TRANSDISCIPLINARY URBAN RESEARCH
STRATEGIES AND TACTICS

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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).

Multiple scholars have developed transdisciplinary concepts, processes, assessment procedures, and practical tools to address real-world problems (Jahn et al. 2012, Lang et al. 2012, Bammer 2017, Fam et al. 2017, Hemström et al. 2021). Due to the complexity of transdisciplinarity issues, early approaches tended to be piecemeal and provided insufficient guidance to be effective (Lang et al. 2012). These deficiencies have been addressed in recent years, notably in the field of Sustainability Science, through the development of approaches that characterise the symptoms and causes of the problems at hand as well as potential solutions (Bergmann et al. 2005, Jahn et al. 2012, Lang et al. 2012, Stigendal and Novy 2018).

This report summarises the insights we developed by conducting a literature review of the dominant approaches and experiences of transdisciplinary urban research. We conducted a World Wide Web search to identify key academic and non-academic publications between 2010 and 2023 in the disciplines of Architecture, Planning, Geography, Urban Studies, and Sustainability Science. We focused on those concepts and strategies of transdisciplinarity that are supported by conceptual models, visualisations, and tools. In this report, we have organised our findings into six themes: border-crossing collaboration, socially robust knowledge, mutual learning, integration, reflexivity, and societal impact (**Figure 1**). We summarise the findings of each theme in the following sections.

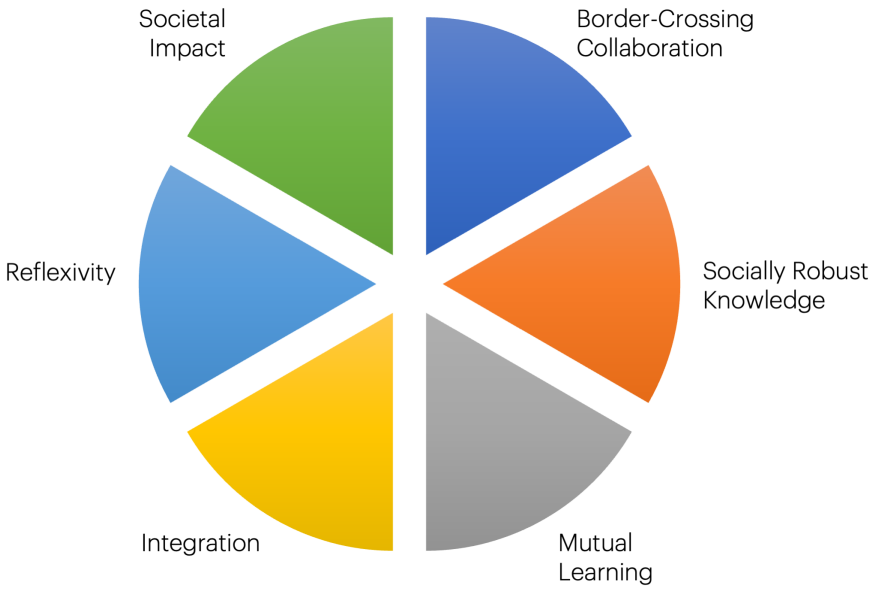

Figure 1 Six themes of transdisciplinary urban research

Border-Crossing Collaboration

The initial step in transdisciplinary research is to assemble a team of collaborators. Project teams are inherently heterogeneous and are designed to include a diversity of perspectives. Ensuring that the project team is equally represented by academics and practitioners can help to ensure a relative balance of interests and goals in a project (Norris et al. 2016). Several overarching questions can be used to assemble a transdisciplinary research team including: Who can help to define the problem as well as potential solutions? Which types of knowledge and experience are needed to address the complexity of the problem? And how can collaborative processes and results be designed to address societal needs? Hemström and colleagues (2021) argue that it is important to clearly define the composition of transdisciplinary teams while also developing transparent working methods to foster long-term trust among the team members.

The team of academics and non-academics is the engine of transdisciplinary research and its composition is essential to the success of the project. In many cases, it can be productive to include a mix of junior and senior team members. Junior team members often have more time for project activities and exercise more free-thinking skills while having less ability to affect change. Senior team members tend to have more decision-making powers but can sometimes rely too heavily on their accumulated experiences and be less open to alternative proposals that are outside of their comfort zone. A combination of junior and senior team members can produce a dynamic team and inspire fresh ways of thinking while having sufficient capacity to achieve project goals (Hansson and Polk 2018). For each team member, it is important to define realistic levels of contribution they can provide throughout the project (Lang et al. 2012, Perry and Russell 2020). And each team member needs to clearly understand how they will benefit from engaging in the project through, for example, extending their professional networks, strengthening connections to other sectors and fields of knowledge, becoming more legitimised and empowered in their respective work environments, and so on (Hansson and Polk 2018, Fritz et al. 2019).

Once the transdisciplinary team is established, it is common to encounter challenges in developing group cohesion. This can be addressed by reflecting upon group dynamics and development. A group rarely evolves linearly and instead follows its own iterative path of development that resonates with the unique attributes of each member. Schauppenlehner-Kloyber and Penker (2015) identified five stages of group development dynamics including (1) orientation and familiarisation, (2) addressing conflicts and disagreements, (3) agreeing on common goals, (4) working constructively towards these goals, and (5) concluding the collaboration when the goals are achieved, enthusiasm for the project is exhausted, or funding expires. Each stage can be achieved through a variety of activities to support the team's shared commitment to transdisciplinary knowledge production.

A common starting point for teams is to adapt a shared definition of transdisciplinary research to serve as the foundation for project activities. **Table 1** includes eight examples of transdisciplinary research definitions that emphasise the importance of collaboration between academics and non-academics to address real-world issues (Jahn et al. 2012, Hoffmann et al. 2017, Karvonen and Brand 2022, Lawrence et al. 2022).

Table 1 Eight definitions of transdisciplinary research

Source	Definition
Fam et al. 2017: 77	'In defining transdisciplinarity, the fundamental principles of such an approach to research and practice are to work in participatory ways and to tackle socially relevant issues with an overarching goal to transcend and integrate disciplinary paradigms.'
Hansson and Polk 2018: 132	'In this article, we will use the term [transdisciplinary] research to refer to problem-solving research where scientific knowledge is combined with values, knowledge, and know-how from practitioner-based practice through in-depth inclusive processes.'
Hemström et al. 2021: 6	'Transdisciplinary co-production refers to collaboratively based processes where academic researchers and other actors and groups come together to share and create knowledge that can be used to face the sustainability challenges of today, while increasing capacity to societal problem-solving in the future.'
Jahn et al. 2012: 4	'Transdisciplinarity is a reflexive research approach that addresses societal problems by means of interdisciplinarity collaboration as well as the collaboration between researchers and extra-scientific actors; its aim is to enable mutual learning processes between science and society; integration is the main cognitive challenge of the research process.'
Lang et al. 2012: 26–27	'Transdisciplinarity is a reflexive, integrative, method-driven scientific principle aiming at the solution or transition of societal problems and concurrently of related scientific problems by differentiating and integrating knowledge from various scientific and societal bodies of knowledge.'
Mitchell and Ross 2017: 172	There are two key features of transdisciplinary research: the number and nature of disciplines and ways of knowing is many and varied; and engagement is explicit, deep and intentional. That means transdisciplinary research is all about learning, it is personally challenging, it requires humility, and it seeks to integrate different ways of knowing from a non-denominational starting point.'
Polk 2014: 440	'Transdisciplinary refers to different types of knowledge production for social change which are based not only on the integration of knowledge from different disciplines (interdisciplinary), but also on the inclusion of values, knowledge, know-how and expertise from non-academic sources.'
Wiek et al. 2014: 118	'All participatory paradigms have some key features in common: they facilitate the collaboration among scientists from different disciplines and non-academic stakeholders from business, government, and the civil society; they strive for generating knowledge that is of relevance to society (context of application); they explicitly include normative aspects (e.g., values, goals, norms) into the collaborative research process; they encourage diversity in knowledge claims and normative stances; they engage participants in processes of reflection, deliberation, and negotiation (not just information and consultation); and they encourage mutual accountability, ownership, and leadership among project participants.'

Socially Robust Knowledge

Producing socially robust knowledge is a primary objective of transdisciplinary research (Bergmann et al. 2005, Jahn et al. 2012, Lang et al. 2012). This is particularly important for academic institutions that have a mandate to serve the public. By engaging with various social actors on real-world problems, academics can ensure that the knowledge produced is not only scientifically sound but also practically applicable and socially beneficial. However, this approach requires more inclusive and participatory forms of knowledge

production when compared to conventional academic research. The insights and experiences of non-academic actors are an integral driver of socially robust knowledge production (Nowotny 2003, Wiek et al. 2014). They can ensure that the initial framing of research objectives and questions includes a combination of scientific and practical insights and experiences. This increases the potential for acceptance and sustained commitment by all team members while increasing the opportunities for research outcomes to influence society. It also encourages shared ownership of the processes and outcomes by all team members (Talwar et al. 2011, Lang et al. 2012, Thompson et al. 2017, Hemström et al. 2021).

At the start of the project, it is important to establish clear goals, intermediate and final deliverables, and overall expectations. This should ideally be informed by all participants to address divergent expectations involving time investment and outputs (Lang et al. 2012, Frantzeskaki and Kabisch 2016). Establishing these foundational aspects in a collaborative way helps to align the diverse perspectives and interests of the team, particularly when academics lead the transdisciplinary processes. Workshops can be a useful way to define how the diverse knowledges of the team can be combined most effectively (Hansson and Polk 2018). Fostering a shared sense of purpose can be achieved through democratic and transparent decision-making processes (Polk 2015).

Adaptability and flexibility are crucial components of transdisciplinary knowledge production (Thapa et al. 2022). The complexity and dynamism of real-world problems necessitates a departure from conventional research methods. Transdisciplinary teams often adopt a more fluid approach to address emerging insights and changing conditions. This adaptability enables the research to remain agile and responsive to the multifaceted nature of societal challenges (Polk 2014). In some cases, academic team members might perceive more fluid, open-ended research approaches as unscientific or lacking in rigour. It can be helpful to create a catalogue of relevant research methods and then discuss how each method could be adapted and customised to the aims and outcomes of the project. It might be necessary to experiment with several methods to test their utility and practicality for the project. Before conducting specific research methods, it is essential to provide training to ensure that everyone understands the objectives, the methodological steps, and what constitutes a successful outcome (Hemström et al. 2021).

Mutual Learning

Mutual learning involves dynamic processes for academic and non-academic actors to engage in shared learning experiences of joint problem-solving (Jahn et al. 2012, Brink et al. 2018). These processes enhance the exchange and integration of diverse forms of academic and non-academic knowledge (Brandt et al. 2013). For transdisciplinary processes to effectively break down the barriers between team members, it is helpful to establish neutral meeting spaces to encourage equal ownership and responsibility of project actions and to ensure that all voices are heard and valued (Polk 2014). Neutral meeting environments allow project team members to share their expertise, experiences, and perspectives away from the everyday hierarchical structures and norms of their respective workplaces (Hansson and Polk 2018).

Shared responsibility is an important element of transdisciplinary research. It is helpful for all team members to invest both time and money to strengthen the collaborative processes as well as the outcomes. Delegating tasks, roles, and responsibilities within the team provides a strong foundation to support mutual learning (Hoffmann et al. 2017). Some research tasks, such as data collection, can be undertaken together while other tasks can be assigned to specific team members with relevant experience

and expertise. Identifying the specific expertise of each team member can be a useful way to motivate engagement and collaboration when framing relevant themes for the results and analysis (Polk 2015).

Mutual learning can also be enhanced by adopting a rotating chairperson for meetings to avoid the dominance of one team member. Having different individuals lead the project meetings can help to draw out different perspectives and support mutual understanding (Hemström et al. 2021). In some cases, it might be necessary to appoint a neutral facilitator to support productive exchange among team members (Fritz et al. 2019). It can also be helpful to develop scenarios to integrate the perspectives of the team members. Such scenarios are based upon scientific and practical knowledge and can serve as a shared internal communication tool for the project team members while also serving as a vehicle to implement the project results (Frantzeskaki and Kabisch 2016). Developing and maintaining a common narrative is another strategy for teams to steer conversations and focus on common goals. It is important to explicitly document this narrative and articulate how it supports the project goals. Key phrases and metaphors as well as visualisations can support the narrative and ensure that it is meaningful to all team members. It can also be helpful to establish practices to update and hone the narrative over time. For example, team members can share their experiences of lessons learned throughout the project (Riedy 2023).

When drafting research findings, it is common for academics to take the lead due to their familiarity with established knowledge production activities. This can be an efficient way to produce project outputs but can also frustrate those team members who do not have the experience or background in research or have diverging opinions about what is relevant. Relatedly, it is often assumed that academics are best positioned to write up project findings while practitioners are not interested or are unaccustomed to writing. This can result in outputs that are oriented towards academic audiences while marginalising the insights of practitioners and the impacts to practice (Polk 2015, Hansson and Polk 2018). To avoid this, project teams can develop collaborative approaches to writing, editing, and reviewing that engage all team members in various capacities. Co-authoring a combination of academic and practice outputs can be an effective way to strengthen the ownership of project outputs and encourage team members to disseminate them within their own organisations and networks (Jahn et al. 2012, Lang et al. 2012, Hoffmann et al. 2019). For example, practitioners can serve as co-authors on academic journal articles while academics can contribute to policy briefs led by practitioners. These outputs can be produced on a regular basis throughout the project (rather than waiting until the end of the project) to create a continuous rhythm of knowledge production (Brink et al. 2018).

Integration

Integration of different knowledges is a fundamental aspect of transdisciplinary research. Indeed, the terms ‘integration research’ and ‘integration science’ are sometimes used as synonyms for transdisciplinarity (Russell et al. 2008, Jahn et al. 2012). Jahn and colleagues (2012: 3) define the hybrid term ‘transdisciplinary integration’ as ‘the cognitive operation that establishes a novel, hitherto non-existent connection between distinct entities of a given context.’ This underscores the innovative character of transdisciplinary activities and the promise to develop and strengthen new connections across distinct knowledge realms. Integration involves iterative and continuous processes of bringing together various sources of expertise to produce complex knowledge (Mobjörk 2010, Lang et al. 2012, Brink et al. 2018, Hoffmann et al. 2019) .

Trust is a common theme in the literature on transdisciplinary research and is a necessary element to establish research environments that are 'sufficiently comfortable, yet confronting' enough to manage conflicting ideas and to stimulate learning (Mitchell and Ross 2017: 187). While a 'safe space' might be used to ensure that everyone's insights are respected, a 'productive space' allows participants to take risks by sharing their doubts and addressing sensitive issues while also creating opportunities to deal with these issues while co-creating new knowledge (Curnier et al. 2023).

The ability to communicate and share individual and collective perspectives is important to ensure an equitable distribution of power. Awareness of the dynamics of meeting and collaboration formats (as well as content) is important to document. This can be achieved through 'creative notetaking' that provides insights on the workflow processes as well as outcomes. While this is more labour-intensive than conventional meeting minutes, it can help to level the playing field among the participants and enable a sense of sharing that goes beyond giving consent and signing off on a product or output. The team members have the opportunity to contribute to the collective narrative with a clearer idea of why certain parts of the process are documented and expanded upon (Hemström et al. 2021).

Knowledge integration requires team members to reflect critically on their own expertise and assumptions and clearly define how they are contributing to the collective knowledge process (Polk 2015). They need to draw upon a wide range of personal skills including listening and communication while also having a willingness to understand the experiences and perspectives of others (Hemström et al. 2021). Suspending judgement, exercising humility, and possessing emotional intelligence and creativity contributes to an overall sense of critical awareness to facilitate knowledge integration (Fam et al. 2017). Personality traits have a strong influence on the collaborative atmosphere, particularly with those individuals who dominate or interrupt conversations or do not treat one another as equals. Team members also need to have patience and perseverance in their quest to challenge 'business as usual' ways of thinking and to generate novel forms of knowledge.

Creating hybrid knowledge that balances academic and practitioner insights can be challenging. There is a constant risk of a project being dominated by one perspective (Polk 2015). Replacing the phrase 'transdisciplinary research' with 'transdisciplinary collaboration' can be a useful way to de-emphasise the role of academics in favour of hybrid knowledge that combines academic and non-academic insights (Angheloiu 2018). Esoteric concepts and research methods can be unfamiliar to some team members (Kareem et al. 2022). There is a need to explore unknown territories and tolerate discomfort to find areas of commonality. In addition, it might be necessary to discuss popular terms and 'buzzwords' to ensure that everyone understands what they mean and how they relate to the project goals (Frantzeskaki and Kabisch 2016).

Project leaders play a key role in establishing responsibility of each team member and encouraging a sense of openness to different perspectives (Hemström et al. 2021). They balance the inputs of the team members and establish constructive spaces for interaction. This can be partially addressed by clarifying the roles and responsibilities of all team members (Lang et al. 2012). Team interactions can be oriented towards scholarly outputs when academics are the more dominant team members or towards advocacy and societal change when practitioners take a central role. Leaders are responsible for steering these dynamics towards the project end goals (Hoffmann et al. 2017).

Reflexivity

Reflexivity is closely related to the concept of mutual learning (Jahn et al. 2012) and encourages participants to consider the assumptions within their respective knowledge domains (Schön 2017). It involves iterative processes of co-producing knowledge and reflecting upon the outcomes to understand how they are situated within the broader context (Hemström et al. 2021). It is helpful for team members to have a thorough understanding of their own positionality and how this relates to the other team members. Reflexivity is also about practicing modesty and fostering supportive environments where the team members are willing to learn, question, and support one another (Hemström et al. 2021). To negotiate the diverse knowledge systems that comprise a transdisciplinary project, it is crucial to recognize that the desired effects and transformations are deeply embedded in value-laden and normative judgments. Such judgments can be articulated through reflexive dialogues to address underlying assumptions, the evolving nature of the project, and the lessons learned along the way (Angheloiu 2018).

Planning for and executing joint reflection is important not only at the end of the project but throughout the project. Documenting how the project evolves over time and brings together various perspectives and goals is beneficial (Hansson and Polk 2018, Hemström et al. 2021). Questionnaires and written evaluations can be combined with reflective conversations to allow team members to adjust and refine the project direction while ensuring it is aligned with the end goals (Schauppenlehner-Kloyber and Penker 2015). Transdisciplinary research is sometimes perceived as overly academic and irrelevant by non-academic team members while academics sometimes critique it as lacking rigour and deep insights (Thapa et al. 2022). Achieving a satisfactory balance requires continuous reflection about the 'bigger picture' and how the process as a whole contributes to systemic changes while iteratively adapting to the continuous dynamics of collaboration (Hemström et al. 2021).

Team leaders play a crucial role in reflexivity by acting as connectors, translators, and community gatekeepers. They sometimes act as knowledge brokers that navigate between the various disciplines and knowledge systems to translate and align different perspectives. They can also act as hosts to support environments and atmospheres that are conducive to learning, critical reflection, and that support various modes of interaction. In some cases, they act as process designers that bring together methods, tools, and approaches based on learning objectives and group dynamics. An underemphasised role for team leaders is to serve as quiet convenors and support one-to-one relationships to build trust and support community building. Relatedly, they can serve as pollinators to connect team members who might not otherwise be connected and as mirrors to reflect patterns and perspectives that help the participants ruminate on their experiences. Leaders can be thermostats that sense the 'temperature' of team members, including their energy and collaboration levels, and adjust the activities accordingly. And finally, they can be norm authorisers that embody desired behaviours and actions through their own conduct (Angheloiu 2018).

Societal Impact

A primary objective of transdisciplinary research is to create actionable knowledge that is simultaneously relevant to academia and society (Hemström et al. 2021). Polk (2014) characterises the relationship between academia and practice as 'paradoxical' because the conditions that are vital to the success of transdisciplinary processes have the potential to diminish its relevance to practice. Consequently, transdisciplinary activities are 'homeless' because they sit somewhere between academia and practice.

There is a need to foster formal and informal linkages in each phase of the project and this involves significant investment of time and effort (Hoffmann et al. 2019). The initiation and framing of transdisciplinary research projects can require months or even years of close dialogue to develop shared ownership and responsibility for processes and potential outcomes (Hansson and Polk 2018). The long-term benefits for such collaborations are clear but how to establish these spaces is not straightforward.

Transdisciplinary research offers multiple opportunities to deliver social impacts but these impacts do not always extend beyond the project boundaries (Polk 2014, Hoffmann et al. 2019, Schneider et al. 2019). Project teams often focus on the practical issues of developing new partnerships and collaboration strategies to realise project goals (Polk 2015, Hemström et al. 2021). There is less emphasis on translating project outputs into policies, regulations, incentives, and other established governance instruments. Dissemination of project results is the most common approach to realising broader impacts. This can involve outputs such as reports, websites, and events as well as non-traditional strategies to reach specific external audiences (Hoffmann et al. 2019). In some cases, 'multipliers' can be used to reach a wide range of stakeholders and ensure that the project outcomes achieve broader impacts (Fritz et al. 2019).

Transdisciplinary research functions as a form of boundary management that simultaneously operates within and beyond the confines of multiple disciplines. This in-between character introduces new and distinct challenges to implement as well as evaluate research outcomes. It is essential to evaluate the societal impacts of transdisciplinary research by documenting how project deliverables are applied in practice, how they have enhanced capacity and extended networks, how they influence broader structural and organisational changes, and how they result in the development of new policies and visions with a demonstrable influence on practice (Wiek et al. 2014, Williams 2017, Hansson and Polk 2018). It is challenging to measure societal progress, particularly when it extends beyond the end date of the project (Mitchell and Willetts 2009). In an empirical study of knowledge dissemination, Fazey and colleagues (2014) identified a strong relationship between conceptualisation of knowledge and knowledge exchange, implementation and evaluation of knowledge, and the field of research. This suggests that project teams need to clearly articulate how they will use the project outcomes to affect broader changes.

Conclusions

Transdisciplinary research is a promising approach to bridge the gap between knowledge generation and practical application in sustainable urban development. By embracing complexity and fostering collaboration, teams can develop knowledge to inform the creation of resilient and thriving cities for future generations. This involves acknowledging the interconnected nature of urban challenges while also actively seeking out and leveraging diverse perspectives. Transdisciplinary research tends to be context-specific and is strongly shaped by individual project team members and their collective capacity. This can limit the influence of transdisciplinary research beyond the project boundaries. However, there are many lessons to be learned from these processes, as described in this report. **Table 2** provides a summary of the key takeaways for each of the 6 themes.

Table 2 A summary of the six themes of transdisciplinary urban research

Border-Crossing Collaboration
- Transdisciplinary research teams need to include a diversity of perspectives from academic and non-academic team members.
- Motivations for individuals and organisations to participate in transdisciplinary projects include network building, empowerment, and legitimation.
- Groups evolve over time and go through stages of familiarisation, confrontation, consensus, independence and dissolution.

Socially Robust Knowledge
- It is helpful to foster mutual ownership through shared responsibility between academic and non-academic team members.
- Establishing clear expectations, goals, and deliverables is necessary to develop a strong foundation for collaborative work.
- Early and balanced engagement by all project team members is necessary to ensure relevant framing of research topics and to establish a culture of collaboration.

Mutual Learning
- It is helpful to create dedicated meeting spaces that take project team members out of their everyday working environments to encourage novel interactions.
- It is important to delegate tasks and responsibilities to team member with relevant expertise.
- Developing scenarios, common narratives, and collaborative practices of writing can strengthen the team's shared sense of purpose.

Integration
- Personal skills such as listening and communicating as well as the willingness to understand the perspectives and experiences of others is essential for knowledge integration.
- It is important to acknowledge and manage power relations in the group to ensure a balance of expertise and contributions.
- Project leaders need to ensure that the inputs of all team members are balanced.

Reflexivity
- Reflexivity encourages team members to challenge their own assumptions while also triggering critical reflection of the project as a whole.
- Engaging in continuous refection throughout the project can be achieved through formal and informal activities to support the development of the project.
- Project leaders can facilitate the interactions among team members in multiple ways.

Societal Impact
- Project teams tend to focus on executing the project itself rather than translating the project outcomes into policies, regulations, and incentives.
- Dissemination can include a combination of standard and non-standard strategies to reach different target audiences.
- It is difficult to evaluate the broader societal impacts of transdisciplinary research.

It is clear that transdisciplinary research provides multiple opportunities to produce socially relevant knowledge by bringing diverse perspectives to bear on specific topics. As this type of research becomes more commonplace, it will potentially become a standard requirement of funding bodies. It will be important to develop principles and approaches that can be adapted and used by various project teams. The insights from the existing body of knowledge on transdisciplinary research indicate that navigating the academic/non-academic divide is challenging but possible and when successful, it can result in novel modes of knowledge production with valuable outcomes for multiple audiences. It is here where transdisciplinary research can create a bridge between knowledge production and social change.

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