TRANSDISCIPLINARY URBAN RESEARCH
VISUALISATION TOOLS

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Introduction

Sustainability has been an influential concept to interpret and inform urban development for several decades. The idea of designing, building, and operating cities to be economically prosperous, environmentally resilient, and socially equitable is a persuasive and comprehensive way for a wide range of researchers, policymakers, politicians, and residents to steer urban development towards more desirable futures. However, translating the concept of sustainability into real world actions has proven to be elusive. In the last two decades, proponents of sustainable urban development have embraced the notion of transdisciplinarity as a bridge between theory and action. Transdisciplinary urban researchers recognise the value of collaboration between academic and non-academic stakeholders to co-create knowledge that is scientifically rigorous as well as socially relevant (Jahn et al. 2012, Fam et al. 2017). In essence, transdisciplinary research holds the potential to bridge the gap between knowledge generation and practical application, unlocking new pathways for sustainable urban development.

Collaboration in transdisciplinary urban research involves the integration of diverse perspectives and the development of innovative solutions to address the complexities of real-world urban contexts. Engaging with stakeholders from governmental organisations, private sector companies, non-profit organisations, and community groups can produce a more holistic understanding of urban challenges and facilitate the co-creation of solutions that are tailored to the unique needs and priorities of different communities. Through the shared ownership of problems, solutions, and processes of integrating and disseminating knowledge, transdisciplinary research can achieve sustainable urban development goals and realise cities that are resilient, inclusive, and thriving for generations to come (Lang et al. 2012, Lawrence et al. 2022).

Visualisations are useful tools to make complex theoretical concepts and methodological processes accessible to a wide range of actors. These tools translate intricate data and abstract concepts into understandable and engaging formats to facilitate communication and collaboration across various fields of study. Furthermore, visualisations can support the development of a common narrative as well as analytical approaches to reveal patterns, trends, and relationships of quantitative and qualitative datasets (Jahn et al. 2012, Lang et al. 2012, Brink et al. 2018, Riedy 2023). They can also promote a shared understanding and common language of collective problem-solving while empowering stakeholders from various sectors to contribute meaningfully to the discourse (Frantzeskaki and Kabisch 2016).

This report provides a summary of 11 visualisations that have been developed by scholars who are engaged in transdisciplinary urban research. We identified the visualisations through a review of academic literature in the disciplines of Architecture, Planning, Geography, Urban Studies, and Sustainability Science between 2010 to 2023. Some of the visualisations are original while others are derived from previous research and have gone through multiple iterations. With each visualisation, we asked the following questions:

- How is transdisciplinary research being framed?
- Which theories or practical approaches does the visualisation address?
- Which actors are represented in the visualisation and how are their interactions characterised?
- How does the visualisation contribute to transdisciplinary research practice?

In the following pages, we have organised the 11 visualisations organised into three categories: 1) conceptual framings, 2) process dynamics, and 3) analytic tools. This is not a comprehensive catalogue of visualisations on transdisciplinary urban research but rather a selection of the work done by scholars to distil transdisciplinary research principles and experiences into accessible and useful diagrams. The visualisations are representative of a larger collection of tools that have been developed by a wide range of transdisciplinary urban researchers over the past 15 years.

Conceptual Framings

Theoretical understandings of transdisciplinary urban research integrate multiple disciplines and knowledge practices. The visualisation by Viable Cities (2019) is one of many similar models that define the transdisciplinary concept in relation to urban research (**Figure 1**). 'Disciplinary research' is conducted in discrete silos with its own methods and tools, 'multidisciplinary research' involves two or more disciplines that focus on a shared objective but work independently, 'interdisciplinary research' includes two or more disciplines that integrate their ideas and activities to focus on a common research question, and 'transdisciplinary research' goes beyond academia to engage with non-academics through processes of knowledge co-creation about socially relevant issues. This visualisation is a useful way to illustrate transdisciplinary urban research as a concept and how it can be applied within a specific project. It serves as a starting point for stakeholders to understand how transdisciplinarity differs from other forms of knowledge production and how it engages academics from multiple disciplines with non-academic actors.
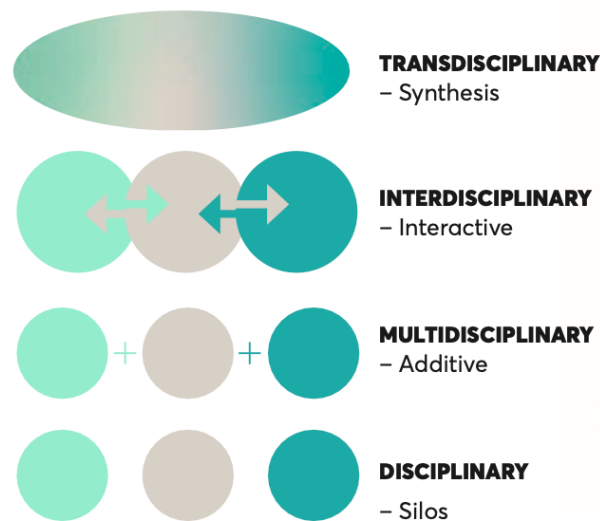
Figure 1 A comparison of four disciplinary approaches to urban research (Viable Cities 2019: 72)

Another approach to interpret the concept of transdisciplinary urban research is to focus on the various forms of expertise that are involved in knowledge production processes. **Figure 2** provides a table to compare and contrast three modes of expertise that employ distinct modes of knowledge production and assumptions about epistemology, attitudes towards other experts and the public, knowledge flows, and the role of power. Similar to the previous visualisation, this table provides a comparison of various ways of conducting research. The roles do not compete with one another but involve different approaches, methods, and epistemological assumptions that are appropriate for a range of research aims and objectives. This typology introduces transdisciplinary in an accessible way and is suitable for a wide range of audiences. It has the potential to be used for educational purposes, to support participation, and to create a shared understanding among the actors.

	The communicative expert	*The collegial expert*	*The collaborative expert*
Cliché role	"The educator"	"The broker"	"The democrat"
Mode of knowledge production	Monodisciplinary	Interdisciplinary	Transdisciplinary
Epistemological assumptions	Core set of scientific principles	Synergism of core sets	Emergent from discourse between experts and non-experts
Attitude toward other experts	Competitors	Necessary partners	One of many sources of knowledge
Attitude toward the public	Receivers of expert wisdom	Not considered	Co-designers in generating solutions
Knowledge flow	Top-down	Lateral and discursive	Multidirectional and discursive
Role of power	Competition between disciplines for the exclusive claim to truth	Emergent from collaboration between disciplines	Shared and contested between experts and non-experts

Figure 2 Different modes of expertise and their disciplinary implications (Karvonen and Brand 2022: 247)

A third way to frame transdisciplinary concepts is to focus on knowledge production. **Figure 3** visualises the relationship among different types of knowledge in transdisciplinary processes. 'Systems Knowledge' encompasses both empirical and theoretical studies, ranging from the specific, disciplinary understanding of a single phenomenon to integrative, interdisciplinary relationships. 'Orientation Knowledge' formulates and justifies the goals and objectives of social change processes by going beyond a single target to address complex societal challenges. 'Transformation Knowledge' engages with understanding and developing the practical means—technical, legal, social, and cultural—to achieve the desired goals or objectives. And 'Process Knowledge' combines the previous knowledges into approaches to design and implement transdisciplinary research.

The figure illustrates the interconnectedness of a diverse range of knowledge systems including practical applications, policy frameworks, and academic fields and emphasises how they can interact synergistically through collaborative exchange. It encompasses theoretical knowledge as well as practical or 'real-world' expertise, and demonstrates how these knowledges can interact through intentional process design. It emphasises the practical execution of transdisciplinary research and the generation of context-specific knowledge that is adaptable and relevant to the unique challenges at hand. While this visualisation does not provide specific ideas on how to design these processes, it underscores the necessity to develop methodologies and actions tailored to the specific context of each issue or project.
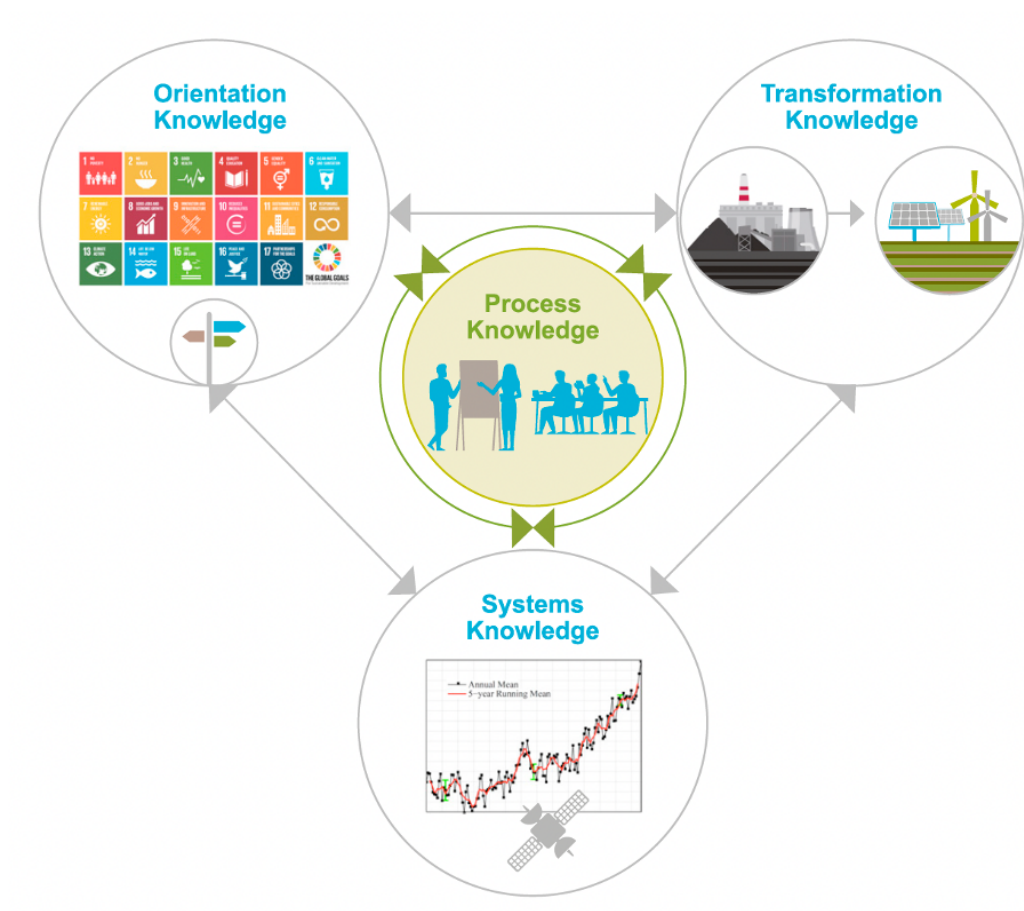

Figure 3 Knowledge production in transdisciplinary research (Lawrence et al. 2022: 54)

Beyond the framing of transdisciplinary research concepts, it is important to evaluate the outcomes. Because transdisciplinarity functions beyond and within the confines of traditional disciplinary boundaries, it can be difficult to produce outcomes and societal effects. **Figure 4** provides a visualisation of three orders of effects:

- 'First Order Effects' are immediate and directly linked to a process, typically emerging soon after a project is completed. These effects include usable products (e.g., technologies, action plans), enhanced capacity (e.g., learning, knowledge co-production), and network effects (e.g., new or strengthened relationships).
- 'Second Order Effects' resemble outcomes and impacts on the broader system within which the process operates. These effects can be economic, policy-related (e.g., new policies, changes in policy discourse), or organisational (e.g., new business models, changes in organisational strategy). They tend to appear later, making it more difficult for researchers to make direct causal attributions.
- 'Third Order Effects' transcend specific institutions or organisations and occur at a societal level. They address the emergence of alternative visions and imaginaries that present different futures, potentially leading to new narratives and shared visions while challenging existing social conceptions. These effects may result in transformed social practices, such as pro-environmental behaviours, and are akin to social innovation, which changes the fundamental routines, resource flows, authority structures, and beliefs that are embedded in broader social systems.
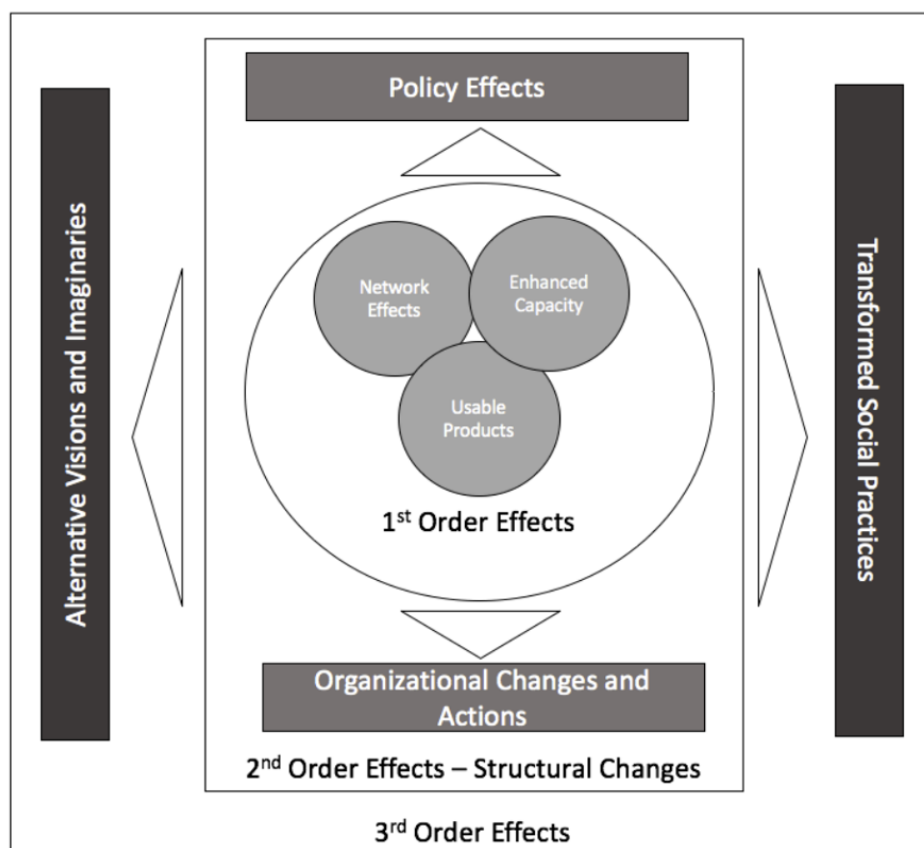

Figure 4 Framing the effects of transdisciplinary research (Williams 2017: 8)

This visualisation provides a way to assess transdisciplinary research at different levels. It can help to address the complex issue of traceability of this type of research and its mission to produce actionable knowledge. The model focuses on societal effects while also addressing the engagement and interaction of the participants that produce these effects. The visualisation can be used in the initial stages of a project to understand what can be expected in future work and in later stages of the project to evaluate the societal effects that have been realised.

Process Dynamics

Transdisciplinary urban research involves new ways of thinking about the world as well as acting upon it. A second set of visualisations focuses on the process dynamics of engaging in transdisciplinary activities. **Figure 5** is a visualisation of these process dynamics that illustrates how societal problems and scientific problems are combined into a common object of research. This involves three stages: 1) 'Formation of a Common Research Object' where societal problems and scientific problems are merged into a common agenda, 2) 'Production of New Knowledge' where transdisciplinary actors create a framework that is then followed by an interdisciplinary research team, and 3) 'Transdisciplinary Integration' where the societal and scientific outcomes are evaluated and then transferred to praxis.
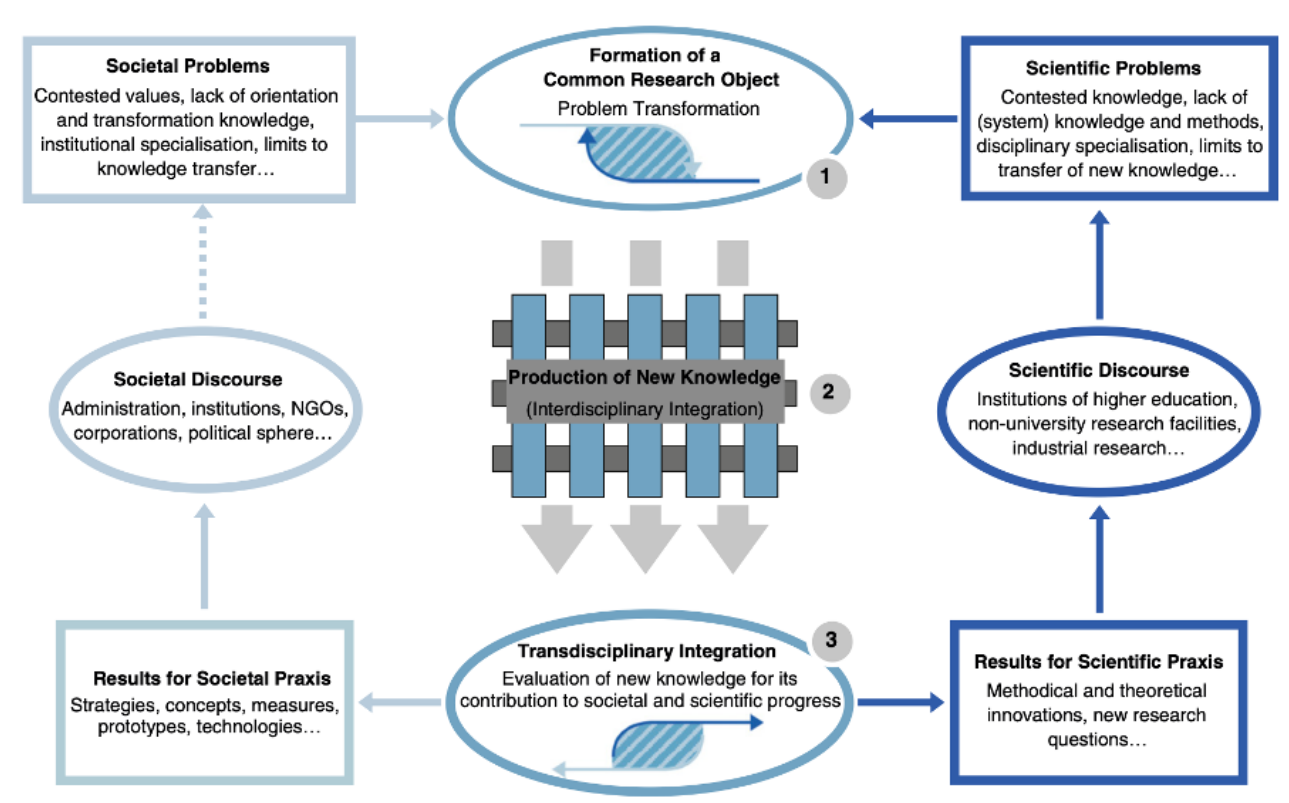

Figure 5 A transdisciplinary research process that combines societal and
scientific problems into a common research object (Jahn et al. 2012: 5)

This visualisation recognises two tracks of knowledge production, one that focuses on societal problems while the other focuses on scientific problems. The two tracks come together through integrated forms of transdisciplinary knowledge production. The outcomes of the process are then fed back into the societal and scientific tracks and form iterative loops of continuous knowledge production. The iterations of each stage ensure that the project remains responsive to both scientific and societal needs, thereby facilitating the creation of solutions that are well-informed by diverse perspectives and practical realities. A unique aspect of this model is the continued promotion of interdisciplinary research alongside transdisciplinary collaboration and the need for scientists to sometimes work independently. The authors argue that this is necessary to generate scientifically robust knowledge while balancing academic and societal aims.

Hoffmann and colleagues (2019) created a new version of this visualisation to include knowledge dissemination (**Figure 6**). Their visualisation places a strong emphasis on connecting processes of knowledge production, dissemination, and utilisation (thick ovals) and establishing informal and formal linkage mechanisms between the project team and the intended target groups in science and practice (thin ovals). Transdisciplinary research involves five phases: 1) defining sustainability problems, 2) producing new knowledge, 3) assessing new knowledge, 4) disseminating new knowledge (in the realms of both science and practice), and 5) using knowledge (also in both realms). Transdisciplinary research projects complete each phase (thin ovals) and progressively extend their boundaries into the realms of both science and practice when assessing new knowledge (medium circle) and disseminating new knowledge (large circle).
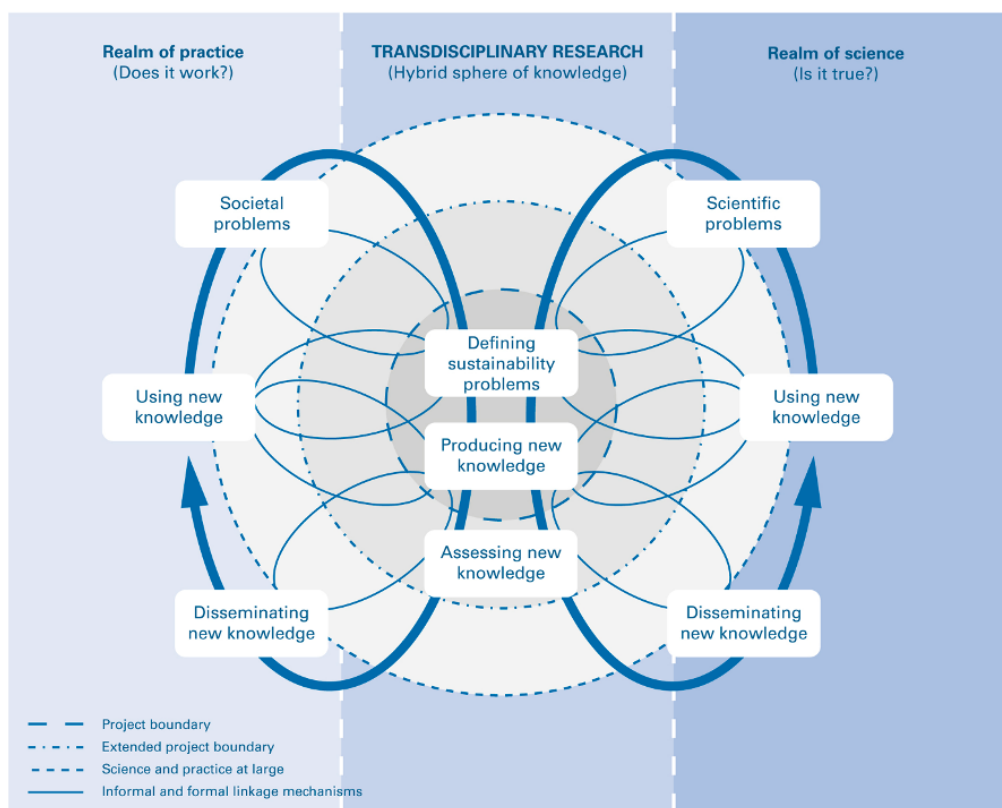

Figure 6 A transdisciplinary research process that emphasises dissemination and application of knowledge (Hoffmann et al. 2019: 40)

The visualisation underscores the importance of integrating scientific and practical insights into a 'hybrid sphere of knowledge' where the boundaries between science and practice are blurred or dissolved entirely. This hybrid sphere not only facilitates the merging of theoretical and practical insights but also ensures that the knowledge generated is both scientifically sound and practically applicable. Similar to **Figure 5**, this visualisation presents two rationalities that need to be balanced throughout the process: 1) the scientific goal of meeting standards of validity and truth and, 2) the practical goal of meeting standards of appropriateness and adequacy. It addresses the significant and persistent gap between the 'socially robust' knowledge produced through transdisciplinary research activities and their ability to promote large-scale change. It also highlights the importance of the social dynamics that are implicated in the emergence, circulation, and practical application of knowledge.

Another way to visualise the process dynamics of transdisciplinary urban research is by articulating the perspectives of stakeholders. **Figure 7** summarises the findings from a thematic analysis of participant perspectives who are engaged in a co-creation research project. It characterises co-created research as a combination of challenges, integration, benefits, and dialogue. The visualisation provides stakeholders with an understanding of what they can expect from a transdisciplinary research project while also providing guidance on communicating the complexity of these projects to external audiences. This approach is useful to those who are new to transdisciplinarity because it showcases the dynamic interactions and co-creation processes that are central to transdisciplinary activities. The visualisation also highlights the potential challenges and opportunities that come with integrating science and practice, and demonstrates how this approach can significantly contribute to the development of individuals, groups, and society as a whole. It can also be used to establish realistic expectations and appreciation for this type of research.
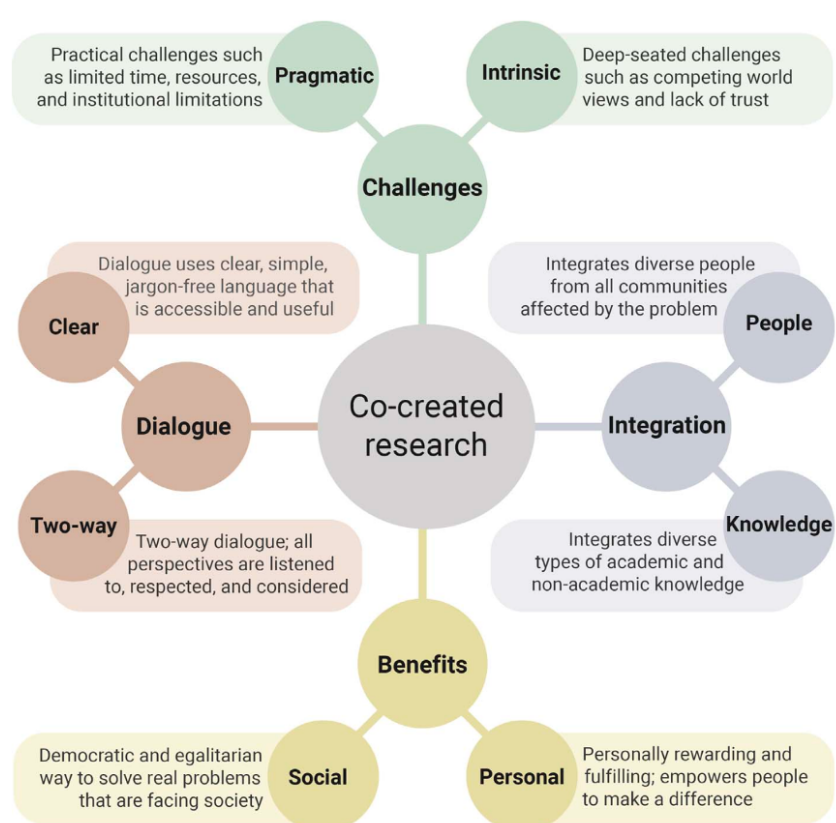

Figure 7 Transdisciplinary research from the perspective of stakeholders (Thompson et al. 2017: 34)

Analytic Tools

Some visualisations are intended as practical tools to support the analysis of transdisciplinary research activities and outcomes. **Figure 8** provides a framework to identify existing tools that can be used to synthesise disciplinary and stakeholder knowledge, to understand and manage diverse unknowns, and to provide research support for changes to policies and practices. Tool selection involves asking specific questions about the aims and beneficiaries of the research, the overarching issues relevant to each domain, how the tasks should be addressed, the specific circumstances in which the research is conducted, and how researchers can evaluate and learn from responses to the previous questions.

The visualisation emphasises the need to draw upon existing bodies of knowledge, while understanding its practical application requires careful reading and consideration of the framing questions (Column 1). It emphasises the need to consider the practical implementation of transdisciplinary research activities project but does not offer specific guidance on how to design these processes and instead directs readers to relevant resources. The visualisation can be used when initiating a new project to identify appropriate tools and methods.

Figure 9 presents two tables with questions and strategic elements to consider how transdisciplinary urban research can be embedded into societal and scientific environments. The first table poses four questions to be answered to embed the research in society. It delineates the impact model for research activities by identifying the intended impact, the elements that need to be taken into account, casual relationships of these elements, approaches to introducing results, and identifying unintended impacts. The second table presents four strategic elements to embed transdisciplinary research in the scientific environment. This includes scientific goals, the content of the research and target disciplines and groups, and types of dissemination. Both tables can be used at different times and phases in the project and offer practical guidance on what needs to be considered.

Question \ Domain	1. Knowledge synthesis	2. Unknowns	3. Supporting change
1. For what and for whom?	The question itself	The question itself	The question itself
2. Of what? – systems – scoping – boundary setting – framing – values – harnessing and managing differences	System dynamics Eight-question scoping framework Critical systems heuristics Understanding and designing metaphors Ethical matrix Collaboration and team science field guide		
3. How?	Knowledge co-production toolkit	Matrix for distinguishing three kinds of unknowns	Engaging and influencing policy toolkit
4. Context? – big picture – authorisation – organizational facilitators and barriers	Set of questions – see Bammer 2013a Set of questions – see Bammer 2013a Set of questions – see Bammer 2013a		
5. Outcome?	Set of questions – see Bammer 2013a	Set of questions – see Bammer 2013a	Set of questions – see Bammer 2013a

Figure 8 Compilation of existing tools for transdisciplinary research (Bammer 2017: 52)

Questions about the impact model	Area of impact		
	Private sector	Civil society	Public agencies
What impact is intended?			
What existing needs, interests, technologies, regulations, practices and power relations need to be taken into account?			
What causal relationships are initially assumed?			
In what form and at what point in time can results be introduced in a way tailored for the target group?			
What are likely unintended impacts, and what "probes" may reveal them?			

Strategic elements	Project phase		
	Problem identification and structuring	Problem analysis	Bringing results to fruition
Goals (scientific/science policy)			
Contents (state of the art in relevant disciplines/state of the art in transdisciplinary research/future research areas/need for institutional action)			
Addressees (disciplines/transdisciplinary groups/science policy actors)			
Forms (publications/organisation of conferences/initiation of research programmes/development of networks/writing of official statements)			

Figure 9 The impact model and strategic elements of transdisciplinary research (Pohl and Hadorn 2021: 65, 67)

Figure 10 illustrates the stages of a transdisciplinary research project, key moments of integration, and which team members need to be involved in each stage. It shows how the various elements interact and contribute throughout the project lifecycle. In the synthesis process, each stage is connected to a corresponding set of integration methods. These methods are essential for bringing diverse knowledge systems together effectively.

The model clearly delineates the processes that underpin transdisciplinary research. It highlights the importance of carefully selected methods and procedures to facilitate collaboration among stakeholders from different disciplines and sectors. By delineating the various types of integration procedures, it emphasises the need for context-specific strategies tailored to the unique challenges and objectives of each project. It also identifies the key actors from the academy and society that interact to inform various forms of integration. The visualisation showcases the complexity of transdisciplinary projects and can be used as a tool for future research projects.
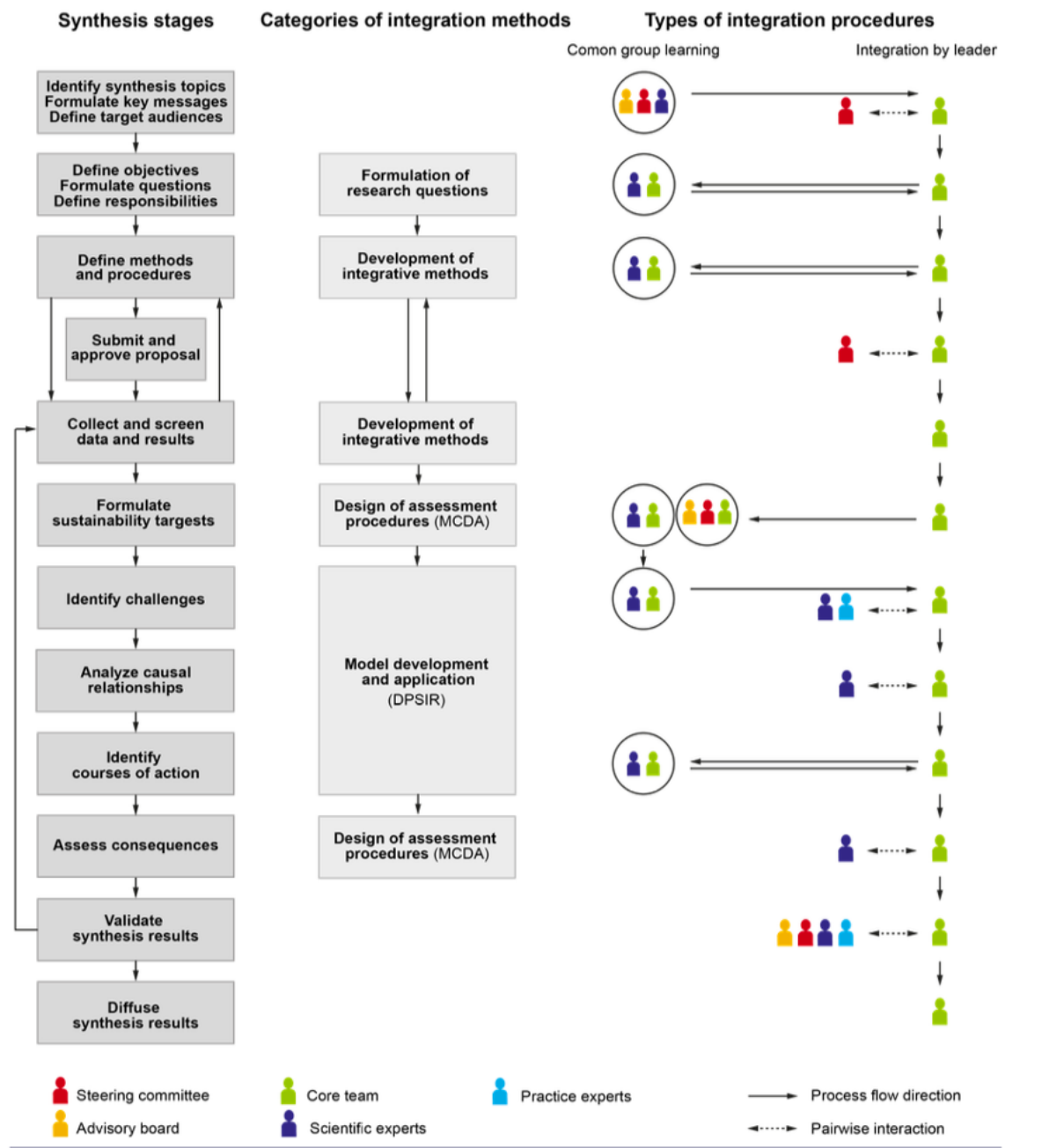
Figure 10 Integration strategies of transdisciplinary research (Hoffman et al. 2017)

Figure 11 provides six wordclouds derived from interviews with participants in transdisciplinary projects. It identifies the most important characteristics of transdisciplinary researchers and emphasises the personality traits and skills that are particularly beneficial to realise effective collaboration among diverse groups of individuals. While these traits and skills are universal, when combined they highlight the underlying mechanisms that are needed to support interaction, exchange, and co-production of transdisciplinary knowledge. The emphasis is on the personalities of effective transdisciplinary researchers and how they engage in projects as leaders or participants. The ideas can be used when establishing a team to establish expectations and working methods while also serving as a reminder about how to achieve effective modes of collaboration throughout the project.
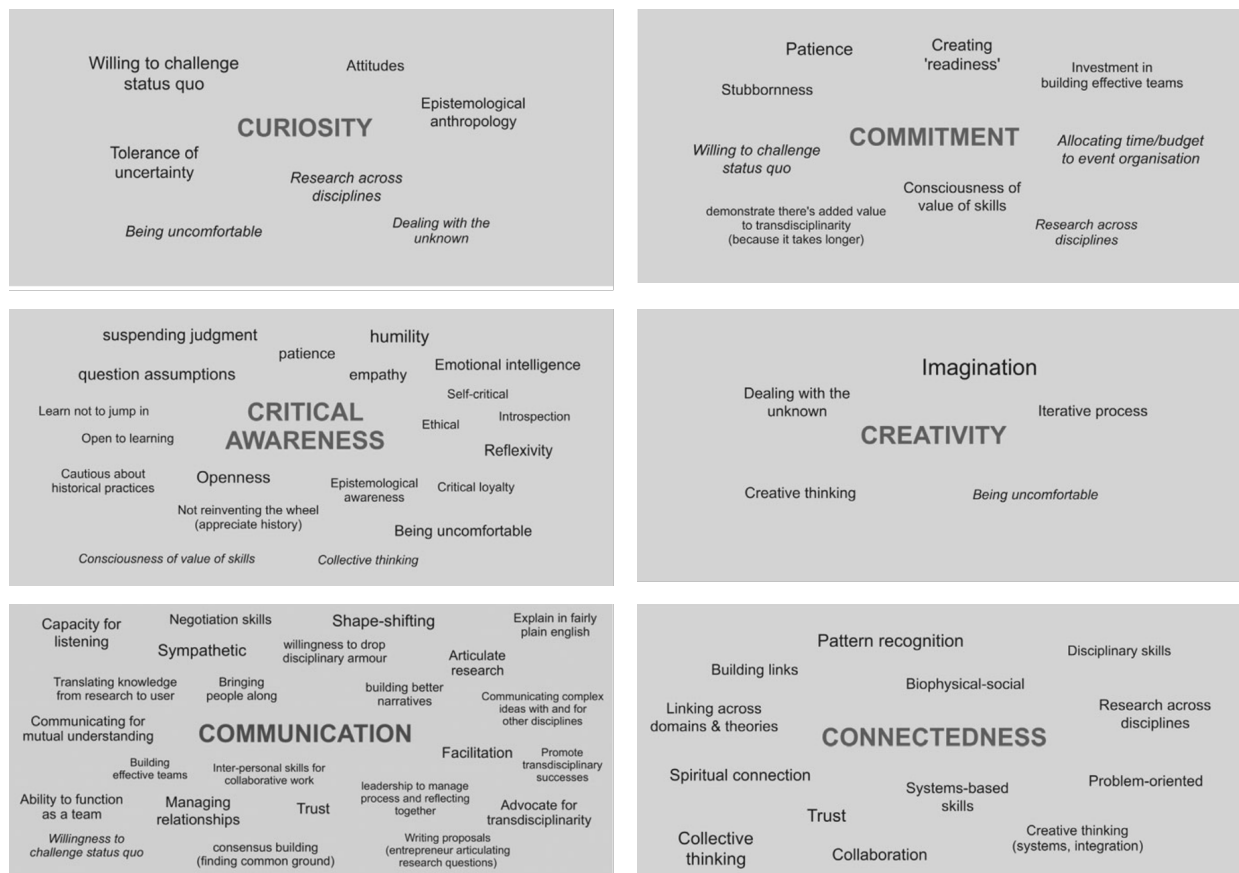
Figure 11 Six characteristics of an effective transdisciplinary researcher (Fam et al. 2017: 80-85)

Conclusion

The eleven visualisations presented in this report provide examples of how transdisciplinary research can be interpreted and presented with respect to concepts, processes, and analytic tools. The visualisations distil complex ideas and processes into diagrams and tables that can be interpreted quickly and adapted for use in specific projects. Some of these visualisations are directed at academic audiences, others are aimed at non-academic audiences, and some are applicable to both groups. These tools serve as a bridge between complex theoretical concepts and practical applications and help academic and non-academic stakeholders to engage with one another and to optimise their research activities and project outputs.

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About

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