

Against this background, this research draws upon extensive theoretical and empirical analyses to conceptualise a practice framework guiding the design and implementation of TD collaboration in planetary health conducted in LMIC settings. Typically, such collaboration would be initiated by HIC funders and researchers who then engage with LMIC academic, government, and community stakeholders. Empirical understanding of how such research is operationalised would provide rich insights into the process of collaboration and how diverse stakeholders and knowledges could come together in meaningful, relevant, and legitimate knowledge co-production.

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Defining a practice framework

A practice framework, as drawn from the field of social work, commonly combines formal theoretical knowledge, and knowledge accumulated through repeated practice (Healy, 2014, pp. 226-332)[1]. While most existing TD research frameworks describe the ideal-typical research process, a practice framework considers higher-level principles and institutional and cultural contexts driving action-oriented practice; conversely, it creates synergies in individuals' practices to be formalised into knowledge and institutionalise improvements in practice (Healy, 2014; Connolly, 2007). Another point of difference is explicit consideration of values, inclusion, and equity, as social work is a values-driven field serving disadvantaged communities.

Focus on stakeholder collaboration

The proposed framework aims to bridge theory and practice by focusing on the praxis of collaboration among stakeholders, providing guidance for practice and a tool for restructuring current institutional contexts of knowledge production (Giddens, 1984). As mentioned earlier, existing frameworks do not specifically elaborate on the stakeholder collaboration process e.g. Lang et al. (2012); Luederitz et al. (2017); Newell and Proust (2012); hence our framework aims to address this gap. The framework is intended to be inclusive, bringing together diverse stakeholders, serving as a "boundary object" (Star & Griesemer, 1989) to enable collaboration. To encourage mutual exploration and understanding, the framework is developed through a bricolage[2] of concepts broadly accepted in the EHD fields, an emergent construction fitted and combined with findings from the literature review of recent practice and planetary health priorities. While some may argue

[1] In social work, a practice framework **'integrates empirical research, practice theories, ethical principles, and experiential knowledge in a compact and convenient format that helps practitioners use the knowledge and principles to inform their everyday work.'** A practice framework is a mapping out of the rationale for practice, and is often devised at a scale where values, theories, and practice are clearly linked. Its purpose is to provide schematic guidance for improving, analysing, and reforming practice (Stanley, 2016).

[2] In qualitative research, bricolage is an interpretive piecing together of concepts, methods, and representation fitted to the specifics of a complex situation in an emergent fashion (Denzin & Lincoln, 2011).

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the fallacy of achieving consensus amidst stakeholder diversity (Nogueira et al., 2021), consensus is not expected in all situations but the process would be actively facilitated to orchestrate and navigate diverse contributions, interests, and power dynamics towards mutual respect and benefit (Touati et al., 2019).

Audience

The intended audience of the practice framework would be the stakeholders of research as a process of knowledge production. A broad definition of the term "stakeholders" is used to signify actors with an interest in and are affected by the governance decisions and sustainability challenge being addressed, including those with relevant knowledge and other resources to contribute, and those who benefit from or are adversely impacted (Deverka et al., 2012). Such a diverse stakeholders setting is expected to be of considerable contestation and unequal power dynamics, requiring a high degree of stakeholder engagement (Schneider & Buser, 2018). Nevertheless, such diversity is crucial for the knowledge produced to pass the credibility, relevance, and legitimacy (CRL) criteria (Clark, van Kerkhoff, et al., 2016), and reflects the breadth of stakeholders in planetary health or sustainable development. Ideally, the audience of the framework would be all research stakeholders, i.e. funders in the public and private sectors, academic institutions and researchers, government, civil society organisations, and communities. This inclusive definition adds a transparency and legitimacy towards a common vision by forming a picture of the whole process for all stakeholders to perceive their potential roles.

When and how to use the framework

We define transdisciplinarity as a research approach involving academic and non-academic stakeholders with a view towards societal application, including action research that simultaneously integrate policy, physical or health innovations. Application to solving societal challenges is needed to accelerate progress towards the SDGs, especially action research by iteratively adapting the intervention through experimentation and reflexivity (Wiek et al.,

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2017). Application of the research could involve developing a novel community infrastructure, or a cross-cutting environment, health, and equity policy (Ebi et al., 2020; West et al., 2019; ISC, 2023).

Hence, the practice framework could be used by stakeholders to provide guidance for reflexivity and co-learning: 1) during the design and inception stage, 2) at multiple points during the process as a continuous monitoring tool, and 3) as a post-mortem evaluation tool to identify refinements and lessons for future TD collaborations, especially in LMICs. Lessons learned could include elements that have worked better than others, and potential reasons for unrealised or unintended outcomes. However, as elaborated in **Section 4**, the framework would be most effectively applied at the pre-development and co-design phase by process initiators and funders assessing TD research proposals for potential funding.

2. Methodology and framework development approach

The practice framework development took place from 2019 to 2023 and incorporated three areas of extensive analyses, namely a literature review, an empirical case study, and a meta-analysis of frameworks. The findings and practice recommendations from these previous analyses are described in detail in **Table 1**, which also provides examples of how they were translated into the framework. In summary, the literature review of practice **(Section 2.1)** identified a leverage point for transformative change in knowledge production systems, in which funding institutions play a pivotal role in influencing project design. Funding institutions are hence identified as one of the primary audiences of the framework. The empirical case study **(Section 2.2)** yielded two publications: the first (Wardani et al., 2023) highlighted the essential elements of collaboration as experienced from LMIC perspectives, which were included as Foundational Considerations **(Section 3.2.1)** around stakeholder engagement in the practice framework; while the second (Wardani et al., forthcoming) illuminated the factors and key stakeholder processes occurring at different stages of the collaboration outlined in the framework, e.g. Stakeholder Contexts

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corresponding with Structural Factors, Stakeholder Contributions with Input Factors, etc. The meta-analysis of frameworks **(Section 2.3)** identified the research phases **(Section 3.1)**, and Foundational Considerations gleaned from development studies around Local Context, Values & Ethics, and Power Dynamics; while TD research frameworks in environment and health enabled the construction of the stages of collaboration (Structure, Input, Process, Output, Outcomes) **(Sections 3.2.2 to 3.2.5)** and the crucial role of Reflexivity and Co-Learning **(Section 3.3)**.

Table 1. Summary of findings and practice strategies from previous analyses
(Tables are pasted in-text for indicative purposes only. See full size tables at the end of this document.)

Publications	Findings	Practice strategies	Examples of translation into practice framework
Wardani et al. (2022). "Enabling transdisciplinary research collaboration for planetary health: Insights from practice at the environment-health-development nexus." *A literature review of 36 publications of recent transdisciplinary research practice, synthesising insights and lessons learned through qualitative thematic analysis across the EHD fields*	• Funding institutions were at the fulcrum of transformative shift, with knowledge and financial resources as leverage	• Balanced inter- and transdisciplinary evaluation process for funding • Flexible timelines allowing open-endedness of outcomes	• Funders identified as providing **structure** shaping the design of a collaboration (Sec 3.2.2) and **primary audience** of framework (Sec 1.1, Sec 4) • Building in **learning and reflexivity** into TD collaboration (Sec 3.3) and in co-monitoring of outputs and outcomes (Sec 3.2.4 and 3.2.5)
	• Project and organisation structures were also enabling as it spans structural, relational, and individual levels, especially in supporting boundary-spanning efforts • Relational factors such as communication and boundary-spanning were the most enabling, but requires much effort and resources by individuals	• Complexity-aware, adaptive project management allowing time for boundary-spanning • Institutional support for collaborative research	• Project design should budget time for the collaborative **process** to allow for adequate social interactions and multi-way and repeated communications (Sec 3.2.4) • Stakeholders' **institutional context** can provide structure and support (Sec 3.2.2)
	• Structural factors were the most constraining, incl. lack of understanding of local socio-cultural and historical contexts and inherently unequal power dynamics; and disciplinary structure of academia • Individual personal characteristics could either constrain or enable collaboration, but experience and training can increase researchers' capacity	• Engage and support LMIC partners in research design and priority- and agenda-setting and build LMIC capacity for research design, data analysis, and publications • Build HIC researcher capacity for inter- and transdisciplinary research, cross-cultural learning e.g. anthropological approaches, sensitivity to underlying power relations	• **Flexibility in project design** to allow for equally valuing all stakeholders' priorities and interests (Fig 2, Sec 3.1) • **Local context, values and ethics, and power dynamics** as foundational considerations (Sec 3.2.1)

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Wardani et al. (2023). "Boundaries as spaces of knowledge integration: Learning from transdisciplinary collaboration on planetary health in Indonesia." *Findings from empirical case study on understanding the essence of collaboration through Indonesian perspectives.*	• Indonesian stakeholders contributed a plethora of disciplinary and non-disciplinary knowledge and other resources, highlighting a web of interdependence of stakeholders' diverse interests and contributions • Opening up of boundary spaces was key to multi-directional knowledge integration, with varying types of interactions observed among stakeholders • Important roles of Indonesian stakeholders as providing 'holding space' for local and indigenous knowledge and cultural predisposition towards plurality, collaboration and mutual assistance • Pertinent themes identified include diversity and interdependence, complementarity, reciprocity, recognising interlinkages, mutual learning, and innovation	<u>For HIC funders and researchers:</u> • Require all (HICs and LMICs) stakeholders to be engaged in research priority-setting and design • Allow more flexible timeline and budget for meaningful engagement and integrating historically undervalued LMIC perspectives and contributions • Create time and space for LMIC partners to co-lead based on their interests and knowledge • Identify interdependent and complementary relationships and potential interaction challenges <u>For LMIC researchers and practitioners:</u> • Recognise the knowledge, skills and other contributions as well as expectations of benefits & outcomes • Request that authorship include LMIC partners and time and space for LMIC-led publications • Support co-design processes to meet national and community priorities • Recognise that collaboration depends on meaningful engagement of all stakeholders (HICs and LMICs)	• **Stakeholders' diverse contributions** (Sec 3.2.3) need to be equally valued • Creation of safe spaces for **stakeholder interactions** through **facilitative co-leadership**, culture of openness and inclusivity, and social learning (Sec 3.2.4) • Importance of **local context** and operational conditions as foundational consideration (Sec 3.2.1) • **Diversity and interdependence** are part of Foundational Considerations (Sec 3.2.1) • LMIC stakeholders' involvement in identifying local priorities in **research co-design** (Phase 1, Sec 3.1) and in producing research publications as a litmus test for **stakeholder integration** (Sec 3.2.4) and Leave No One Behind • **Boundary spanning** requires considerable effort and resources and should be a foundational consideration in project design and budgeting (Sec 3.2.1)
Wardani et al. (forthcoming). "From complexity to mutual understanding and acceptance: Participants' experiences of a transdisciplinary planetary health collaboration in Indonesia" (draft title) *Findings from empirical case study on understanding the enabling and constraining factors of collaboration based on participants' experiences*	• Engaging multiple stakeholders with diverse and interdependent interests takes a long time to ensure communication and alignment of perspectives and expectations due to high complexity of structural, political, land-related uncertainties and differences • Developing mutual understanding and acceptance takes a long time through meaningful engagement and repeated formal and informal interactions to build familiarity and trust	• Highlights the importance of considering stakeholders' diverse and interdependence of interests early on • Attend to local LMIC context specificities (challenges and opportunities) • Meaningful engagement includes meeting all parties' interests/needs, genuine respect, shared leadership, and equally valuing contributions • Clear roles and responsibilities, strong facilitative leadership, and developing a common vision enabled mutual understanding	• **Diversity and interdependence** are part of Foundational Considerations (Sec 3.2.1) • Importance of **local socio-cultural, political, economic and historical context** as foundational consideration (Sec 3.2.1) • **Process of stakeholder interaction** (Sec 3.2.4) is dependent on valuing stakeholder contributions (Sec 3.2.3), contexts (3.2.2), and foundational considerations (3.2.1) • **Boundary spanning** as foundational consideration (Sec 3.2.1) and key to **mutual understanding** (Sec 3.2.4)

Table 1 caption: Findings and practice strategies from previous analyses were incorporated into the development of the practice framework, supplementing the theoretical meta-analysis of existing TD frameworks in the EHD fields. In summary, these previous analyses identified the leverage point for transformative change of knowledge production (i.e. funding institutions), revealed severe constraints relating to understanding local contexts and power dynamics, provided strategic guidance for process design and management, and highlighted pertinent foundational themes of interdependence and diversity of stakeholders' interests. These findings inform our practice frameworks, specifically in formulating the Foundational Considerations, Structure, Input, and Process Factors, and in identifying the primary audience of the framework (i.e. funding institutions and initiators of collaborations).

2.1 Literature review of recent TD practice

A literature review of 36 publications was conducted to draw insights on lessons learned from recent transdisciplinary research practice in the respective EHD fields. These lessons learned were qualitatively analysed to obtain second-order understanding of the factors enabling and constraining collaboration. These factors were then inductively clustered into structural, relational, and individual factors enabling and constraining collaboration. These findings have been published (Wardani et al., 2022), and described the interplay between factors that enhanced understanding of the collaborative process. Recommendations for

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practice were identified, emphasising leverage points for change at the structural level through funding requirements and the project design of such research.

2.2 Empirical case study of TD research in LMIC setting

A unique case study of a contemporary large-scale planetary health research collaboration allowed for an empirical deep-dive. The case study site was the Revitalising Informal Settlements and their Environments (RISE) program, a planetary health collaboration aiming to implement and assess the environmental, health, and socio-economic benefits of decentralised green infrastructure upgrades of integrative water and sanitation services in a total of 26 informal settlements in Makassar, Indonesia and Suva, Fiji (Brown et al., 2018). Data collection in the case study consisted of 47 semi-structured interviews and 6 individual reflections in English and Indonesian languages, and 2 focus groups in Indonesian. Indonesian interviews and reflections were translated into English, and thematic analysis was conducted using NVivo software following an inductive, grounded theory approach (Charmaz, 2015; Braun & Clarke, 2006). The case study yielded two publications; the first on the meaning of collaboration from the perspectives and experiences of Indonesian and LMIC stakeholders (Wardani et al., 2023) and the second on the enabling and constraining factors found in the case study based on experiences of all participants (Wardani et al., forthcoming). Findings from both publications yielded practice strategies that intertwined with and informed the framework development process as elaborated below.

2.3 Meta-analysis of existing TD frameworks

A theoretical meta-analysis was conducted of existing TD frameworks commonly used in the EHD fields. Seeking commonalities and complementary perspectives across the EHD nexus was intended to result in a more comprehensive framework that is more readily accepted in these fields. Throughout the framework analysis and development, ongoing feedback was sought from an academic panel representing the EHD fields, which served as validation within an expanded community of academic practice (Cundill et al., 2015). The rationale for

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selection of included frameworks are detailed in Table 2 and further elaborated below as part of the iterative framework development process. Table 2 also highlights how these were incorporated into the framework.

Table 2. Existing TD frameworks in planetary health and EHD fields in the meta-analysis
(Tables are pasted in-text for indicative purposes only. See full size tables at the end of this document.)

Fields	TD framework and brief description	Rationale for selection	Examples of translation into practice framework
Planetary health	**TD research approaches and priorities (Ebi et al., 2021)** Principles of TD research focusing on multiple scales, inclusivity and equality, and broad communication and outreach	• Espouses values of inclusivity in co-design and implementation • Responsive to intersectionality and intergenerational equity encouraging diverse partnerships and representation in research projects	• **Values & ethics** as foundational considerations (Sec 3.1) • **Power dynamics and diversity & interdependence** as foundational consideration (Sec 3.1)
	Collaborative Conceptual Modelling (Newell & Proust, 2012)	• Focus on respect and value for diversity of knowledge and perspectives through listening and social learning • Employs complex systems thinking as embedded in specific local context including history, system behaviour, and leverage points	• **Diversity** as a foundational consideration (Sec 3.1), and key to **social learning** during stakeholder interactions (Sec 3.2.4) • **Local context** as foundational consideration (Sec 3.1) and leverage point identified for transformative shift at the **funding level** (Sec 3.2.2)
Environmental sustainability	**TD research in sustainability science (Lang et al., 2012)** Conceptual model of ideal-typical TD research process adapted from several models outlining similar phases **Ten reflective steps for TD research (Pohl et al., 2017)** Aims to provide systematic procedure for producing socially relevant knowledge linking science and society **Conceptualising TD integration as a multidimensional interactive process (Pohl et al., 2021)** Integration defined as a process, and its characteristics and features elaborated further	• Main framework selected for review from environmental sustainability, with below frameworks as supplementary. • Widely used and accepted as indicated by high citation value (>3000 as of Aug 2023). • Provided useful design principles including phases of research, integrating scientific and societal practice, and challenges for further research. • Practitioner feedback as evidence of usefulness of the ten steps, interlinked with a four-stage policy process as an interplay of actors in the public, private, civil, and academic sectors. • Explicit attempt to elaborate on the process of integration.	• **Research phases** adopted in practice framework (Sec 3.1) • Identified challenges around knowledge integration, organisational structures, and communicative aspects to be complemented by other frameworks in **Compilation of frameworks** (Sec 2.1) • **Stakeholder integration** (Sec 3.2.4) proposed in practice framework to be an output of the collaborative process, as a result of **stakeholder interactions** (Sec 3.2.3)
	Sustainability transition (Luederitz et al., 2017) Tentative scheme for evaluating the design and effectiveness of sustainability transition experiments which aims to be generic, comprehensive, operational, and formative. **Environmental management (Dienontin & Meadow, 2018)** The art of co-production of knowledge in environmental sciences and management: lessons from international practice **Natural resource management (Hakkarainen et al., 2022)** Integrative understanding of co-concepts (co-creation, co-design, co-production, adaptive co-management, and co-learning) in understanding collaborative resource governance	• Builds on Lang et al 2012 and other frameworks (e.g. Ostrom 2009) to evaluate sustainability experiments integrating research and action. • Features and iterative Input-Process-Output-Outcomes format which clarifies categories of factors to be considered or expected in each phase. • Input-Process-Output-Outcomes format similar yet complements Donebedian model in public health featuring Structure-Process-Outcomes, with Context and Impacts added in Dienontin & Meadow (2018). This similarity in format is hoped to broaden acceptability. It also resonates with collaborative governance model based on network dynamics (Innes & Booher 2018). • Recognise importance of local context and international perspectives in adapting and implementing the research and experiments.	• **Structure-Input-Process-Output-Outcome** format similar to public health model, adopted in framework (Sec 3.2) • **Local context and stakeholder contexts** as foundational consideration and structure, adopted in framework (Sec 3.2.1 and 3.2.2) • **Co-concepts** adopted in framework as it represents current integrative understanding of the co-concepts as research phases (Sec 3.1)
	Collaborative governance (Innes & Booher, 2018) Diversity, Interdependence, Authentic Dialogue (DIAD) network dynamics theory of collaborative rationality in urban and regional environmental planning and governance, developed from 40 years of research of collaborative governance practices	• Extensive elaboration on the process and actor network dynamics of collaboration for complex systems change, complementing other frameworks which rarely detail but refer generically to collaboration • Validates empirical case study and literature review of practice on the importance of boundary spanning, referred to as communicative rationality through authentic dialogue, its underlying preconditions of diversity and interdependence	• **Diversity & interdependence** identified as foundational consideration (Sec 3.2.1) • Authentic dialogue as key in **boundary spanning**, a foundational consideration in the framework (Sec 3.2.1) • Contributes **detailed, evidence-based understanding of collaborative process** and its many features (throughout the framework)

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Public health	**Transdisciplinary public health model (Stokols et al., 2013)** Shared definitions, characteristics, and strategies for transdisciplinary health initiatives bridging research and practice to solve public health problems using a team-based approach and working collaboratively with diverse communities	• Developed jointly and bridging between academic and practice perspectives • Identified four phases in a transdisciplinary public health initiative (Development, Conceptualisation, Implementation, and Translation) • Provided basis for iteration by planetary health scholars spanning built environment and public health (e.g. Pineo et al 2021) indicating acceptability and relevance	• **Research phases** complemented that in environmental sustainability, recent iteration included in the framework (Sec 3.1)
	A new transdisciplinary research model (Pineo et al., 2021) Built upon Stokols et al (2013) to include two additional phases to address complex health challenges including climate crisis and global inequalities	• Includes scholars in environment and health with ongoing consultation with community of practice. • Expanded to include two ongoing phases: Co-Learning, and Reflection and Refinement recognising distributed knowledge generation and mutual learning, and emergent priorities.	• **Co-Learning and Reflection** adopted as integral to this practice framework (Sec 3.3) • **Refinement** adopted in framework as part of research Phase 3: Monitoring & Refinement (Co-Monitoring) (Sec 3.1)
	Implementation science (Peters et al., 2013) Bridging multiple disciplines and practice in global health, offers principles for inquiry into implementation strategies and outcomes of policies, programs, or practices (interventions) in the real world	• Highlights importance of local context and users' concerns • Implementation outcomes reflect the practical usefulness of research, including acceptability, adoption, appropriateness, feasibility, fidelity, implementation cost, coverage, and sustainability, echoing the Credibility, Relevance, Legitimacy, and Equity (CRLE) criteria	• **Local context** as foundational consideration (Sec 3.2.1) • Importance of user involvement in determining adoption, acceptability, appropriateness, highlights concept of **diversity & interdependence** as foundational consideration (Sec 3.2.1)
Development studies / Decolonising methodologies	**Participatory action research (Cornish et al., 2023)** Values-based research approach for conducting integrated research and action, led by and for the user communities themselves	• Widely used across environment and health fields, promotes emancipatory values of social change and epistemic equity aligned with planetary health • Collaborative, iterative, experimental and open-ended, appropriate for engaging broad range of stakeholders, with local experiential knowledge valued in all stages • Offers four stages of cycle (problem definition, action, observe, and reflect), emphasising relationality of knowledge production	• **Values & ethics** as foundational consideration (Sec 3.2.1) • **Adaptive, open-ended project design** during initial phase (Sec 3.1) reflected in lighter shade of blue in Figure 2 • **Cyclical, iterative research phases** adopted in framework (round shape of Figure 2), with observe and reflect incorporated into **Phase 3: Monitoring & Refinement (Co-Monitoring)** and **Co-Learning & Reflection** (Sec 3.3)
	Decolonising methodologies for research with indigenous peoples (Smith, 2021) Foundations in decolonisation of knowledge production and methodological guidance, rooted in Aotearoa/New Zealand indigenous thought **Indigenous research methodologies (Chilisa, 2019)** Outlines epistemological and methodological grounding in postcolonial Indigenous knowledge production rooted in African knowledge systems	• Widely used across environment and health fields, seeks to address pervasive power dynamics in Western, colonial research traditions of erasure and marginalisation of Indigenous knowledge • Offers principles of respect, responsibility, reciprocity, holism, interrelatedness and synergy towards authentic, relational, and situated knowledge production	• **Values of equity, diversity & interdependence,** and addressing **power dynamics** as foundational considerations (Sec 3.2.1) • **Indigenous knowledge** as important foundational consideration in Local Contexts (Sec 3.2.1)

Table 2 caption: Starting with values and approaches proposed by planetary health scholarship, existing frameworks in EHD fields were selected and analysed to inform the practice framework development. Based on comparative analysis and a bricolage of useful concepts and frameworks, we compiled common elements and explored differences to seek resolution, aiming for broad applicability and common ground across disparate yet interrelated EHD fields. Our practice framework highlights the importance of local context, values of equity and inclusivity, and power dynamics, and focuses on the process of stakeholder collaboration, against the background of research phases and co-concepts found in existing frameworks (**Section 3.1**).

2.4 Practice framework development process

The framework development followed an iterative design process adapted from Romme and Meijer (2020), starting with 1) selection and compilation of frameworks, 2) comparative assessment interweaving inductive theorisation from previous analyses; and 3) theoretical validation. Findings from previous studies provided empirical validation of the frameworks, as they were compared and triangulated with the meta-analysis to inform the practice framework development. The iterative framework development process, including the interplays among previous analyses, are detailed below.

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1) Compilation and Assessment: Comparative analysis of frameworks

The framework development process started with the selection of existing TD frameworks from the EHD fields for comparative analysis. Three selection criteria were used: 1) the existing framework is broadly used and accepted in their respective fields; 2) the existing framework is relevant to and aligns with planetary health priorities and imperatives (Ebi et al., 2020); and 3) the frameworks show some similarities and differences complementing each other. Exclusion criteria are frameworks outside the EHD fields, as they are beyond the scope of comparison for this research. Table 2 lists the frameworks selected and detailed justification for their inclusion.

The most significant planetary health imperatives that were not explicitly mentioned in existing environmental sustainability frameworks is that TD collaborations must be inclusive, intergenerationally equitable across HICs and LMICs, and embedded within local contexts and geographies. These led to the inclusion of public health, development studies and Participatory Action Research (PAR) frameworks which emphasise attending to power dynamics to address values of equity, inclusivity, and local context and knowledge (Littman et al., 2021; Corburn & Gottlieb, 2005). Indigenous knowledge and decolonising methodologies scholarship were also included as they align with these values. Other frameworks that did not mention these values explicitly were not excluded, as they contribute useful complementary understanding about the research process.

From this compilation of frameworks emerged similarities in components, serving as initial building blocks for our framework. The Structure-Process-Outcome format commonly used in public health service delivery (Donabedian, 2003), in particular, resonates with a number of other frameworks in environmental sustainability (Luederitz et al., 2017; Djenontin & Meadow, 2018) and collaborative governance (Innes & Booher, 2018). Hence, our practice framework retains the Structure-Process-Outcome format to enhance familiarity and

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acceptability across fields. Input and output components were added drawing from the abovementioned environmental sustainability frameworks.

While similarities provided useful starting points for collaboration, differences among frameworks suggested areas of complementarity and tension for further exploration. For example, the TD research framework widely used in sustainability science (Lang et al., 2012), provides a useful ideal-typical model and design principles for a TD research process. The authors identified challenges around lack of integration across knowledge types, organisational structures, and technical and communicative aspects. These challenges reflect structural factors which were not explicitly addressed in that framework, e.g. disciplinary and institutional contexts that predetermine stakeholders' epistemologies, organisational priorities, and communication styles. Therefore, the Structure component was added to our framework, also depicted as Context factors in the co-production framework in environmental management (Djenontin & Meadow, 2018). Advance consideration and improving understanding of these rigid structural factors and how they may shape the process can help facilitate collaboration and address constraints.

Another common element across frameworks in the EHD fields is the time-sequential phases of the research, with one key difference. While some frameworks depict the research process as more linear (Djenontin & Meadow, 2018), most frameworks agree that different phases are interdependent and iterative, e.g. Lang et al. (2012); Luederitz et al. (2017); Stokols et al. (2013); Cornish et al. (2023). Different terms may be used in different frameworks; however, we focus on the overall intentions of each phase which were more alike than different. For example, TD initiatives in public health are described as occurring in four phases, Development, Conceptualisation, Implementation, and Translation (Stokols et al., 2013), and we considered additional phases from a more recent iteration to include Reflection & Refinement, and Co-Learning (Pineo et al., 2021). The iterative PAR phases are Observe reality; Reflect on gaps; Plan improvements; Act to test improvements; and

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Observe outcomes (Crane & Richardson, 2000). Although these reflect a more integrated action-research approach, the phases are similar to those in the public health TD model, for example in encouraging reflection, refinement, and research and observation. A synthesis of these phases, and the collaborative process alongside them, are described in more detail in **Section 3**.

2) Assessment and Inductive Theorisation: Empirical research

Previous studies provided empirical validation for the importance of attention to structural factors. Wardani et al. (2022) found structural factors, including the disciplinary traditions and structures of academia (Becher, 2001), to be the greatest constraints in a collaboration. Beyond academic structures, in LMIC research settings, a lack of understanding of the local socio-cultural, political, economic, geographic and historical context also caused constraints, challenges, and inequitable division of labour due to nuanced communication and cultural differences (Sillitoe, 2018) and power imbalance (Gunasekara, 2020). The importance of local context and knowledge contributed by LMIC stakeholders were also highlighted in Wardani et al. (2023).

Beyond structural factors, the collaborative governance framework suggests underlying preconditions to be considered prior and throughout the collaboration, specifically, notions of interdependence and complementarity among a diversity of stakeholders' interests (Innes & Booher, 2018). These notions are echoed in co-production models in public administration (Ostrom, 1996) and Science and Technology Studies (STS) (Jasanoff, 2004). In public administration, involving the general public as end-users is deemed necessary as the latter contributes relevant knowledge and skills in co-producing public services (Loeffler & Bovaird, 2021). In STS, knowledge is understood to be interdependent and co-evolving jointly with its social and political context (Jasanoff, 2004). Likewise, planetary health scholarship aims to highlight systemic interlinkages (Whitmee et al., 2015), while transnational studies and globalisation scholars emphasise interdependence across global development contexts

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(Sassen, 2016, 2019). Understanding interdependence among diverse stakeholders goes a long way in enabling collaboration, as validated in the empirical case study (Wardani et al., 2023). **Section 3** below details further interdependence and other foundational considerations related to stakeholder engagement.

Another significant foundational consideration drawn from the literature review of practice was that of boundary spanning, or communication and relational factors, which were found to be the most enabling (Clark, Tomich, et al., 2016; Norström et al., 2020; Pohl et al., 2017). Suggested practice strategies include accounting for transaction costs of boundary spanning in project design and management, and researcher training to build individual capacity (Wardani et al., 2022). The empirical case study further cemented that communication and repeated social interactions were required to build trust and relationships, and eventually mutual understanding and acceptance of differences among stakeholders (Wardani et al, forthcoming). Boundaries were found to be the spaces of knowledge integration, therefore creating these spaces were key to bringing together and bridging across different knowledge systems and stakeholders (Wardani et al., 2023). These findings echo the collaborative governance literature, indicating that 'communicative rationality' was an ideal condition that could take extensive effort (Innes & Booher, 2018).

3) Theorisation & Validation

Regardless of the field, existing TD frameworks often mention "collaboration" and "integration" as a generic process, without detailing how the collaborative process might unfold. This practice framework aims to complement this gap using the collaborative governance framework (Innes & Booher, 2018); hence, the cornerstone and focus of this practice framework is on the stakeholder collaboration process. The Structure, Input, Process, Output and Outcomes Factors relate respectively to stakeholders' contexts, contributions, interactions, integration, and collective benefits. The Foundational Considerations in **Section 3.2.1** relate to stakeholder engagement, which include factors

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that process initiators might reflect on when building the team, designing the collaboration, and during continuous monitoring. Finally, we draw from natural resource management scholarship on an integrative understanding of "co-concepts," intended to support and enable TD collaboration (Hakkarainen et al., 2022). Each co-concept is aligned with the stakeholder collaboration process and research phases in our practice framework, as elaborated below in **Section 3**.

3. Towards a practice framework for transdisciplinary collaboration

While our framework selection and assessment drew from the broader EHD fields, the "co-concepts" (co-creation, co-production, co-design, co-learning, and adaptive co-management) were a useful starting point as they represent a contemporary and integrated understanding of "collaborative modes of knowledge production and the engagement of non-academic participants" intended to support TD collaboration. This practice framework refers to collaboration as a transformative co-production process, where "a group of actors engage in developing shared understandings and novel ideas of how to intervene in social-ecological systems, requiring deep and protracted stakeholder engagement" (Galafassi et al., 2018; Shackleton et al., 2019; in Hakkarainen et al., 2022). This is aligned with co-production in highly contested socio-ecological and knowledge systems in sustainability science (Schneider & Buser, 2018; Clark, Tomich, et al., 2016; Norström et al., 2020). The factors to be considered are provided in the Foundational Considerations, and in the Structure-Input-Process-Output-Outcomes format, which serves as guide posts in developing a TD collaboration.

The practice framework consists of a graphic diagram (**Figure 2**) and a matrix of reflexive practice questions (**Table 3**) designed to guide the initial development of and throughout the collaborative process. **Figure 2** illustrates how the different elements of the collaboration are integrated, including the research phases, foundational considerations, and collaborative process components and the factors to be considered under each one, as explained in the

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next section. **Table 3** reinforces the framework's focus on stakeholder engagement, with the Foundational Considerations outlined in the left-most column and suggested questions corresponding to each component in the collaborative process. The suggested questions in **Table 3** are intended to clarify the points under each component in **Figure 2** but relate to broader interpretation centred upon the Foundational Considerations as they correspond to each collaborative component.

3.1 Research phases in the practice framework

The practice framework offers a conceptualisation of TD research phases aligned with their respective co-concepts (Hakkarainen et al., 2022), namely *Phase 1: Predevelopment & Initiation (Co-Design)*; *Phase 2: Implementation (Adaptive Co-Management)*; and *Phase 3: Monitoring & Refinement (Co-Monitoring)*. These stages of the research process are depicted in blue in **Figure 2**, arranged in order from the most open-ended (in lighter shades of blue) to more certain (in darker shades of blue). Specifically, the research design should initially be open-ended and adaptable alongside evolving stakeholder priorities, and gain more certainty during implementation and monitoring.

Each phase will be described further below, however it is worth mentioning that *Phase 2: Implementation (Adaptive Co-Management)* could simultaneously integrate research and action, following an iterative, emergent, experimental approach as practiced in sustainability transitions (Wiek et al., 2017; van Breda & Swilling, 2018). While some argue that transdisciplinarity aims towards usable or actionable knowledge (Clark, van Kerkhoff, et al., 2016) this implies production of knowledge (research) *then* implementation of intervention (action). Some suggest integrated action research would achieve more immediate impact (West et al., 2019), trialling at a smaller scale initially to reduce risks of unintended negative impact. Lessons learned can inform subsequent iterations of the intervention (van Breda & Swilling, 2018), consistent with experiential, 'learning-by-doing' approaches in built environment (Raymond et al., 2017) and PAR in urban health (Barke et al., 2020).

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Development studies and implementation science in public health further agree on locally embedding, developing, implementing, and refining interventions iteratively, as feasibility, effectiveness, and adoption may not be as expected when moving across HIC-LMIC or LMIC contexts (Roy, 2009; Reidpath et al., 2022).

However, academic research globally remains bounded in discovery research separate from direct application or translation. Efforts to transcend disciplines and involving non-academic stakeholders would be necessary to address constraints due to academic disciplinary structures (OECD, 2020). Conducting research with a view towards application to a real-world problem, whether in physical, policy, or other forms, would be the transformative shift required if our knowledge systems were to accelerate progress towards the SDGs. Regardless of approach, research implementation would occur in *Phase 2: Implementation (Adaptive Co-Management)*, followed by *Phase 3: Monitoring & Refinement (Co-Monitoring)*.

Phase 1: Pre-Development & Initiation (Co-Design)

Reflections on the Foundational Considerations (**Section 3.2.1**), Structural Factors (**Section 3.2.2**), and Input Factors (**Section 3.2.3**) should ideally take place during Phase 1, to inform an analysis of stakeholders to be engaged in setting the agenda and priorities for the research, their institutional and other contexts, and potential contributions. Through meaningful stakeholder engagement and analysis using the reflexive practice questions in Table 3, this phase should also result in a shared understanding of the local context within which the research should be firmly embedded, the current system and sustainability challenge to be addressed, and a broad, inclusive vision of the future transformed system (see **Figure 2**).

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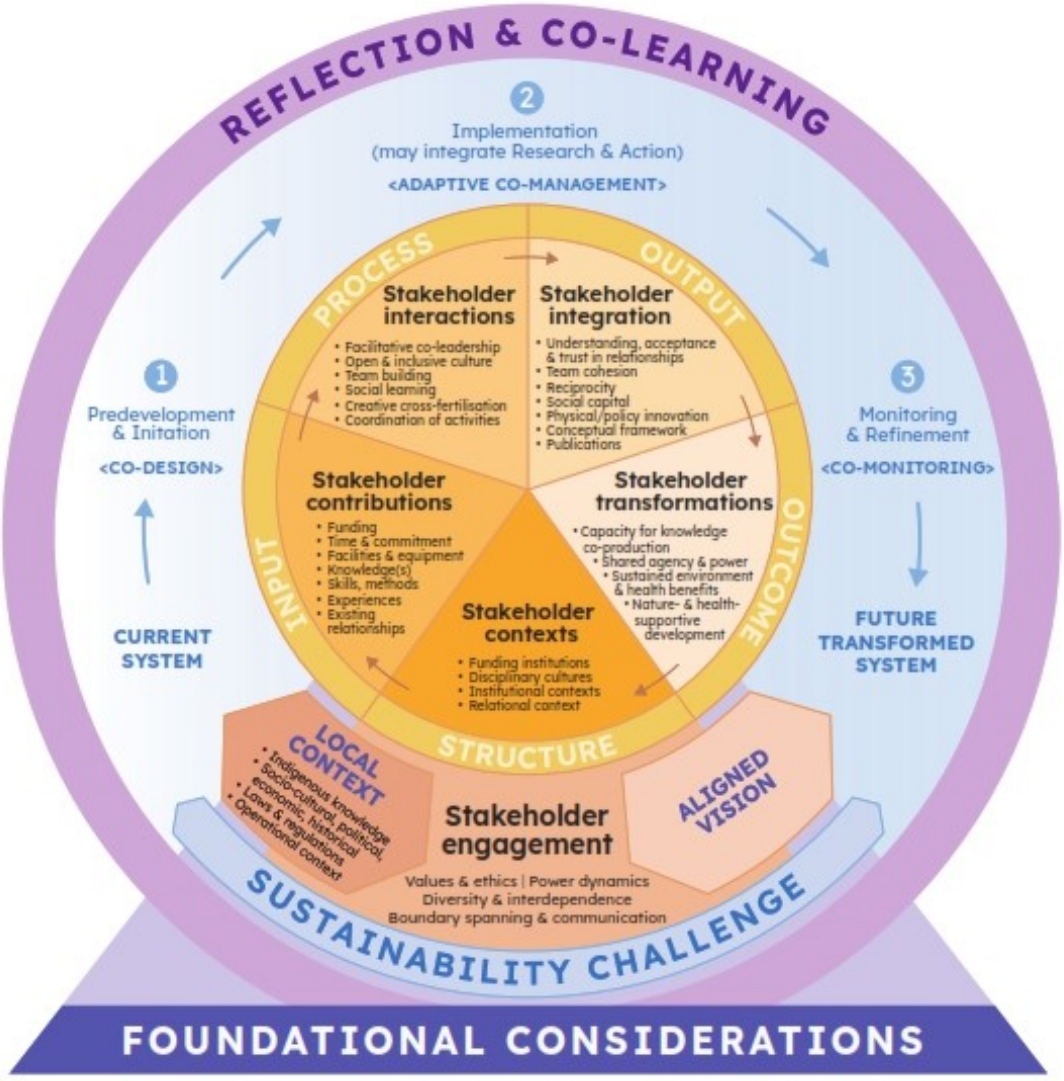
Figure 2. A practice framework for transdisciplinary collaboration in planetary health



Phase 2: Implementation (Adaptive Co-Management)

As previously mentioned, this practice framework encourages integrated action and research to accelerate impact through direct intervention and experiential learning, as commonly practiced in 'Living Labs' (Wiek et al., 2017). An adaptive, emergent approach is recommended in LMIC or other highly fluid and complex contexts (van Breda & Swilling, 2018), which requires high degree of flexibility and adaptability while maintaining vision alignment (Bos et al., 2013). Open-endedness is also important for innovation (Norström et al., 2020). An integrated approach can allow iterative and incremental reflection on stakeholders' perspectives, interests and contributions through the foundational considerations, and reveal other structural issues that could present challenges later.

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In conditions of contested values, a high degree of stakeholder engagement is necessary (Schneider & Buser, 2018). Intensity of stakeholder engagement was found to be a heavy burden due to steep learning curves in developing new relationships and repeated back-and-forth communication required (Wardani et al., forthcoming). However, creating the conditions, space, and time for authentic dialogue and mutual understanding is critical to ensure meaningful engagement and equity in agenda- and priority-setting, especially in a power-diverse collaborative process (Littman et al., 2021; Pratt et al., 2016). Integrating research and action stakeholders from the start can influence *Phase 1: Predevelopment & Initiation (Co-Design)* and *Phase 2: Implementation (Adaptive Co-Management)*, by creating spaces for all contributions to be equally valued through a shared learning agenda exploring perspectives and mutual interdependence (Pineo et al., 2021; Bos et al., 2013). These would likely have an effect on the Process Factors around Stakeholder Integration, as described in **Section 3.2.4** below.

Phase 3: Monitoring & Refinement (Co-Monitoring)

During this phase, a monitoring of outputs and outcomes could take place, along with ongoing reflection on previously identified priorities and objectives, to identify possible reasons for unmet or unintended outcomes. Stakeholder outputs and outcomes (**Sections 3.2.5** and **3.2.6**) could be distinguished from but are no less important than research outputs, such as a conceptual framework, publications, and the policy or practice solution. Although co-monitoring is not one of the co-concepts identified by Hakkarainen et al. (2022), it is included in the practice framework as an important element identified in PAR (Crane & Richardson, 2000) to ensure outcomes and changes in reality are observed and monitored, and the proposed improvement or solution is continually refined through ongoing translation as suggested TD frameworks in public health (Stokols et al., 2013; Pineo et al., 2021). Such a co-monitoring approach, when carried out involving diverse stakeholders, could be useful in combining different knowledge systems, including local ecological knowledge, indigenous

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knowledge, and scientific knowledge and lead to a more effective, equitable, and inclusive monitoring (Peacock et al., 2020).

3.2 Process of stakeholder collaboration

Against the background of these research phases and "co-concepts," this practice framework focuses and elaborates on stakeholders as active agents, mediating towards shifts in structural power and institutional change as drawn from the scholarship on collaborative praxis and sustainability transitions (Innes & Booher, 2018; Giddens, 1984; Sovacool & Brisbois, 2019). The factors that may influence the collaborative process, are arranged in order in **Figure 2** and **Table 3**, from most foundational and difficult to change (in darker shades of orange), to most open and uncertain in the future (in lighter shades of orange).

Table 3. Matrix of reflexive practice questions
(Tables are pasted in-text for indicative purposes only. See full size tables at the end of this document.)

REFLECTION & CO-LEARNING					
Foundational considerations	**Structure**	**Input**	**Process**	**Output**	**Outcomes**
Stakeholder engagement	**Stakeholder contexts**	**Stakeholder contributions**	**Stakeholder interactions**	**Stakeholder integration**	**Stakeholder & systems transformations**
Predevelopment, Initiation, and agenda setting (Co-Design)					
		Implementation (Adaptive Co-Management)			
			Monitoring & Refinement (Co-Monitoring)		
Local context	Which individuals, groups and institutions in the academic, government, community, and private sectors in the LMIC have an interest in the sustainability challenge? What existing indigenous knowledge can contribute to addressing this challenge? What are similarities and differences in LMIC & HIC stakeholders' perceptions of the sustainability challenge? Do HIC stakeholders have a good understanding of the local context including language, culture, and power dynamics? What laws and regulations and operational conditions pertain to human resources, taxation, data management, research, transport of equipment, samples, etc that require compliance?	Are LMIC stakeholders' interests and priorities reflected in the research agenda, as well as HIC stakeholders' interests and priorities? What disciplinary and non-disciplinary knowledge, skills, and methods do LMIC stakeholders contribute and have an interest to gain? What professional and personal lived experiences do LMIC stakeholders bring to the collaboration? What facilities and equipment do LMIC stakeholders contribute, and stand to benefit? What other non-material contributions (e.g. time, political support) do LMIC stakeholders contribute and how are these valued?	What co-governance processes are in place to encourage meaningful engagement and interactions among HIC-LMIC stakeholders? Are there LMIC stakeholders represented in project co-leadership? What powers and decision-making authority do LMIC stakeholders hold? How does the collaboration demonstrate commitment to transparency and building an open and inclusive culture across geographical divides?	What boundary-spanning and communication efforts are required to ensure meaningful integration of LMIC stakeholders and interests? What is the extent of cross-fertilisation, understanding, acceptance, and trust among stakeholders? Is there cohesion perceived through mutual assistance and support within teams, between teams, and across sectoral, cultural, and geographical differences? How have LMIC & HIC stakeholders benefited from the social capital generated by the collaboration?	How have LMIC stakeholders gained capacity for collaborative research and locally relevant problem solving? Have LMIC & HIC stakeholders benefited equally from the collaboration? Are there sustained benefits to the environment, health, and socio-economic development in the LMIC? Does the knowledge and innovation produced satisfy credibility and relevance criteria in the LMIC context, i.e. solutions are accepted and used by intended stakeholders?

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Values & ethics	What values are being emphasised in the collaboration and how do those reflect LMIC & HIC stakeholders' values, priorities, and concerns? What is the possible impact of including or excluding certain stakeholders on equity and innovation outcomes?	Are LMIC & HIC stakeholders' contributions equally and inclusively valued, e.g. in budget allocation, division of roles, other benefits?	Is the collaboration being facilitated to allow equal and inclusive engagement and meeting of diverse interests? What values alignment can be used as a compass to guide decision-making?	Which stakeholders benefit the most from the social and political capital and other outputs generated and which stakeholders the least? What innovation can we achieve by including diverse stakeholders that may not be typically engaged?	Have LMIC & HIC stakeholders gained equally in capacity for collaborative research and problem solving? Do LMIC stakeholders have the know-how and capacity to sustain the intervention and its benefits? Do outcomes reflect equal valuing of LMIC & HIC stakeholders' interests and perspectives?
Power dynamics	What power, knowledge, and financial resources do HIC stakeholders derive through their institutions, disciplines, and positionalities? What are the power dynamics among LMIC stakeholders based on institution, social status, abilities, and identities?	Which stakeholders' contributions are explicitly and implicitly valued over others? Which stakeholders contribute crucial input but are inadvertently excluded? What challenges in generating legitimacy and relevance can we expect through inadvertent exclusion?	Is the collaboration facilitated to allow cross-fertilisation, social learning to occur in multiple ways and directions, e.g. through social interactions, team building and other venues that 'level the field'? What important differences in knowledge and perspectives exist and how can they be mutually learned and understood?	How are power dynamics facilitated and navigated in the collaboration to allow for equal distribution of benefits and opportunities for engagement? How can understanding and trust be facilitated amidst stakeholders with power diversity and conflicting values, interests, and identities?	To what extent has there been a yielding and wielding of power among HIC and LMIC stakeholders towards a more balanced and shared power dynamics? Does the knowledge and innovation produced satisfy legitimacy and equity criteria?
Diversity & interdependence	Does the collaboration have the required individual and institutional diversity to implement the research or address the sustainability challenge? What do stakeholders perceive to benefit from engagement in the collaboration over doing it alone?	Does the collaboration have the diversity of contributions relevant to addressing the sustainability challenge? Who decides what contributions are relevant, legitimate, and valuable? How are stakeholders' interests and contributions interdependent?	How does the collaboration provide spaces that respect diversity of perspectives and contributions? How can interdependence be highlighted through knowledge exchange and team building? What creative cross-fertilisation can take place among diverse stakeholders?	How can interdependence be leveraged to generate understanding, trust and acceptance amidst diversity? Are there signs of reciprocity observed among stakeholders, including personal or professional?	Did the knowledge or innovation benefit a diversity of stakeholders including disadvantaged groups (gender, disability, race & ethnicity, etc)? How were a diversity of user needs considered in implementing the research and innovation?
Boundary spanning & communication	What communication and boundary-spanning efforts are required to bridge institutional level differences? To what extent are TD and collaborative efforts financially and institutionally supported?	Which individual and institutional stakeholders have the experience and ability to create boundary spaces, e.g. boundary organisations, intermediaries, bridging and facilitating across disciplines, institutions, sectors, and cultures? What training and mentorship can be provided to individuals to develop collaborative capacity?	What specific events and venues create a boundary space for diverse stakeholders to come together? Are there language and cultural barriers that need support to overcome? What formal and informal mechanisms of boundary spanning and communication exist?	What boundary-spanning efforts are required to encourage mutual understanding, acceptance, and trust in relationships? Has there been multi-directional flows in knowledge including through language, social, and cultural interactions?	How have stakeholders increased their capacity for boundary spanning through the collaborative experience? How have the environment, health, and development benefits of the collaboration perceived across differences in perspectives and backgrounds?
Aligned vision	What do stakeholders envision the collaboration will achieve in the medium to long term? What short- and medium-term outcomes are expected to support this vision? To what extent is there vision alignment among stakeholders?	What do stakeholders expect to contribute towards the aligned vision in the short, medium, and long terms? What are stakeholders' motivations and interests for engagement in the collaboration?	How are different voices listened to and have power to influence the long-term vision of the collaboration? How much flexibility and adaptation are there to broaden the vision and include complementary or conflicting voices and interests? Who decides which vision is relevant and which is not?	What knowledge outputs and innovative solutions have been produced? To what extent are these outputs aligned with the medium- and long-term vision? Are there conflicting interests remaining and if so, how can they be resolved? To what extent has team cohesion, reciprocity, and social capital been generated towards achieving the vision?	To what extent do the realised vision and outcomes reflect all stakeholders' expectations? Have there been certain stakeholders excluded or marginalised due to perceived and irreconcilable vision misalignment? Have there been certain stakeholders that were inadvertently excluded despite vision alignment?

Table 3 caption: The above matrix of reflexive practice questions is an integral part of the framework and is to be used together with the framework diagram in **Figure 2**. The questions are centred upon the Foundational Considerations in the left-most column, reinforcing the framework's focus on stakeholder engagement. The header rows here correspond in colour with the framework diagram, with reflexivity and co-learning as important throughout in both. The stakeholder collaboration stages (in orange) are aligned with the research phases (in blue). The practice questions are intended to be used for individual and collective reflection both at the beginning and as subsequent stakeholders join in the collaboration.

3.2.1 Foundational Considerations | Stakeholder Engagement

Following collaborative governance literature, preconditions underlying collaboration require reflection prior to *Phase 1: Predevelopment & Initiation (Co-Design)*, but these Foundational

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Considerations (**Figure 2** in purple, including all elements therein) should be applied continuously throughout the process, e.g. when additional stakeholders are engaged. These Foundational Considerations provide a set of principles that guide process design on a philosophical level, which are necessary to reach in-depth value and power differences among stakeholders. Along with questions in **Table 3**, these are considerations for stakeholder engagement especially in relation to the Local Context and Vision Alignment, and can influence the framing of the Sustainability Challenge being addressed. Process initiators would need to maintain openness and flexibility in their vision of the transformed system to adapt particular research questions, methodology, and desired outputs to meet all stakeholders' interests. In LMIC and resource-poor contexts, these considerations are especially pertinent to safeguard against unintended consequences of asymmetrical power dynamics. The Foundational Considerations are: Local Context; Values & Ethics; Power Dynamics; Diversity & Interdependence; Boundary Spanning; and Aligned Vision.

- *Local Context:* Depicted in darker peach in **Figure 2**, the socio-cultural, political, economic, geographic and historical context of the research setting is of paramount importance to ensure relevance and legitimacy of the knowledge or solution produced (Capon, 2017). Lack of deep and nuanced understanding of the local context, including administrative and legal barriers and operational conditions could present severe structural constraints, such as risks of failure and increased costs due to uncertainties, ambiguities, and constant changes (Cundill et al., 2018; White et al., 2018; Pineo et al., 2020). LMIC stakeholders also provide specific local and indigenous knowledge systems, research and societal priorities, and knowledge on political and power dynamics (Corburn & Gottlieb, 2005). Power and resource differences especially among HIC and LMIC partners need to be acknowledged so as to avoid marginalisation of indigenous knowledge and stakeholders (Littman et al., 2021; van Breda & Swilling, 2018). Moreover, nuances in power dynamics and other complexities within and among LMICs which can influence outcomes (Pratt et al., 2016; Reidpath et al., 2022). LMIC

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stakeholders' priorities and interests need to be central in the co-design for equitable outcomes and to meet relevant needs (Pratt & Hyder, 2017); hence LMIC stakeholders need to be engaged in research agenda setting, leadership, and decision-making (Peters et al., 2013; Littman et al., 2021; Clark, Tomich, et al., 2016).

- *Values & Ethics:* Consistent with planetary health priorities for intergenerational justice and equity (Ebi et al., 2020; Zeinali et al., 2020), TD collaborations must equally value and include relevant actors, sectors, and scales (Pongsiri & Bassi, 2021) through open listening, dialogue, and respect for different perspectives (Newell & Proust, 2012). These values of equity and inclusivity are compatible with indigenous and decolonising principles and methodologies (Smith, 2021; Chilisa, 2011). These values are also central in social work and PAR approaches and in health which recognise the co-production of values and relations in collaborations (Filipe et al., 2017; Corburn & Gottlieb, 2005).

  Intergenerational stewardship values are implicit in environmental sustainability frameworks (Lang et al., 2012; Luederitz et al., 2017), and in producing 'target knowledge' about the normatively desirable future (Schneider & Buser, 2018). Likewise, environmental sustainability explicitly recognise personal values as intertwined with authentic leadership (McIntosh & Taylor, 2013) and social learning and innovation processes (Bos et al., 2013; Bos & Brown, 2012). These latter processes are inherently value-laden, requiring higher order or 'double-loop' and 'triple-loop' learning (Tosey et al., 2012) asking the questions *"are we doing the right things" and "how do we decide what is right?"*, in contrast to single-loop learning which focuses on efficiency and maintaining the status quo by asking *"are we doing things right".* Social learning, through opening up perceptions of diverse possibilities, thus facilitates a fundamental questioning of the status quo with the potential to transform power relations, ways of knowing, and underlying values.

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It is important to note that sustainability challenges would require collaboration among stakeholders with diverse values; however, as suggested by collaborative governance scholars, values alignment is not always necessary (Forester, 2006). Nonetheless, it may be a challenge to reconcile deep-seated differences, as reflected in epistemological differences among HASS and STEM, quantitative and qualitative methodologies, and disciplinary cultures and values (Becher, 2001). For example, Randomised Controlled Trials (RCTs) as a public health 'gold standard' methodology stem from positivist epistemology which views knowledge as objective and value-free (Bryman, 2016, p. 24). Such ontology and axiology contrast with social constructivism or critical epistemologies where individual and collective values are made explicit in the co-construction of knowledge, e.g. in addressing social justice among marginalised groups (Creswell & Poth, 2018, pp. 34-35). In natural resource management, opposing environmental values among conservationist and economic use stakeholders are both necessary for longevity of the solution (Zietsma & Lawrence, 2010). Sustainability science scholars have proposed four perspectives to address differences in values, to enable moving beyond general importance-of-values discussions; reflect on the positionality of one's values; and the contextual operationalisation of values (Horcea-Milcu et al., 2019).

- *Power Dynamics:* Consistent with values of intergenerational equity and commitment to "Leave No One Behind", TD collaborations in LMIC settings need to be cognisant of power dynamics for the proactive avoidance of potential negative impacts including inadvertent erasure of existing knowledge systems (Littman et al., 2021; Reidpath & Allotey, 2019). Mapping and making sense of power dynamics has been suggested to increase the transformative potential of TD research as suggested in natural resource management (Hakkarainen et al., 2022), in sustainability transitions (de Geus et al., 2023), in global health consortia (Pratt & Hyder, 2017), and in PAR approaches (Littman et al., 2021). As posited in collaborative governance and other fields, knowledge is

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emancipatory in uncovering reified power relations and unacknowledged assumptions (Innes & Booher, 2018) , which are critical for shifting power dynamics (Avelino & Wittmayer, 2016). Unequal power dynamics may also arise from persistent hierarchies among academic disciplines, and among HIC academic and local or indigenous knowledge (MacMynowski, 2007; Moser, 2016). Critical self-reflection and collective power reflexivity are important in encouraging equal valuing of diverse epistemologies and knowledge systems (Pineo et al., 2021; Forester, 2013) while offering greater variety of knowledge produced (Hopkins et al., 2020).

Power is not simply a force one holds over others, but intersubjectively co-constructed within social and relational contexts, as demonstrated in the intersectionalities of power, privilege and disadvantage (Severs et al., 2016; Crenshaw, 1989; Avelino, 2021). Considering intersectionality is one way of mapping power dynamics and inequalities related to personal, professional, and social identities and the myriad discrimination that individuals and groups may face (Hankivsky et al., 2010; Larson et al., 2016). Internal factors, e.g. agency, knowledge and skills, and access to and control over resources and opportunities; and external factors, e.g. laws and policies, and social norms and exclusionary practices mediate stakeholders' ability to shift structural power through everyday practices (Sovacool & Brisbois, 2019; Avelino & Wittmayer, 2016). Explicitly acknowledging stakeholders' values, positionality, and contributions can help ensure meaningful engagement and equal valuing of all interests and contributions.

Conducting research in LMIC settings is subject to a different set of power and resource conditions than in HICs. Most TD frameworks have emerged from well-resourced, HIC academic institutions in largely formal and legitimised contexts where societal and academic stakeholders can engage on equal footing, e.g. van Breda & Swilling (2019). Transnational and development studies scholars argue such resource and power differences are manifest in deeply uneven geographies of knowledge production, with

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HIC theories often universalised and flowing unidirectionally towards LMIC settings (Sassen, 2014, 2019; Roy, 2009, 2016; Sillitoe, 2018). These views are echoed in public and global health and justice research (e.g. PAR approaches), which question notions of expertise and thus usually conducted by and for communities (Littman et al., 2021; Corburn & Gottlieb, 2005), and in health where principles of equality of partners and primacy of end-user could safeguard against exploitation and "trickle down science" (Heaton et al., 2016; Reidpath & Allotey, 2019). Our literature review of practice also revealed such unevenness in division of labour, with HIC partners involved in high-level agenda setting and research design, while LMIC partners tend to be involved in data collection (Gunasekara, 2020; Pryor et al., 2009).

- *Diversity and Interdependence:* Following collaborative and environmental governance scholarship, collaboration necessarily serves diverse and interdependent stakeholders who contribute relevant and complementary knowledge and resources, but also rely on other stakeholders to achieve common and respective interests (Moser, 2016; Inner & Booher, 2018). Diversity and inclusion help ensure relevance and legitimacy, including those who benefit and those potentially harmed, stronger and weaker interests, deal makers and deal breakers, and contrarian and disadvantaged stakeholders (Forester, 2006). Collective reflexivity can feed the potential for creativity and innovation, reciprocity, and discovery of mutual benefits (Wittmayer & Schäpke, 2014).

  Recognising interdependence was identified as a way to equally value LMIC stakeholders' knowledge and contributions, who generously supported the research despite relative lack of resources (Wardani et al., 2023). Research field workers, community, and government stakeholders contributed local contextual knowledge and resources crucial to intervention design, and facilities, time, and moral support for household surveys and data and sample collection. Interdependence was also found to be a key ingredient underlying stakeholders' motivation to engage. Case study

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participants' responses to the meaning of collaboration, such as "*you can't do it alone,*" "*all stakeholders need each other*" and "*they won't engage if they don't perceive to get something out of it*" underlined such interdependence, where diverse participants must rely on each other to achieve a common goal (quotes from Wardani et al., 2023). Likewise, interdependence is reflected in the collaborative governance and co-production of public services literature (Innes & Booher 2018, Ostrom, 1996).

- *Boundary spanning and communication:* Upon reflection of diversity in values, power dynamics, epistemologies, and local contexts, the collaboration must consider the resources needed for boundary spanning. Used in the sustainability transitions field and drawn from institutional theory (Zietsma & Lawrence, 2010), boundary spanning include "strategies that connect different worlds," such as facilitating dialogue, negotiation of interests, and reconciliation of potential tensions (Smink et al., 2015). Water sustainability scholars have also proposed the T-shaped concept highlighting three core group of skills to be developed by boundary spanners, including technical and functional understanding of one's own and collaborators' disciplines; organizing and management; and influence leadership (McIntosh & Taylor, 2013). Such efforts can be a time- and resource-intensive endeavour and individuals acting as boundary-spanners tend to be underappreciated, but are necessary to build mutual understanding, acceptance, and trust in relationships (Brown et al., 2019; Innes & Booher, 2018; Moser, 2016; Schneider & Buser, 2018; Harris & Lyon, 2013; Clark, van Kerkhoff, et al., 2016). Deep and meaningful engagement and respect for diverse stakeholders' perspectives and interests, are essential to collaborations (Hakkarainen et al., 2022), and should not be avoided at the expense of efficiency (Littman et al., 2021). These represent transaction costs of facilitating a process from complexity towards mutual understanding, which need to be built into budgets and timelines, especially when working across multiple scales and diverse geographies (Brown et al., 2019; Moser, 2016; Wardani et al., 2023).

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In power-diverse settings, individual and collective reflexivity, itself a form of boundary spanning, is required to encourage mutual learning and accountability, yielding and wielding of power, and using values and vision alignment as a guide (Hakkarainen et al., 2022; Littman et al., 2021; Brown et al., 2019; Tawake et al., 2021). Integration of diverse knowledges require boundary spaces, conducive for social interactions, multi-way communication, relationship building knowledge exchange, and social learning (Bos et al., 2013; Marzano et al., 2006).

- *Aligned vision:* Another form of boundary spanning, an alignment of vision redraws an inclusive boundary and drives stakeholders towards a common direction and purpose (Brown et al., 2019; Brown et al., 2015). It is an essential part of collaboration bringing together diverse stakeholders towards "*a common aim*" alongside "*different classes of outcomes*" (Wardani et al., 2023). This is reflected in recent TD practice in EHD fields, which identified a shared vision, common ground, group safety and transparency as enabling factors (Black et al., 2018). Forging a shared mission requires visionary leadership in engaging stakeholders in *Phase 1: Predevelopment & Initiation (Co-Design)*, but also facilitative co-leadership in *Phase 2) Implementation (Adaptive Co-management)* phase to encourage transparent governance and for others lead and develop the process (Wardani et al., forthcoming).

3.2.2 Structural Factors | Stakeholder Contexts

Structural factors may be difficult to change, but may also be assets to the collaboration. With stakeholders as the focus of collaboration, structural factors relate to stakeholders' disciplinary, institutional, and cultural contexts. Not least important are funding institutions at the fulcrum of change with financial and knowledge resources as leverage to institutionalise collaboration (Wardani et al., 2022; Abson et al., 2017). Funders play an important role in the evaluation, design and mechanisms of international TD collaborations; reflexivity is required

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to explicitly map values and power held by global funders vis-à-vis recipients of funding and communities benefiting from an intervention.

Disciplinary and institutional contexts of stakeholders can affect propensity towards collaboration, epistemological and axiological standpoints, and power dynamics within and across HIC and LMIC settings. Disciplines considered academic purists may view interdisciplinarity as risky, while those more applied and practical or formed at the boundary of two disciplines may be more encouraging of inter- and transdisciplinarity (Becher, 2001; Klein, 1996). Institutions that identify as 'boundary organisations' at the interface of science, policy and practice, such as policy think-tanks and applied research centres may be more experienced with facilitating interactions and mutual understanding among diverse epistemological and values perspectives (Kivimaa et al., 2019; Gustafsson & Lidskog, 2018). Within HIC academic settings, institutional ranking and traditional hierarchies (e.g. HASS vs. STEM) may create power dynamics that require reflexivity to identify and address proactively for balanced engagement (MacMynowski, 2007). LMIC settings are not homogenous, with geographical, resource and training disparities across countries and complex power dynamics within each context (Gunasekara, 2020).

Relational contexts can also predetermine power dynamics and value clusters among stakeholders. Process initiators may draw from existing networks and prior collaboration in identifying partners, as a preference over the steep learning curve required for establishing new relationships amidst managing funding uncertainties (Moser, 2016). Prior collaboration may mean sufficient mutual understanding and trust, while little prior knowledge and shared experience requires greater intensity and facilitation of interactions (Harris & Lyon, 2013; Schneider & Buser, 2018). Existing relationships may bear significant power and values clustering that may be a barrier for 'newer' partners, while complementarity and interdependence should be considered in balance, i.e. some stakeholders are critical, while others may add value but also complexity (Wardani et al., forthcoming).

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3.2.3 Input Factors | Stakeholder Contributions

Consideration of inputs is iterative with that of stakeholder engagement and structural contexts. Additional stakeholders may be required to provide relevant knowledge and as such prompt reflection on foundational considerations and structural contexts. Different stakeholders may also have different understanding of the societal challenge being addressed and different concepts depending on disciplinary and cultural backgrounds. Facilitating exploration of such differences and coming to a shared understanding is important in the initiation stage (Moser, 2016). Further, openness and ability to adapt to changes must be maintained throughout, as stakeholders may contribute differently than initially expected. In the framework diagram (**Figure 2**), this is reflected in the lighter shading of *Phase 1: Predevelopment & Initiation (Co-Design)* and in the need for an adaptive approach to co-management (Hakkarainen et al., 2022; Norström et al., 2020).

As found in the empirical case study, collaboration depended on a variety of stakeholder contributions, including tangible and intangible contributions (Wardani et al., 2023). Tangible contributions, such as funding and material resources, were typically contributed by HIC funders and researchers, while intangible ones, such as time, commitment, moral and political support, existing relationships and use of existing facilities for gatherings, sampling events, and laboratories were typically contributed by LMIC academic, government, and community stakeholders. Scientific and technical knowledge and skills tend to come from HIC stakeholders, while LMIC stakeholders contribute locally relevant applications, and contextual knowledge that may not be easily identified, described, and valued. Nonetheless, due to interdependence, without LMIC stakeholders' contributions, by completing surveys, providing biological and environmental samples, and providing community land tenure information, the research could risk implementation failure. Highlighting such interdependence could help equalise power dynamics (Wardani et al., 2023).

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3.2.4 Process Factors | Stakeholder Interactions

Strategically incorporating foundational considerations into process design and management can help enable collaboration, as the project level can span structural, relational, and individual factors and offer multi-level opportunities (Wardani et al., 2022). Organisational conditions, for example, can be established to encourage follow-on effects in stakeholder interactions (Process Factors), for example by forging common vision, values, and identity which also develops commitment and ownership (Brown et al., 2019). Likewise, creating a culture of openness and transparency in decision-making, listening and respect for diverse perspectives, and group psychological safety which help ensure equity in negotiating power dynamics (Littman et al., 2021; Edmonson, 2019; Black et al., 2018).

Another example of a structural Process factor that can be established include clear and equitable division of roles and responsibilities, institutional support for dedicated staffing and a base for a Project Management Unit (PMU), clear rules and policies, and information and communication technology (ICT) (Bark et al., 2016). Clear roles and responsibilities were highly cited as enabling, an absence of which creates ambiguity and confusion leading to misunderstanding, tension and conflict (Nix et al., 2018). Equitable division of roles means LMIC stakeholders' involvement is not limited to data collection, but should include representation in governance, agenda -setting, co-design, data analysis and authorship (Gunasekara, 2020; Pratt et al., 2016).

Strong facilitative leadership is likely to enable collaboration (Wardani et al., forthcoming), along with power-reflexive co-governance structure including sectoral and HIC-LMIC representation (Littman et al., 2021). Co-governance helps ensure relevance and legitimacy and lack of engagement of societal stakeholders could compromise dissemination and impact (Heaton et al., 2016). Processes of governance, team building, learning, and innovation must be established, to effectively orchestrate stakeholder interactions. These processes are pivotal in creating the conditions, space and time for authentic dialogue,

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boundary spanning, and build trust, understanding and relationships (Hakkarainen et al., 2022; Harris & Lyon, 2013). Facilitative leadership helps encourage the sharing of power with leaders showing willingness to step back and yield to emerging leaders, allowing them to take greater ownership (Tawake et al., 2021). Facilitation can help with developing consensual theoretical, methodological, and evaluation frameworks, establishing common language for shared understanding (e.g. evolving text for negotiation) (Innes & Booher, 2018).

Facilitation can help build team cohesion by providing semi-formal spaces for social interactions, social learning, and creative cross-fertilisation. This helps build trust through familiarity and repetition (Wardani et al., forthcoming), which helps achieve the conditions for authentic dialogue where stakeholder interactions are mutually comprehensible, accurate, sincere, and inclusive (Bracken & Oughton, 2006). Social learning can be facilitated by encouraging reflexivity, listening, openness, and valuing of different perspectives (McIntosh & Taylor, 2013) to achieve triple-loop learning and systemic change (Bos et al., 2013). Creative cross-fertilisation is necessary for innovation, producing knowledge and solutions through bricolage, borrowing of concepts, and looking at problems through complementary lenses (Klein, 1996).

In addition, facilitation can help stakeholders have equal access to knowledge, and that their knowledge and interests are being equally valued. High complexity, as proxied by degree of contestation and diversity requires careful design, planning and facilitation, and sound knowledge of power dynamics and stakeholder interests for knowledge exchange and production to happen (Schneider & Buser, 2018). Sustaining engagement through shared understanding, trust, and relationships is important due to the inherent uncertainties and ambiguities (Harris & Lyon, 2013). Collaborative governance scholarship note stakeholders may engage initially for instrumental reasons, but over time sustain their motivation for learning complementary viewpoints and personal friendships (Innes & Booher, 2018).

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3.2.4 Output Factors | Stakeholder Integration

Through facilitated interactions, the collaboration may start to see intermediate outputs within *Phase 2: Implementation (Adaptive Co-Management)* and into *Phase 3: Monitoring & Refinement (Co-Monitoring)*. Occurring in conducive boundary spaces, social learning and creative cross-fertilisation can bring stakeholders to discover reciprocity and interdependence amongst their interests, and innovative problem-solving beyond initial expectation, which may snowball into greater motivation and cohesion for mutual support and accountability (Innes & Booher, 2018). Repeated social interactions build familiarity, mutual understanding, trust and acceptance, which eventually develop into team cohesion, and social and political capital (Sabatier, 2005; Putnam, 2000). Experiencing the initial uncertainties of the collaborative process together may build stakeholders' adaptive capacity to solve future problems, a sign of transformative triple-loop learning whereby stakeholders recalibrate their perspectives through collective decision-making.

These Output Factors are expected in parallel with specific knowledge outputs which may be the formal 'deliverables' of the project, including physical and policy innovation for the societal challenge at hand, a jointly developed conceptual framework, and academic co-publications. Innovative solutions and heuristics serve as boundary objects relevant and legitimate to all stakeholders, held together by 'communicative rationality' (Innes & Booher, 2018). For research equity, LMIC stakeholders should be involved in governance, leadership, coordination, and analysis activities, including co-authorship of research outputs (Gunasekara, 2020; Pryor et al., 2009). Building trust and shared heuristics, like achieving conditions for authentic dialogue, requires formidable effort, time and resources (Innes & Booher, 2018). However, diversity should not be foregone in the interest of efficiency (Littman et al., 2020), and excluding certain stakeholders may create obstacles later on in the process (Wardani et al., 2023).

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3.2.5 Outcomes | Stakeholder & system transformations

As TD action research seeks to address a societal challenge, a litmus test for success is sustained improvements in human health, the environment, and social equity – a whole system transformation (Abson et al., 2019) or systems adaptation through innovation (Innes & Booher, 2018; Luederitz et al., 2017). Co-creation of solution-oriented knowledge (Lang et al., 2012) towards nature- and health-supportive development involves a shift in the power dynamics in decision making. A systematic shift in power dynamics is crucial in upending deeply entrenched legacies of colonialism and reification and imposition of 'universalised' HIC values, knowledge and cultures to LMIC contexts (Odora Hoppers, 2011; Tawake et al., 2021). Sustainability scholarship and PAR approaches emphasise the reflexive role of HIC researchers and stakeholders in not only recognising the different thought styles and power dynamics (Christian Pohl, 2010), but also in yielding power and centring LMIC interests in such collaborations (Littman et al., 2021). Power reflexivity can help avoid inadvertent exclusion of certain stakeholders' interests and subsequently, the knowledge or resource they contribute. Socio-economic wellbeing and intra- and intergenerational equity are expected (Luederitz et al., 2017).

Sustained benefits in health and environment include socio-ecological integrity, resource maintenance and stewardship (Luederitz et al., 2017; Sabatier, 2005), and a more integrative appreciation of the interdependence between nature and health for all stakeholders (Boyden, 2016). Examples of development mechanism meeting health, environmental, and social objectives include the Green New Deal, prioritising renewable energy, with positive health impact through improved air quality, reduced carbon emissions, and investments in inclusive upskilling centred on traditionally disadvantaged communities (Calhoun & Fong, 2022).

Knowledge produced collaboratively is hoped to meet the credibility, relevance, and legitimacy (CRL) criteria the notion of 'socially robust knowledge' (Clark, Tomich, et al.,

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2016; Nowotny et al., 2003) – or knowledge transformation. Adoption and sustainability of the intervention are important outcomes to monitor, as suggested by implementation science (Peters et al., 2013) and attests to knowledge CRL. Legitimacy implies that all stakeholders' interests are satisfactorily communicated, listened to and addressed, even if they were not fully met; otherwise, long-term sustainability is compromised. Transformation of the current system towards the desired state needs to abide by the CRL and equity (CRL+E) criteria if we are to avoid decision making by a powerful elite at the disadvantage of certain groups; and such decision making rely on a transformation of praxis described below.

With increased collective capacity for problem solving and social learning, collaborative experience is hoped to bring about transformation of praxis, a change in the system and practices of knowledge production. Following Giddens' structuration theory (1984), our practice framework centres upon stakeholders as agents of change, and knowledge production and innovation practices conceived and embedded within its socio-political context, are more likely to yield transformative solutions and lead to the institutionalisation of new norms for sustained systemic transformation. Power reflexivity, and centring historically marginalised and LMIC interests, need to be core to praxis to reverse and avoid further harm caused by colonialism and neoliberalism with enduring negative systemic effects (Pratt & Hyder, 2017; Littman et al., 2021).

3.3 Reflexivity & Co-Learning

Continuous and iterative reflexivity and co-learning is important in *Phase 1: Predevelopment & Initiation (Co-Design)* and at multiple touchpoints throughout. This is depicted in a purple band encircling the entire process in **Figure 2**. Initially during stakeholder engagement, explicitly mapping out values clusters and power dynamics in a stakeholder analysis (Littman et al., 2021), and spending time understanding the local socio-cultural, geographical, political, economic, and historical contexts through lived experience and/or learning the LMIC language, can lead to deeper understanding of potential opportunities and constraints

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(Gunasekara, 2020; Sillitoe, 2018). In environmental sustainability, reflexivity is a type of social learning supporting TD collaboration through self-positioning, acknowledgement of values and epistemic worldviews, and increasing mutual understanding of a complex natural system (Hakkarainen et al., 2022).

Engaging a diversity of stakeholders at various stages would likely bring some differences that must be reconciled, and values and vision alignment can be useful mitigation strategies (Littman et al., 2021). Due to mismatched institutional logics, stakeholders do not always agree on reasons, goals, and values; but importantly need a shared understanding of the problem to be addressed and direction to be taken, and trust that their shared and interdependent interests can be met through collaboration (Innes & Booher, 2018; Smink et al., 2015; Harris & Lyon 2013). Developing shared understanding is another form of co-learning; here, academic researchers can provide mutually credible, high-quality systems, target, and transformative knowledge (Schneider & Buser, 2018). Joint agenda setting is important to reach common ground and ensure diverse stakeholders' interests are met, especially LMIC priorities that may not always be central in international research consortia (Pratt & Hyder, 2016). Discussions around target knowledge can help determine the common vision, through mapping out power dynamics and practicing reflexivity for more equitable outcomes (Littman et al., 2021).

During all phases, skilled facilitation is highly recommended across EHD, in planning and coordinating knowledge exchange, learning, and deliberations around key decisions. Facilitators may encourage self-reflexivity around power, diversity, and interdependence, and provide spaces for creative cross-fertilisation (Bos et al., 2013, Innes & Booher, 2018). Orchestrating stakeholders' contributions and responsibilities in a fair and equitable way is another important role of a facilitative project manager, creating the conditions for boundary spaces for all stakeholders (Touati et al., 2019; Zietsma & Lawrence, 2010).

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Reflexivity and co-learning could occur during *Phase 3: Monitoring & Refinement (Co-Monitoring)*, through a facilitated process to develop an implementation and monitoring framework observing intended and unintended outputs and outcomes. These include formal project deliverables and lessons learned on the process of collaboration and implementation of solution, through reflexive reporting which some funding institutions have begun to adopt, e.g. Most Significant Change (MSC) monitoring and reflection method (Davies & Dart, 2005) which could yield immediate learnings for *Phase 2: Implementation (Adaptive Co-Management)* and implementation. These learnings and refinements could include technical improvements, additional stakeholders with needed knowledge and skills, or improvement in the process of stakeholder interactions.

4. Application of the practice framework

Without unpacking the process of collaboration and inquiring into stakeholder interactions and dynamics, the design and context of TD collaboration remains a black box and risks failure to deliver the outcomes and aspirations of system transformations. The proposed practice framework aims to shed light on stages of the stakeholder collaboration process and the factors influencing it. **Figure 2** outlines how these stages come together, alongside the phases of TD research, and is to be used in tandem with **Table 3**, a matrix of reflexive practice questions providing specific guidance throughout the cycle of research collaboration. Although each collaboration will differ in specifics, the questions can facilitate the creation of a boundary space for diverse stakeholders to practice individual and collective reflexivity, discuss potential roles and contributions; governance, leadership, and culture; and alignment of aims, objectives, and team expectations (Wardani et al., 2023; Hakkarainen et al., 2022; Brown et al., 2019; Brown et al., 2015).

We propose that the framework would be most effectively applied from at start at or prior to *Phase 1: Predevelopment & Initiation (Co-Design)* by process initiators and funding institutions assessing TD process design proposals for potential funding. As previously

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identified, funding institutions are at the fulcrum of transformative shifts with significant leverage to influence process design (Wardani et al., 2022), and hence can use the questions to guide their assessment of TD funding proposals. Early application of the framework at *Phase 1: Predevelopment & Initiation (Co-Design)* would proactively set the stage for the collaboration. The framework can also be used by stakeholders subsequent joining the process, as reference point for discussing the complex, multi-faceted dimensions of collaboration. This helps create transparency by providing a view of the process as a whole, and thus aligning expectations. While outputs and outcomes will be observed later during *Phase 3: Monitoring & Refinement (Co-Monitoring)*, and may be less apparent initially, the reflexive practice questions in Table 3 can pre-empt important factors to be considered early on.

5. Conclusion

Despite increasing recognition of the importance of TD approaches in producing credible, relevant, and legitimate (CRL) knowledge and solutions for 'wicked' and complex sustainability challenges (Rittel & Webber, 1973; Innes & Booher, 2018; Clark, Tomich, et al., 2016), progress towards the SDGs remains slow and multi-stakeholder processes need more substantial guidance in its design and implementation. As LMICs and the world's poorest will face the greatest threats and disproportionate burden from climate and environmental degradation (Thiery et al., 2021), indigenous peoples and knowledges have proven most effective in conservation and management efforts (Dawson et al., 2021). We propose that additional emphasis on addressing knowledge inequities by practicing reflexivity, consciously mapping power dynamics, and reconfiguring the collaborative process (Hakkarainen et al., 2022; Littman et al., 2021; Forester, 2013; Zeinali et al., 2020).

The research and analyses leading to the development of this practice framework included 1) a theoretical meta-analysis of existing TD frameworks in the EHD fields; 2) a literature review of enabling and constraining factors synthesised from recent practice in these fields

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(Wardani et al., 2022), and 3) an empirical case study (Wardani et al., 2023). Such theoretical and practical syntheses were helpful in connecting across diverse fields' perspectives; while the in-depth case study offered a unique and instructive context to understanding a broad, large-scale collaboration, and a focus on the early stages of conceptualisation and implementation in an LMIC setting. These contribute towards a good starting point for such a framework guiding TD practice, but further empirical research is needed to continue refining the framework and more fully understand such collaborative process, as well as its design and implementation.

The application and audience of this practice framework is envisioned to be in TD collaborations involving HIC and LMIC stakeholders. However, with its particular attention to power dynamics and stakeholder engagement, the framework may also be applicable in resource-poor, power-diverse, and vulnerable settings within HICs and in LMIC-LMIC collaborations. These may include indigenous communities or low-income or culturally and linguistically diverse groups in areas of public health and sustainability in HICs, or in informal settlements or refugee communities in LMICs. Such settings are vulnerable to well-intentioned collaborators bringing resources and associated power from outside the community (Avelino, 2021), and requires power reflexivity to avoid unintended consequences.

Admittedly, a broad application of the framework may raise limitations in meeting the specificity required in practice; however, we hope the framework offers an expansive space to carefully reflect upon a broad diversity of stakeholders and their potential interests and contributions. Moreover, further testing and refinement through reflexive practice over time could increase the relevance and enhance the usefulness of the framework for specific contexts. For the foreseeable future, more prioritisation of LMIC perspectives is needed to shift the balance towards knowledge equity.

- End of manuscript -

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Author Contributions

Jane Wardani: Conceptualisation, Methodology, Investigation, Data curation, Formal analysis, Visualisation, Writing - original draft, review & editing; **J. J. (Annette) Bos**: Supervision, Conceptualisation, Methodology, Writing - review & editing; **Diego Ramirez-Lovering**: Funding acquisition, Supervision, Conceptualisation, Writing - review & editing; **Anthony G. Capon**: Supervision, Conceptualisation, Writing - review & editing

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Conflicts of Interest

All authors declare no conflict of interest.

Research Transparency and Reproducibility

All data and methods have been included in the article itself. De-identified and aggregated data have been provided as far as it is safe and practical to do so.

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References

Alsayyad, N., & Roy, A. (2004). *Urban informality: Transnational perspectives from the Middle East, Latin America, and South Asia.* Lanham, MD; Oxford, UK: Lexington.

Archibald, J.-a. Q. u. Q. u. X., Lee-Morgan, J. B. J., & De Santolo, J. (2019). *Decolonizing research : indigenous storywork as methodology*. London: ZED Books Ltd.

Avelino, F. (2021). Theories of power and social change. Power contestations and their implications for research on social change and innovation. *Journal of Political Power, 14*(3), 425-448. doi:10.1080/2158379X.2021.1875307

Avelino, F., & Wittmayer, J. M. (2016). Shifting Power Relations in Sustainability Transitions: A Multi-actor Perspective. *Journal of Environmental Policy & Planning, 18*(5), 628-649. doi:10.1080/1523908X.2015.1112259

Bark, R. H., Kragt, M. E., & Robson, B. J. (2016). Evaluating an interdisciplinary research project: Lessons learned for organisations, researchers and funders. *International Journal of Project Management, 34*(8), 1449-1459. doi:10.1016/j.ijproman.2016.08.004

Barke, J., Thomas-Hughes, H., & Howard, M. (2020). Reflections from the field: Researchers' experiences of co-production. *Research for All, 4*(2), 169-179. doi:10.14324/rfa.04.2.03

Becher, T. (2001). *Academic tribes and territories : intellectual enquiry and the culture of disciplines* (2nd ed. ed.). Buckingham: Buckingham : Open University Press.

Black, D., Scally, G., Orme, J., Hunt, A., Pilkington, P., Lawrence, R., & Ebi, K. (2018). Moving Health Upstream in Urban Development: Reflections on the Operationalization of a Transdisciplinary Case Study. *Global Challenges, 3*(4). doi:10.1002/gch2.201700103

Bos, J. J., & Brown, R. R. (2012). Governance experimentation and factors of success in socio-technical transitions in the urban water sector. *Technological Forecasting and Social Change, 79*(7), 1340-1353. doi:https://doi.org/10.1016/j.techfore.2012.04.006

Bos, J. J., Brown, R. R., & Farrelly, M. A. (2013). A design framework for creating social learning situations. *Global Environmental Change, 23*, 398-412. doi:http://dx.doi.org/10.1OJ6/j.gloenvcha.2012.12.003

Boyden, S. (2004). *The biology of civilisation : understanding human culture as a force in nature*. Sydney: Sydney : UNSW Press.

Boyden, S. (2016). *Bionarrative : The story of life and hope for the future*: Canberra : ANU Press.

Bracken, L. J., & Oughton, E. A. (2006). 'What do you mean?' The importance of language in developing interdisciplinary research. *Transactions of the Institute of British Geographers, 31*(3), 371-382. doi:https://doi.org/10.1111/j.1475-5661.2006.00218.x

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77-101. doi:10.1191/1478088706qp063oa

Brown, R., Leder, K., Wong, T., French, M., Diego Ramirez, L., Chown, S. L., . . . Cahan, B. (2018). Improving human and environmental health in urban informal settlements: the Revitalising Informal Settlements and their Environments (RISE) programme. *The Lancet Planetary Health, 2*, S29. doi:10.1016/S2542-5196(18)30114-1

Brown, R., Werbeloff, L., & Raven, R. (2019). Interdisciplinary Research and Impact. *Global Challenges, 3*(4). doi:10.1002/gch2.201900020

Brown, R., Wong, T., & Deletic, A. (2015). How to catalyse collaboration. *Nature, 525*, 315-317.
Browne, K., Dzebo, A., Iacobuta, G., Faus Onbargi, A., Shawoo, Z., Dombrowsky, I., . . . Persson, Å. (2023). How does policy coherence shape effectiveness and inequality? Implications for sustainable development and the 2030 Agenda. *Sustainable Development, n/a*(n/a). doi:https://doi.org/10.1002/sd.2598
Bryman, A. (2016). *Social Research Methods* (5th ed.). Oxford, UK: Oxford University Press.
Calhoun, C., & Fong, B. (Eds.). (2022). *The Green New Deal and the Future of Work*. New York: Columbia University Press.
Capon, A. (2017). Harnessing urbanisation for human wellbeing and planetary health. *The Lancet Planetary Health, 1*(1), e6-e7. doi:10.1016/s2542-5196(17)30005-0
Chakrabarty, D. (2000). *Provincializing Europe : postcolonial thought and historical difference*. Princeton, N.J.: Princeton, N.J. : Princeton University Press.
Charmaz, K. (2015). Teaching Theory Construction With Initial Grounded Theory Tools: A Reflection on Lessons and Learning. *Qual Health Res, 25*(12), 1610-1622. doi:10.1177/1049732315613982
Chilisa, B. (2011). *Indigenous research methodologies*: SAGE.
Christian Pohl, S. R., Anne Zimmermann, Patricia Fry, Ghana S Gurung, Flurina Schneider, Chinwe Ifejika Speranza, Boniface Kiteme, Sébastian Boillat, Elvira Serrano, Gertrude Hirsch Hadorn and Urs Wiesmann. (2010). Researchers' roles in knowledge co-production: experience from sustainability research in Kenya, Switzerland, Bolivia and Nepal. *Science and Public Policy, , 37*(4), 267–281.
Clark, W. C., Tomich, T. P., van Noordwijk, M., Guston, D., Catacutan, D., Dickson, N. M., & McNie, E. (2016). Boundary work for sustainable development: Natural resource management at the Consultative Group on International Agricultural Research (CGIAR). *Proc Natl Acad Sci U S A, 113*(17), 4615-4622. doi:10.1073/pnas.0900231108
Clark, W. C., van Kerkhoff, L., Lebel, L., & Gallopin, G. C. (2016). Crafting usable knowledge for sustainable development. *Proc Natl Acad Sci U S A, 113*(17), 4570-4578. doi:10.1073/pnas.1601266113
Connolly, M. (2007). Practice frameworks: Conceptual maps to guide interventions in child welfare. *The British Journal of Social Work, 37*(5), 825-837. doi:https://doi.org/10.1093/bjsw/bcl049
Corburn, J., & Gottlieb, R. (2005). *Street Science : Community Knowledge and Environmental Health Justice*. Cambridge, UNITED STATES: MIT Press.
Cornish, F., Breton, N., Moreno-Tabarez, U., Delgado, J., Rua, M., de-Graft Aikins, A., & Hodgetts, D. (2023). Participatory action research. *Nature Reviews Methods Primers, 3*(1), 34. doi:10.1038/s43586-023-00214-1
Crane, P., & Richardson, L. (2000). *Reconnect action research kit*. Canberra, A.C.T.: Canberra, A.C.T. : Dept. of Family and Community Services.
Crenshaw, K. (1989). *Demarginalizing the intersection of race and sex: A black feminist critique of antidiscrimination doctrine (pp. 139–168).* Paper presented at the University of Chicago legal forum.
Creswell, J. W., & Poth, C. N. (2018). *Qualitative inquiry and research design: Choosing among five approaches* (4th ed.). Los Angeles, CA: SAGE.
Cundill, G., Harvey, B., Tebboth, M., Cochrane, L., Currie‐Alder, B., Vincent, K., . . . Landry, M. E. (2018). Large‐Scale Transdisciplinary Collaboration for Adaptation Research: Challenges and Insights. *Global Challenges, 3*(4). doi:10.1002/gch2.201700132

https://doi.org/10.1017/sus.2024.6 Published online by Cambridge University Press

Cundill, G., Roux, D. J., & Parker, J. N. (2015). Nurturing communities of practice for transdisciplinary research. *Ecology and Society; part of a Special Feature on Programme on Ecosystem Change and Society (PECS): Knowledge for Sustainable Stewardship of Social-ecological Systems, 20*(2). doi:http://dx.doi.org/10.5751/ES-07580-200222

David J. Abson, Joern Fischer, Julia Leventon, Jens Newig, Thomas Schomerus, Ulli Vilsmaier, . . . Lang, D. J. (2017). Leverage points for sustainability transformation. *Ambio, 46*, 30-39. doi:10.1007/s13280-016-0800-y

Davies, R., & Dart, J. (2005). *The 'Most Significant Change' (MSC) Technique: A Guide to Its Use*. Retrieved from

Dawson, N. M., Coolsaet, B., Sterling, E. J., Loveridge, R., Gross-Camp, N. D., Wongbusarakum, S., . . . Rosado-May, F. J. (2021). The role of Indigenous peoples and local communities in effective and equitable conservation. *Ecology and Society, 26*(3). doi:10.5751/ES-12625-260319

de Geus, T., Avelino, F., Strumińska-Kutra, M., Pitzer, M., Wittmayer, J. M., Hendrikx, L., . . . Rogge, K. (2023). Making sense of power through transdisciplinary sustainability research: insights from a Transformative Power Lab. *Sustainability Science, 18*(3), 1311-1327. doi:10.1007/s11625-023-01294-4

Demaio, A. R., & Rockström, J. (2015). Human and planetary health: towards a common language. *The Lancet, 386*(10007), e36-e37. doi:10.1016/s0140-6736(15)61044-3

Denzin, N. K., & Lincoln, Y. S. (2011). *The Sage handbook of qualitative research*: sage.

Deverka, P. A., Lavallee, D. C., Desai, P. J., Esmail, L. C., Ramsey, S. D., Veenstra, D. L., & Tunis, S. R. (2012). Stakeholder participation in comparative effectiveness research: defining a framework for effective engagement. *Journal of Comparative Effectiveness Research, 1*(2), 181-194. doi:doi:10.2217/cer.12.7

Djenontin, I. N. S., & Meadow, A. M. (2018). The art of co-production of knowledge in environmental sciences and management: lessons from international practice. *Environ Manage, 61*(6), 885-903. doi:10.1007/s00267-018-1028-3

Donabedian, A. (2003). *An introduction to quality assurance in health care*. Oxford

New York: Oxford

New York : Oxford University Press.

Ebi, K. L., Harris, F., Sioen, G. B., Wannous, C., Anyamba, A., Bi, P., . . . Capon, A. (2020). Transdisciplinary Research Priorities for Human and Planetary Health in the Context of the 2030 Agenda for Sustainable Development. *International Journal of Environmental Research and Public Health, 17*(23), 8890. Retrieved from https://www.mdpi.com/1660-4601/17/23/8890

Edmonson, A. (2019). *The Fearless Organization*. Hoboken, NJ: John Wiley & Sons.

Ely, A., Marin, A., Charli-Joseph, L., Abrol, D., Apgar, M., Atela, J., . . . Yang, L. (2020). Structured Collaboration Across a Transformative Knowledge Network—Learning Across Disciplines, Cultures and Contexts? *Sustainability, 12*(6). doi:10.3390/su12062499

Filipe, A., Renedo, A., & Marston, C. (2017). The co-production of what? Knowledge, values, and social relations in health care. *PLoS Biol, 15*(5), e2001403. doi:10.1371/journal.pbio.2001403

Forester, J. (2006). Making participation work when interests conflict: moving from facilitating dialogue and moderating debate to mediating negotiations. *Journal of the American Planning Association, 72*, 447-456. doi:https://doi.org/10.1080/01944360608976765

https://doi.org/10.1017/sus.2024.6 Published online by Cambridge University Press

Forester, J. (2013). On the theory and practice of critical pragmatism: Deliberative practice and creative negotiations. *Planning Theory, 12*(1), 5-22. doi:10.1177/1473095212448750

Galafassi, D., Daw, T. M., Thyresson, M., Rosendo, S., Chaigneau, T., Bandeira, S., . . . Brown, K. (2018). Stories in social-ecological knowledge cocreation. *Ecology and Society, 23*(1). doi:10.5751/ES-09932-230123

Giddens, A. (1984). *The constitution of society : outline of the theory of structuration*. Cambridge: Cambridge : Polity.

Gunasekara, V. (2020). (Un)packing Baggage: A Reflection on the 'Battle Over Ideas' and Labour Hierarchies in Collaborative North–South Research. *The European Journal of Development Research 32*, 503–513. doi:https://doi.org/10.1057/s41287-020-00275-y

Gustafsson, K. M., & Lidskog, R. (2018). Boundary organizations and environmental governance: Performance, institutional design, and conceptual development. *Climate Risk Management, 19*, 1-11. doi:https://doi.org/10.1016/j.crm.2017.11.001

Hakkarainen, V., Mäkinen-Rostedt, K., Horcea-Milcu, A., D'Amato, D., Jämsä, J., & Soini, K. (2022). Transdisciplinary research in natural resources management: Towards an integrative and transformative use of co-concepts. *Sustainable Development, 30*(2), 309-325. doi:https://doi.org/10.1002/sd.2276

Hall, K., Stipelman, B. A., Stokols, D., & Vogel, A. L. (2017). Understanding Cross-Disciplinary Team-Based Research: Concepts and Conceptual Models from the Science of Team Science. In (2 ed.): Oxford University Press.

Hankivsky, O., Reid, C., Cormier, R., Varcoe, C., Clark, N., Benoit, C., & Brotman, S. (2010). Exploring the promises of intersectionality for advancing women's health research. *International Journal for Equity in Health, 9*(1), 5. doi:10.1186/1475-9276-9-5

Harris, F., & Lyon, F. (2013). Transdisciplinary environmental research: Building trust across professional cultures. *Environmental Science & Policy, 31*, 109-119. doi:https://doi.org/10.1016/j.envsci.2013.02.006

Healy, K. (2014). *Social Work Theories in Context : Creating Frameworks for Practice*. London, UNITED KINGDOM: Bloomsbury Publishing Plc.

Heaton, J., Day, J., & Britten, N. (2016). Collaborative research and the co-production of knowledge for practice: an illustrative case study. *Implement Sci, 11*, 20. doi:10.1186/s13012-016-0383-9

Hopkins, D., Kester, J., Meelen, T., & Schwanen, T. (2020). Not more but different: A comment on the transitions research agenda. *Environmental innovation and societal transitions, 34*, 4-6. doi:10.1016/j.eist.2019.11.008

Horcea-Milcu, A.-I., Abson, D. J., Apetrei, C. I., Duse, I. A., Freeth, R., Riechers, M., . . . Lang, D. J. (2019). Values in transformational sustainability science: four perspectives for change. *Sustainability Science, 14*(5), 1425-1437. doi:10.1007/s11625-019-00656-1

Innes, J. E., & Booher, D. E. (2018). *Planning with Complexity: An introduction to collaborative rationality for public policy*. Oxon, UK and New York, USA: Routledge.

ISC. (2023). *A Model for Implementing Mission Science for Sustainability*. Retrieved from Paris, France: https://council.science/publications/a-model-forimplementing-mission-science-for-sustainability

Jasanoff, S. (2004). The idiom of co-production. In S. Jasanoff (Ed.), *States of Knowledge: The Co-Production of Science*: Taylor & Francis Group.

https://doi.org/10.1017/sus.2024.6 Published online by Cambridge University Press

Jenkins, A., Capon, A., Negin, J., Marais, B., Sorrell, T., Parkes, M., & Horwitz, P. (2018). Watersheds in planetary health research and action. *The Lancet Planetary Health, 2*(12), e510-e511. doi:10.1016/s2542-5196(18)30228-6

Kimmerer, R. W. (2013). *Braiding Sweetgrass: Indigenous Wisdom, Scientific Knowledge, and the Teachings of Plants*: Penguin Books.

Kivimaa, P., Boon, W., Hyysalo, S., & Klerkx, L. (2019). Towards a typology of intermediaries in sustainability transitions: A systematic review and a research agenda. *Research Policy, 48*(4), 1062-1075. doi:https://doi.org/10.1016/j.respol.2018.10.006

Klein, J. T. (1996). *Crossing boundaries : knowledge, disciplinarities, and interdisciplinarities*. Charlottesville, Va.: Charlottesville, Va. : University Press of Virginia.

Kovach, M. (2009). *Indigenous Methodologies: Characteristics, Conversations, and Contexts*. Toronto, ON: University of Toronto Press.

Lang, D. J., Wiek, A., Bergmann, M., Stauffacher, M., Martens, P., Moll, P., . . . Thomas, C. J. (2012). Transdisciplinary research in sustainability science: practice, principles, and challenges. *Sustainability Science, 7*(S1), 25-43. doi:10.1007/s11625-011-0149-x

Larson, E., George, A., Morgan, R., & Poteat, T. (2016). 10 Best resources on… intersectionality with an emphasis on low- and middle-income countries. *Health Policy and Planning, 31*(8), 964-969. doi:10.1093/heapol/czw020

Littman, D. M., Bender, K., Mollica, M., Erangey, J., Lucas, T., & Marvin, C. (2021). Making power explicit: Using values and power mapping to guide power-diverse Participatory Action Research processes. *J Community Psychol, 49*(2), 266-282. doi:10.1002/jcop.22456

Loeffler, E., & Bovaird, A. G. (2021). *The Palgrave handbook of co-production of public services and outcomes* (1st 2021. ed.): Cham, Switzerland : Palgrave Macmillan.

Luederitz, C., Schapke, N., Wiek, A., ..., & Westley, F. (2017). Learning through evaluation - A tentative evaluative scheme for sustainability transition experiments. *Journal of Cleaner Production, 169*, 61-76.

MacMynowski, D. P. (2007). Pausing at the Brink of Interdisciplinarity: Power and Knowledge at the Meeting of Social and Biophysical Science. *Ecology and Society, 12*(1). Retrieved from http://www.ecologyandsociety.org/vol12/iss1/art20/

Marzano, M., Carss, D. N., & Bell, S. (2006). Working to Make Interdisciplinarity Work: Investing in Communication and Interpersonal Relationships. *Journal of Agricultural Economics, 57*(2), 185–197.

McIntosh, B. S., & Taylor, A. (2013). Developing T‐Shaped Water Professionals: Building Capacity in Collaboration, Learning, and Leadership to Drive Innovation. *Journal of Contemporary Water Research & Education, 150*(1), 6-17. doi:10.1111/j.1936-704X.2013.03143.x

McMichael, A. J. (2013). Impediments to Comprehensive Research on Climate Change and Health. *International Journal of Environmental Research and Public Health, 10*(11), 6096-6105. Retrieved from https://www.mdpi.com/1660-4601/10/11/6096

Moser, S. C. (2016). Can science on transformation transform science? Lessons from co-design. *Current Opinion in Environmental Sustainability, 20*, 106-115. doi:http://dx.doi.org/10.1016/j.cosust.2016.10.007

Newell, B., & Proust, K. (2012). *Introduction to Collaborative Conceptual Modelling*. Retrieved from Canberra, ACT: https://digitalcollections.anu.edu.au/handle/1885/9386

Nix, E., Paulose, J., Shrubsole, C., Altamirano‐Medina, H., Belesova, K., Davies, M., . . . Wilkinson, P. (2018). Participatory Action Research as a Framework for

https://doi.org/10.1017/sus.2024.6 Published online by Cambridge University Press

Transdisciplinary Collaboration: A Pilot Study on Healthy, Sustainable, Low‐Income Housing in Delhi, India. *Global Challenges, 3*(4). doi:10.1002/gch2.201800054

Nogueira, L. A., Bjørkan, M., & Dale, B. (2021). Conducting Research in a Post-normal Paradigm: Practical Guidance for Applying Co-production of Knowledge. *Frontiers in Environmental Science, 9*. doi:10.3389/fenvs.2021.699397

Norström, A. V., Balvanera, P., Cvitanovic, C., Löf, M. F., West, S., Bednarek, A. T., . . . Österblom, H. (2020). Principles for knowledge co-production in sustainability research. *Nature Sustainability, 3*, 182–190. doi:https://doi.org/10.1038/s41893-019-0448-2

Nowotny, H., Scott, P., & Gibbons, M. (2003). Introduction: `Mode 2' Revisited: The New Production of Knowledge. *Minerva, 41*(3), 179-194. doi:10.1023/A:1025505528250

Odora Hoppers, C. A. (2011). Towards the Integration of Knowledge Systems: Challenges to Thought and Practice. In S. Harding (Ed.), *The Postcolonial Science and Technology Studies Reader* (pp. 0): Duke University Press.

OECD. (2020). *Addressing societal challenges using transdisciplinary research*. Retrieved from

Ostrom, E. (1996). Crossing the great divide: Coproduction, synergy, and development. *World Development, 24*(6), 1073-1087.

Peters, D. H., Adam, T., Alonge, O., Agyepong, I. A., & Tran, N. (2013). Implementation research: what it is and how to do it. *Bmj, 347*.

Pineo, H., Audia, C., Black, D., French, M., Gemmell, E., Lovasi, G. S., . . . Taruc, R. R. (2020). Building a Methodological Foundation for Impactful Urban Planetary Health Science. *J Urban Health*. doi:10.1007/s11524-020-00463-5

Pineo, H., Turnbull, E. R., Davies, M., Rowson, M., Hayward, A. C., Hart, G., . . . Aldridge, R. W. (2021). A new transdisciplinary research model to investigate and improve the health of the public. *Health Promotion International, 36*(2), 481-492. doi:10.1093/heapro/daaa125

Pohl, C., Klein, J. T., Hoffmann, S., Mitchell, C., & Fam, D. (2021). Conceptualising transdisciplinary integration as a multidimensional

interactive process. *Environmental Science and Policy, 118*, 18-26. doi:https://doi.org/10.1016/j.envsci.2020.12.005

Pohl, C., Krütli, P., & Stauffacher, M. (2017). Ten Reflective Steps for Rendering Research Societally Relevant. *GAIA - Ecological Perspectives for Science and Society, 26*(1), 43-51. doi:10.14512/gaia.26.1.10

Pongsiri, M. J., & Bassi, A. M. (2021). A Systems Understanding Underpins Actions at the Climate and Health Nexus. *International Journal of Environmental Research and Public Health, 18*(5), 2398. Retrieved from https://www.mdpi.com/1660-4601/18/5/2398

Pongsiri, M. J., Gatzweiler, F. W., Bassi, A. M., Haines, A., & Demassieux, F. (2017). The need for a systems approach to planetary health. *The Lancet Planetary Health, 1*(7), e257-e259. doi:10.1016/s2542-5196(17)30116-x

Pratt, B., & Hyder, A. A. (2017). Governance of global health research consortia: Sharing sovereignty and resources within Future Health Systems. *Soc Sci Med, 174*, 113-121. doi:10.1016/j.socscimed.2016.11.039

Pratt, B., Merritt, M., & Hyder, A. A. (2016). Towards deep inclusion for equity-oriented health research priority-setting: A working model. *Soc Sci Med, 151*, 215-224. doi:10.1016/j.socscimed.2016.01.018

https://doi.org/10.1017/sus.2024.6 Published online by Cambridge University Press

Pryor, J., Kuupole, A., Kutor, N., Dunne, M., & Adu‐Yeboah, C. (2009). Exploring the fault lines of cross‐cultural collaborative research. *Compare: A Journal of Comparative and International Education, 39*(6), 769-782. doi:10.1080/03057920903220130

Putnam, R. (2000). *Bowling Alone: The Collapse and Revival of American Community*. New York: Simon & Schuster.

Raymond, C. M., Frantzeskaki, N., Kabisch, N., Berry, P., Breil, M., Nita, M. R., . . . Calfapietra, C. (2017). A framework for assessing and implementing the co-benefits of nature-based solutions in urban areas. *Environmental Science & Policy, 77*, 15-24. doi:https://doi.org/10.1016/j.envsci.2017.07.008

Reidpath, D. D., & Allotey, P. (2019). The problem of 'trickle-down science' from the Global North to the Global South. *BMJ Global Health, 4*(4), e001719. doi:10.1136/bmjgh-2019-001719

Reidpath, D. D., Allotey, P., Barker, S. F., Clasen, T., French, M., Leder, K., . . . Siri, J. (2022). Implementing "from here to there": A case study of conceptual and practical challenges in implementation science. *Social Science & Medicine, 301*, 114959. doi:https://doi.org/10.1016/j.socscimed.2022.114959

Rittel, H. W. J., & Webber, M. M. (1973). Dilemmas in a general theory of planning. *Policy Sciences, 4*(2), 155-169. doi:10.1007/BF01405730

Romme, A. G. L., & Meijer, A. (2020). Applying design science in public policy and administration research. *Policy and politics, 48*(1), 149-165. doi:10.1332/030557319X15613699981234

Roy, A. (2009). The 21st-Century Metropolis: New Geographies of Theory. *Regional Studies, 43*(6), 819-830. doi:10.1080/00343400701809665

Roy, A. (2016). Who's Afraid of Postcolonial Theory? *International Journal of Urban and Regional Research, 40*(1), 200-209. doi:https://doi.org/10.1111/1468-2427.12274

Sabatier, P. A. (2005). *Swimming upstream : collaborative approaches to watershed management / edited by Paul A. Sabatier ... [et al.]*. Cambridge, Mass: MIT Press.

Sassen, S. (2014). *Expulsions : Brutality and Complexity in the Global Economy*: Cambridge, MA : Harvard University Press.

Sassen, S. (2016). *Global Networks, Linked Cities*: Taylor & Francis.

Sassen, S. (2019). *Cities in a world economy* (Fifth edition. ed.): Thousand Oaks, California : SAGE Publications, Inc.

Schneider, F., & Buser, T. (2018). Promising degrees of stakeholder interaction in research for sustainable development. *Sustainability Science, 13*, 129-142. doi:https://doi.org/10.1007/s11625-017-0507-4

Severs, E., Celis, K., & Erzeel, S. (2016). Power, privilege and disadvantage: Intersectionality theory and political representation. *Politics, 36*(4), 346-354. doi:10.1177/0263395716630987

Shackleton, R. T., Adriaens, T., Brundu, G., Dehnen-Schmutz, K., Estévez, R. A., Fried, J., . . . Richardson, D. M. (2019). Stakeholder engagement in the study and management of invasive alien species. *Journal of Environmental Management, 229*, 88-101. doi:https://doi.org/10.1016/j.jenvman.2018.04.044

Sillitoe, P. (2018). Some challenges of collaborative research with local knowledge. *Antropologia Pubblica, 4*(1), 31-50. doi:10.1473/anpub.v4i1.126

Smith, L. T. (2021). *Decolonizing methodologies : research and indigenous peoples*: London : Zed Books : Bloomsbury Publishing.

Sovacool, B. K., & Brisbois, M.-C. (2019). Elite power in low-carbon transitions: A critical and interdisciplinary review. *Energy research & social science, 57*, 101242. doi:10.1016/j.erss.2019.101242

https://doi.org/10.1017/sus.2024.6 Published online by Cambridge University Press

Stanley, T. (2016). A practice framework to support the Care Act 2014. *The Journal of Adult Protection, 18*(1), 53-64. doi:10.1108/JAP-07-2015-0020

Star, S. L., & Griesemer, J. R. (1989). Institutional Ecology, 'Translations' and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39. *Social Studies of Science, 19*(3), 387-420. Retrieved from http://www.jstor.org/stable/285080

Stokols, D. (2006). Toward a Science of Transdisciplinary Action Research. *American Journal of Community Psychology, 38*, 63-77. doi:10.1007/s10464-006-9060-5

Stokols, D., Hall, K. L., & Vogel, A. L. (2013). Transdisciplinary Public Health: Definitions, Core Characteristics, and Strategies for Success. In D. Haire-Joshu & T. D. McBride (Eds.), *Transdisciplinary Public Health: Research, Education, and Practice* (1 ed.). San Francisco: Jossey-Bass: John Wiley & Sons, Incorporated.

Tawake, P., Rokotuibau, M., Kalpokas-Doan, J., Illingworth, A. M., Gibert, A., & Smith, Y. (2021). Retrieved from

Thiery, W., Lange, S., Rogelj, J., Schleussner, C.-F., Gudmundsson, L., Seneviratne, S. I., . . . Wada, Y. (2021). Intergenerational inequities in exposure to climate extremes. *Science, 374*(6564), 158-160. doi:doi:10.1126/science.abi7339

Tosey, P., Visser, M., & Saunders, M. N. (2012). The origins and conceptualizations of 'triple-loop' learning: A critical review. *Management Learning, 43*(3), 291-307. doi:10.1177/1350507611426239

Touati, N., Denis, J. L., Grenier, C., & Smits, P. (2019). Implementing Spaces to Favor the Emergence of Ecologies of Complex Innovation in the Public Sector: An Empirical Analysis. *Administration & Society, 51*(3), 463-490. doi:10.1177/0095399716659734

van Breda, J., & Swilling, M. (2018). The guiding logics and principles for designing emergent transdisciplinary research processes: learning experiences and reflections from a transdisciplinary urban case study in Enkanini informal settlement, South Africa. *Sustainability Science, 14*(3), 823-841. doi:10.1007/s11625-018-0606-x

Wardani, J., Bos, J. A. J., Ramirez-Lovering, D., & Capon, A. G. (forthcoming). From complexity to mutual understanding and acceptance: Participants' experiences of a transdisciplinary planetary health collaboration in Indonesia (draft title).

Wardani, J., Bos, J. J., Ramirez-Lovering, D., & Capon, A. G. (2023). Boundaries as Spaces of Knowledge Integration: Learning from transdisciplinary collaboration on planetary health in Indonesia. *The Journal of Climate Change and Health, 11*, 100242. doi:https://doi.org/10.1016/j.joclim.2023.100242

Wardani, J., Bos, J. J. A., Ramirez-Lovering, D., & Capon, A. G. (2022). Enabling transdisciplinary research collaboration for planetary health: Insights from practice at the environment-healthdevelopment nexus. *Sustainable Development, 30*, 375–392. doi:DOI: 10.1002/sd.2280

West, S., van Kerkhoff, L., & Wagenaar, H. (2019). Beyond "linking knowledge and action": towards a practice-based approach to transdisciplinary sustainability interventions. *Policy Studies, 40*(5), 534-555. doi:10.1080/01442872.2019.1618810

White, D. D., Lawless, K. L., Vivoni, E. R., Mascaro, G., Pahle, R., Kumar, I., . . . Asfora, M. (2018). Co‐Producing Interdisciplinary Knowledge and Action for Sustainable Water Governance: Lessons from the Development of a Water Resources Decision Support System in Pernambuco, Brazil. *Global Challenges, 3*(4). doi:10.1002/gch2.201800012

Whitmee, S., Haines, A., Beyrer, C., Boltz, F., Capon, A. G., de Souza Dias, B. F., . . . Yach, D. (2015). Safeguarding human health in the Anthropocene epoch: report of The Rockefeller Foundation–Lancet Commission on planetary health. *The Lancet, 386*(10007), 1973-2028. doi:10.1016/s0140-6736(15)60901-1

https://doi.org/10.1017/sus.2024.6 Published online by Cambridge University Press

Wiek, A., Kay, B., & Forrest, N. (2017). Worth the Trouble An Evaluative Scheme for Urban Sustainability Transition Labs USTL and an Application to the USTL in Phoenix Arizona. In e. a. Niki Frantzeskaki (Ed.), *Urban Sustainability Transitions*: Routledge.

Wittmayer, J. M., & Schäpke, N. (2014). Action, research and participation: roles of researchers in sustainability transitions. *Sustainability Science, 9*(4), 483-496. doi:10.1007/s11625-014-0258-4

Zeinali, Z., Bulc, B., Lal, A., van Daalen, K. R., Campbell-Lendrum, D., Ezzine, T., . . . Whitmee, S. (2020). A roadmap for intergenerational leadership in planetary health. *The Lancet Planetary Health, 4*(8), e306-e308. doi:10.1016/S2542-5196(20)30171-6

Zietsma, C., & Lawrence, T. B. (2010). Institutional Work in the Transformation of an Organizational Field: The Interplay of Boundary Work and Practice Work. *Administrative Science Quarterly, 55*(2), 189-221. doi:10.2189/asqu.2010.55.2.189

https://doi.org/10.1017/sus.2024.6 Published online by Cambridge University Press