Environmental Science and Policy 176 (2026) 104317

Contents lists available at ScienceDirect

Environmental Science and Policy

journal homepage: www.elsevier.com/locate/envsci

Transdisciplinarity in water management: A systematic review of concepts, practices, and challenges

Ana Paula de Carvalho Silva [a], Margarida Ribau Teixeira [b,*], Luís Miguel Nunes [c]

[a] Faculty of Science and Technology, University of Algarve, Campus de Gambelas, Faro 8005–139, Portugal
[b] CENSE — Center for Environmental and Sustainability Research & CHANGE — Global Change and Sustainability Institute, Faculty of Science and Technology, University of Algarve, Gambelas Campus, Ed. 7, Faro 8005-139, Portugal
[c] CERIS — Civil Engineering Research and Innovation for Sustainability, Faculty of Science and Technology, University of Algarve, Gambelas Campus, Faro 8005-139, Portugal

ARTICLE INFO

Keywords:
Transdisciplinarity
Water governance
Knowledge co-production
Systematic review
Participatory management
Sustainability

ABSTRACT

Transdisciplinarity has become a central paradigm for addressing complex socio-environmental challenges that transcend disciplinary and institutional boundaries. This article revisits the concept from the perspective of water resources management, questioning whether its increasing application has achieved the depth and transformative potential originally envisioned. A systematic review and bibliometric analysis were conducted to examine how transdisciplinarity has been conceptualized and operationalized across 61 international initiatives covering multiple governance scales and institutional contexts. The findings reveal that, although transdisciplinarity is now widely recognized in scientific and policy agendas, its implementation often remains rhetorical or fragmented. Persistent barriers include limited knowledge co-production, asymmetry between scientific and local expertise, and weak participatory mechanisms. Nonetheless, promising experiences demonstrate that when communities are engaged as co-authors of decisions, water governance becomes more legitimate, adaptive, and sustainable. By integrating empirical evidence with conceptual reflection, this study advances understanding of how ethical and methodological co-production can move transdisciplinarity from a normative paradigm toward an actionable framework for water governance.

1. Introduction

Scientific and funding agendas increasingly promote the integration of social sciences and humanities with technoscientific research. Yet, interdisciplinary collaboration still faces structural and epistemological barriers (Vienni-Baptista and Pohl, 2023), notably the persistence of disciplinary silos that reinforce hierarchical knowledge structures and hinder inclusive, dialogical research (Aicardi, Reinsborough and Rose, 2018).

In response, interdisciplinary and transdisciplinary approaches have gained traction for addressing complex societal problems. While interdisciplinarity facilitates methodological exchange between disciplines, transdisciplinarity promotes deeper transformation by incorporating the experiential knowledge of civil society, practitioners, and non-academic actors (Schroeder, 2022). These boundary-crossing efforts challenge academic compartmentalization and open new possibilities for socially engaged science.

Emerging in the 1970s through the works of Piaget (1972) and Nicolescu (1997), transdisciplinarity arose as a critique of the compartmentalization of knowledge and the limitations of disciplinary thinking (Rittel and Webber, 1973). Unlike interdisciplinarity, which promotes partial methodological exchange, transdisciplinarity seeks a deeper transformation that bridges academic and non-academic knowledge systems.

Fig. 1 depicts the conceptual evolution from disciplinarity to transdisciplinarity, progressing from isolated to integrative frameworks (Piaget, 1972; Nicolescu, 1996; Choi and Pak, 2006; Schroeder, 2022).

At the intermediate stages, multidisciplinarity links related disciplines, while pluridisciplinarity connects diverse fields, broadening methodological exchange and complementarity. Figs. 2 and 3 further clarifies this distinction, showing how collaboration between disciplines has historically expanded to address complex problems that transcend academic boundaries.

As formulated by Nicolescu (1996) in his *Arch of Knowledge*,

* Corresponding author.
E-mail address: mribau@ualg.pt (M. Ribau Teixeira).

https://doi.org/10.1016/j.envsci.2026.104317
Received 29 May 2025; Received in revised form 30 October 2025; Accepted 13 January 2026
Available online 23 January 2026

transdisciplinarity represents an epistemological progression from disciplinary isolation to integrative and transformative systems of knowledge. However, it is often applied superficially, without the epistemological depth required for real transformation (Messerli and Messerli, 2008). Contemporary literature emphasizes the need to reconnect fragmented scientific domains with societal perspectives, valuing localized knowledge and participatory collaboration (Choi and Pak, 2006; Schroeder, 2022; Hoffmann-Riem, 2008; Grzybowski, 2010). Transdisciplinarity thus emerges as a pathway for inclusive and context-sensitive co-production of knowledge. However, it is essential to differentiate transdisciplinarity from multidisciplinarity and interdisciplinarity, as conceptualized by Nicolescu (1996), which illustrates the transition from disciplinary isolation to integrative and transformative knowledge systems. In Nicolescu's view, transdisciplinarity transcends disciplinary and interdisciplinary approaches by bridging distinct levels of reality and linking scientific knowledge with philosophical and ethical dimensions. Over time, this concept evolved from a philosophical idea into a research orientation centered on real-world challenges. Today, it is recognized not merely as a method, but as a paradigm shift that aligns science with democratic engagement and societal relevance.

Academic specialization often narrows inquiry and distances science from societal needs. Transdisciplinary dialogue restores this connection, emphasizing the interdependence between scientific expertise and civil society, where even small contributions may generate significant and unpredictable effects—the "butterfly effect" observed in wicked problems (Hartel et al., 2019; Grzybowski, 2010; Wognum et al., 2019).

The complexity of water-related global challenges requires integrating diverse discourses—technical, social, political, and cultural. A transdisciplinary approach enables such integration. As Brennan et al. (2021) argue, only through this lens can we reconcile competing narratives and build solutions that are not only technically effective but also socially just and politically viable.

This article revisits the concept of transdisciplinarity and examines its current implementation, particularly in the context of water governance. Through theoretical synthesis and bibliometric analysis, we assess how transdisciplinarity has been conceptualized, institutionalized, and applied, offering critical insights into its transformative potential and operational challenges in managing water resources. The study advances the state of the art by: (i) consolidating evidence on the practical challenges of transdisciplinarity in water management; (ii) proposing an analytical framework that distinguishes governance scale, initiative type, and degree of co-production; and (iii) deriving operational recommendations for policies and projects aiming to turn transdisciplinary discourse into effective practice.

2. Methodology

2.1. Overview of transdisciplinarity in different fields of study

Transdisciplinarity has progressively evolved across distinct academic domains, including environmental sciences, engineering, health, and the social sciences. To explore this evolution and identify knowledge gaps, a systematic review and bibliometric mapping were conducted.

2.2. Systematic review design and bibliometric analysis

The review followed a protocol inspired by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Data were collected from the Web of Science (WoS) Core Collection as of August 2024. The search string combined the root term transdiscipl with associated keywords reflecting conceptual, methodological, and applied dimensions of transdisciplinarity: *concep*, discipl*, multidiscipl*, interdiscipl*, Morin, communic*, conflic*, definition, engin*, ethic*, Lencastre, managem*, sustain*, susten*, transvers*, transdiscipl* and Water resourc**, using various permutations and combinations.

The research resulted in 28,917 publications, distributed across major subject areas (Fig. 2). Environmental Sciences leads the list, with 3232 publications (11.2 % of the total), followed by Environmental Studies (6.40 %), Public, Environmental and Occupational Health (5.62 %), Green Sciences and Sustainable Technologies (4.46 %), Educational Research (4.44 %), and Industrial Engineering (4.41 %). These results reflect the broad and growing diffusion of transdisciplinary approaches across research domains.

Building upon the bibliometric overview, the next stage involved refining the dataset and developing an analytical framework to enable a comparative assessment of transdisciplinary initiatives in water governance.

2.3. Data selection, categorization, and analytical framework

The final dataset used for in-depth analysis was refined through inclusion and exclusion criteria based on relevance to water governance and explicit reference to transdisciplinary principles (knowledge co-production, participatory processes, and integration across science–policy–society interfaces). In addition to peer-reviewed publications, institutional documents and reports from UNESCO, WHO, World Bank, and UN-Water were consulted to capture practical cases.

Following the bibliometric overview, a purposive sampling approach identified 61 international initiatives representing diverse governance scales and institutional contexts. Each initiative was coded according to three analytical dimensions:

- Governance scale (transnational, regional, national, basin, or local);
- Initiative type (policy/governance, network/platform, academic/research, NGO/implementation, or diplomacy/cooperation);
- Degree of co-production (consultative, participatory, co-productive, or co-decisional).

These dimensions were defined based on established frameworks for cross-domain integration (Lang et al., 2012; Klein, 2008) and validated through cross-referencing among authors. This analytical framework served as the foundation for the comparative analysis presented in Section 4. This analysis encompasses initiatives operating at multiple

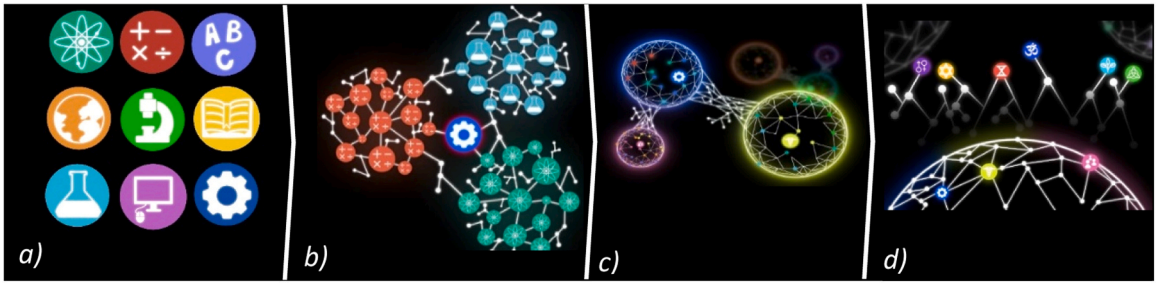

Fig. 1. Trace evolution of the concepts a) Disciplinarity, b) Interdisciplinarity, c) Multidisciplinarity, d) Transdisciplinarity. Images created by the author.

governance levels — from global and transnational frameworks to basin and local-scale actions — to capture how transdisciplinary principles are implemented across contexts.

3. Results and discussion

3.1. Bibliometric overview of transdisciplinary research

The weighted analysis shows higher relative prevalence of transdisciplinary research in Social Sciences, Humanities and Arts, Interdisciplinary Social Sciences, and Multidisciplinary Sciences. Despite ongoing conceptual and methodological challenges, the approach is becoming more institutionalized, reflecting both practical application and critical reflection across contexts (Felt et al., 2016). Integrating multiple perspectives enriches dialogue and fosters a more systemic view of science.

Environmental Sciences and Engineering appear with lower relative weight, yet they remain central in scientific, political, and ethical arenas, where collaboration between experts and the public is increasingly crucial for informed decision-making.

Transdisciplinarity spans Health Sciences, Natural and Earth Sciences, Social Sciences and Humanities, and Engineering, with field-specific adoption patterns Lencastre, (2008). Beyond disciplinary impact, it plays a key role in political and ethical contexts, where expert–public collaboration supports informed decisions (Felt et al., 2016). This breadth raises a critical question: is the term being applied consistently and correctly?

3.2. Intersections of transdisciplinarity with specific domains: communication, awareness raising and engineering

3.2.1. Transdisciplinarity and wicked problems across knowledge domains

Transdisciplinarity intersects with communication, public awareness, sustainability, education, ethics, and engineering—domains marked by "wicked problems" that exceed the reach of isolated disciplines (Water governance is addressed separately in 3.3.)

Despite integrative rhetoric, many initiatives remain multi- or interdisciplinary, with limited engagement of communities and traditional knowledge (Table 1). In areas such as food security and health, technical solutions often prevail over participatory governance, constraining social legitimacy and long-term sustainability.

As Klein (2008) notes, transdisciplinarity's transformative capacity depends on embracing uncertainty, values, and lived experience. Without authentic co-production, solutions may be scientifically robust yet socially disconnected or culturally inadequate. Participation often remains consultative, excluding communities from core research and decision cycles and undermining shared ownership and mutual responsibility—principles central to transdisciplinary work (Lang et al., 2012).

Table 1 shows that participatory elements are rarely integrated end to end. Effective responses to wicked problems require not only technical fixes but also epistemological openness and institutional flexibility. In engineering, transdisciplinarity means shifting from linear problem-solving to reflexive, collaborative practice. Scholz and Steiner (2015) (2015) argue this demands sustained dialogue among scientists, policymakers, and stakeholders. Confronted with climate and resource challenges, engineering benefits from co-producing solutions that reflect real-world complexity and democratic engagement (Grzybowski, 2010).

3.2.2. Transdisciplinary communication and awareness strategies

Transdisciplinary communication bridges domains and enables collaborative responses to complex issues by strategically integrating diverse knowledge and methodologies, generating innovative, multidimensional solutions (Misra and Lotrecchiano, 2018).

Widely cited models describe four iterative phases (Wang, Aenis and Siew, 2019): (i) defining shared goals; (ii) co-formulating questions, frameworks, and design; (iii) developing communication strategies; and (iv) applying and refining results. While context-dependent, these phases provide a recognized architecture for effective collaboration.

Recent studies underscore the need for shared understanding of concepts, terms, and methods across disciplines (Fischer et al., 2024) and the early identification of common goals through open, collaborative communication (Fleming et al., 2021). Authors recommend combining written, oral, visual, and interactive formats, coordinated via central platforms and tailored to diverse stakeholders, including non-academic audiences.

As summarized in Table 2, multi-format strategies are most effective when supported by structured platforms and embedded in project frameworks (Fischer et al., 2024), extending impact at the science–society interface (Misra and Lotrecchiano, 2018). A major challenge is the diversity of technical languages across disciplines Overcoming linguistic barriers and cultivating intellectual empathy—understanding epistemologies, values, and cultural contexts of other fields—are essential to avoid misunderstandings and conflicts (Callaos, 2022), as verified in Table 2- Building empathy.

Interdisciplinary glossaries help bridge terminology and make technical concepts accessible (Von Wehrden et al., 2019). Collaborative workshops align objectives and build shared language (Deutsch et al.,

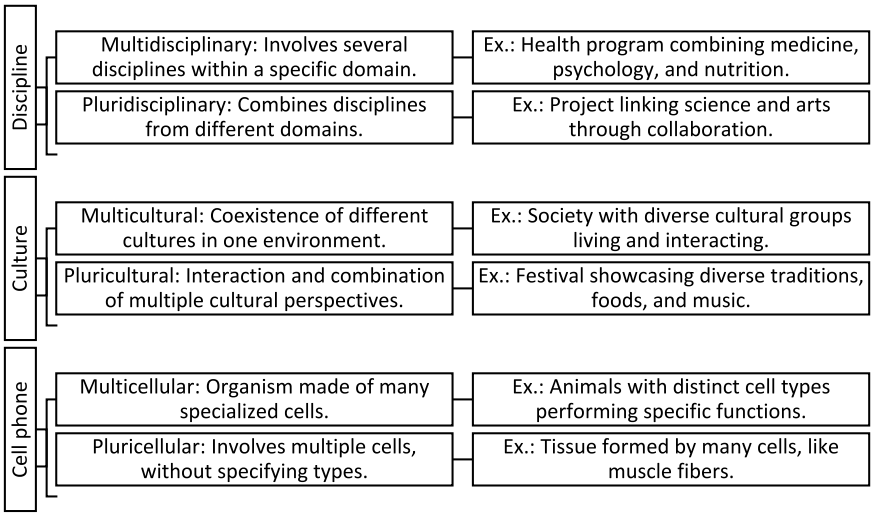

Fig. 2. Prefixes – "Multi" vs " Pluri " in different contexts.

2023), while narrative approaches (e.g., storytelling, case studies) connect human and scientific dimensions and foster participation (Cortes Arevalo et al., 2023).

As demonstrated in Table 2, effective transdisciplinary communication combines technological tools, visual storytelling, shared vocabulary, and empathy. Together, these mechanisms circulate knowledge across silos, enhance mutual intelligibility, and legitimize decision-making—vital conditions for transformative collaboration.

3.2.3. Transdisciplinarity in engineering

Knowledge production in social contexts is inherently multidisciplinary (Hoffmann-Riem, 2008), driving a shift in engineering toward a transdisciplinary approach that transcends traditional boundaries to address challenges conventional engineering cannot fully resolve.

Transdisciplinary engineering differs by emphasizing broad collaboration and joint solutions to complex, systemic problems, integrating knowledge and methods from domains beyond conventional engineering (Table 3).

This shift redefines engineers as collaborators who connect knowledge across domains and co-create solutions, implying education that couples technical skills with systemic and social awareness.

The growing diversity of initiatives (Table 4) indicates wider adoption of transdisciplinarity in engineering as a response to contemporary "wicked problems," integrating technical expertise with collaboration among policymakers, social scientists, communities, and international institutions. Conferences such as the International Conference on Transdisciplinary Engineering (ICTE) and the International Transdisciplinarity Conference (ITD) underscore the value of cross-disciplinary exchange for developing methods and guidelines. Networks like the Network for Transdisciplinary Research (td-net) and the World Federation of Engineering Organizations (WFEO) show that transdisciplinary engineering extends beyond academia to inform public policy and sustainable industrial practice.

Initiatives such as Future Earth and the Belmont Forum apply transdisciplinary approaches to engineering in order to address *"wicked problems"*, particularly those related to sustainability and environmental governance, while platforms like MIT Solve illustrate the field's potential when technological innovation is aligned with socially relevant knowledge. This institutionalization marks important progress, yet consolidation remains uneven. Overcoming methodological and structural barriers—together with a sustained commitment to integrating diverse knowledge systems—will be essential for engineering to address complex contemporary challenges effectively.

3.3. Transdisciplinarity in water resources management: lessons from international case analyses

The comparative review of 61 international initiatives provides concrete evidence of how transdisciplinarity has been incorporated into water resources management across governance scales. Although 71 % of the Earth's surface is covered by water, only 0.3 % corresponds to freshwater—essential for human needs (Khatriÿ and Tyagi, 2015). With global population growth, water scarcity is an increasingly urgent challenge (Akhtar et al., 2021). Approximately 2.1×10^9 people lack access to safely managed drinking water services, and 4.5×10^9 lack basic sanitation, according to 2015 data (World Health Organization and United Nations Children's Fund, 2017), often resulting in unsustainable water use.

Water-related conflicts encompass territorial, political, and economic dimensions, exacerbated by pollution, mismanagement, and climate change (Jiang, 2018; Hoffmann-Riem, 2008). Addressing these challenges requires technical, social, and participatory approaches that frame water as a socio-environmental, rather than purely technical, issue. The effectiveness of management depends on civil society's understanding of and commitment to participatory engagement. When communities act as co-authors of decisions, outcomes gain legitimacy, relevance, and long-term viability.

Within this context, Table 5 compiles these initiatives reviewed, drawn from literature, institutional databases (UNESCO, WHO, World Bank, UN-Water), and recent policy documents and project reports. The selection emphasized relevance, diversity, and adherence to explicit transdisciplinary principles—such as participatory governance, co-production of knowledge, epistemological integration, and cross-sector collaboration—while ensuring thematic variety across sectors (e.g., sanitation, conservation, agriculture, diplomacy). Cases documenting both achievements and limitations were included to provide a balanced view of progress and challenges.

Collectively, these initiatives demonstrate how the integration of

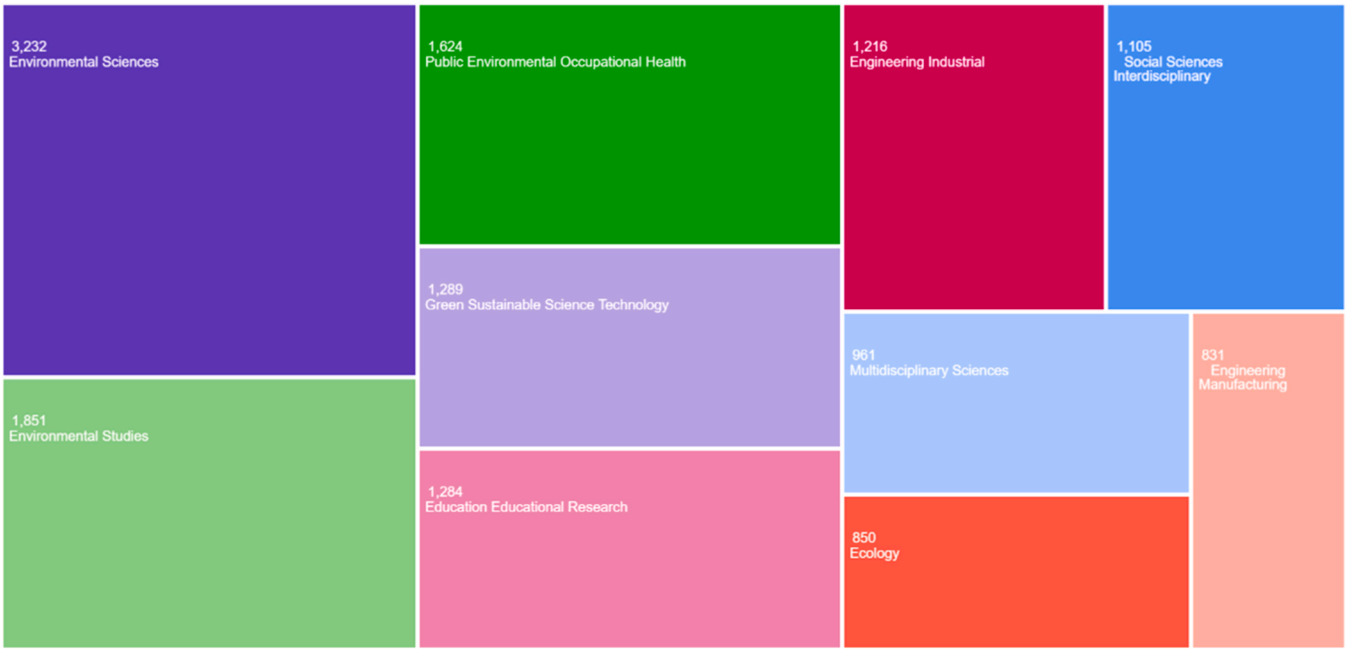

Fig. 3. TreeMap - Web of Science - Search engine: transdiscipl * (in all fields). - August 29, 2024.

Table 1
Use of transdisciplinary solutions for "wicked problems".

Wicked Problem	Project Name	Comments	Reference
Global Sustainable Development	UN 2030 Agenda for Sustainable Development and its 17 Sustainable Development Goals (SDGs)	Although aligned with transdisciplinarity in principle, its development lacked real integration between science and society.	(General Assembly, 2015)
Global Water Crisis	UN sustainability goals in transdisciplinary partnership through networked learning	Discourse is transdisciplinary, but practice remains technical and top-down, with weak community co-production.	(Dreyer-Gibney et al., 2024)
Sustainable Urban Development	Initiatives that bring together urban planners, ecologists, sociologists and local communities to design sustainable and livable cities	Interdisciplinary in practice, with limited civil society engagement and five key integration challenges.	(Rittel and Webber, 1973; Brandt et al., 2013)
Public Health and Disease Prevention	Collaborations that integrate medical research, social work, public policy, and community engagement to address complex health crises such as obesity and pandemics	Systems modeling is used, but participatory processes and local knowledge inclusion are still limited.	(Hirsch, Levine and Miller, 2007)
Food Security and Agricultural Sustainability	Agroecology networks that engage farmers, scientists, policy makers and consumers for sustainable agricultural practices	Agroecology promotes integration, but science often marginalizes farmer knowledge, weakening co-production.	(Wezel et al., 2009)
Biodiversity Conservation	Conservation programs that combine ecological science, policy management and indigenous knowledge to protect threatened ecosystems	Indigenous knowledge is acknowledged but rarely co-produced; integration remains limited and asymmetrical.	(Tengö et al., 2014; Mistry and Berardi, 2016)
Pandemics And Global Health Security	International strategies that combine epidemiology, global governance, social sciences and economics to respond to global health crises	Biomedical dominance persists; lack of social integration undermines the effectiveness and equity of responses.	(Khorram-Manesh, Burkle Jr and Goniewicz, 2024)
Collaborative Water Governance and Institutional Fragmentation	Strategies involving local communities, scientists and policy makers to address water pollution and scarcity in the Katari River basin.	Local knowledge is partially integrated; institutional fragmentation still limits full transdisciplinary governance.	(Akiyama et al., 2022)

multiple knowledge systems and actors enhances responses to complex global problems. They reflect key features of transdisciplinarity discussed throughout this article, including the dissolution of disciplinary boundaries, the recognition of local knowledge, and the promotion of participatory governance mechanisms.

Among them, the H_2Oliva Project stands out as an illustration of how transdisciplinarity can be operationalized by linking technological innovation to sustainable water use in agriculture. The initiative promotes efficiency, knowledge transfer, and the creation of pedagogical resources that support the replicability of good practices. This perspective transcends the mere application of technology, embedding it within a broader context of social and environmental sustainability.

The Hydro Nation Programme exemplifies the integration of innovation, economic development, and public policy in constructing a governance model that values both environmental protection and economic growth. Its components—such as the Hydro Nation Scholarship Programme and the implementation of advanced technologies—demonstrate the pivotal role of applied science in transdisciplinary strategies, while striving to balance economic and ecological outcomes and strengthen resilience.

Similarly, initiatives such as Water Diplomacy, jointly developed by MIT and Harvard University, underscore the relevance of collaborative frameworks in addressing water conflicts. By bridging science, policy, and negotiation, these initiatives not only generate technical solutions but also create platforms for dialogue and consensus—especially vital in regions where scarcity exacerbates social and political tensions.

Other governance frameworks, including those promoted by the Global Water Partnership (GWP) and Integrated Water Resources Management (IWRM) model, reaffirm the importance of integrated approaches in addressing water-related challenges. Both bring together local communities, governments, and international organizations to foster systemic strategies that consider the technical, social, and economic dimensions of water governance.

Despite their achievements, these experiences also reveal persistent limitations in implementing transdisciplinary principles. The integration of academic and non-academic knowledge often faces structural and methodological barriers, while local and traditional knowledge is frequently incorporated only marginally—reducing its influence on decision-making and, consequently, the legitimacy and effectiveness of resulting policies.

Overall, the cases summarized in Table 5 illustrate both advances and constraints in applying transdisciplinarity to water governance. Despite their geographic, thematic, and institutional diversity, recurring patterns reveal a persistent gap between the discourse of knowledge integration and the co-production of grounded, context-sensitive solutions.

These observations confirm the intrinsic complexity of transdisciplinary water management and the need to rethink the institutional, methodological, and ethical models that sustain it. When meaningfully applied, transdisciplinarity offers a credible pathway to transform environmental challenges into opportunities for social innovation. Overcoming power asymmetries, valuing situated knowledge, and establishing permanent co-decision mechanisms remain key to advancing democratic and sustainable water governance.

The following table presents a diverse set of international initiatives that exemplify these opportunities and challenges, offering insights into the operationalization of transdisciplinarity in water management. It constitutes the empirical core of this study, enabling a structured comparison between initiatives based on principles such as knowledge co-production, governance scale coherence, and participatory equity.

The asymmetry between technical expertise and local knowledge remains one of the main obstacles to legitimacy and effectiveness. Initiatives 4, 14, and 34 illustrate technocratic approaches often disconnected from community realities, whereas initiatives 17 and 20, despite aligning more closely with territorialized co-production, still face barriers to institutional recognition and financial sustainability.

Regarding social participation, symbolic consultation often replaces shared deliberation. Initiatives 29 and 43 promote multilateral forums that appear inclusive, yet the genuine incorporation of marginalized voices remains limited. Even in projects addressing human rights, such as 54 and 57, participation of vulnerable groups tends to be residual, compromising the structural transformation that transdisciplinarity seeks to advance.

The analysis of scale reveals the "pilot paradox": successful local initiatives (e.g., 7, 10, 20, and 42) frequently encounter resistance when scaled up. Fragmented institutional frameworks (52 and 59), bureaucratic rigidity (19), and dependence on short-term funding (39) hinder the sustainability and expansion of participatory practices. Meanwhile, institutional and diplomatically oriented efforts such as 5, 40, and 44 play a vital role in fostering peace and cooperation but often lack

Table 2
Contribution to transdisciplinarity. Tools by domain.

Domains	Designation	Tools	Reference
Communication	RLC 2040 Project	Used digital platforms (whiteboards, voting, email, websites) and visual outputs (films, sketchnotes) to support engagement. Communication experts played a key role in success.	(Fischer et al., 2024)
	Sustainable Rubber Cultivation in the Mekong Region (SURUMER)	Adopted an iterative communication framework with "loop activities" that enabled feedback incorporation, impact evaluation, and adaptive adjustment throughout the process.	(Wang, Aenis and Siew, 2019)
	Rivercare Research Programme	Applied participatory modeling, storytelling, dashboards, and GIS tools to integrate scientific and stakeholder perspectives, fostering mutual understanding among researchers, policymakers, and communities.	(Cortes Arevalo et al., 2023)
	ITD Alliance – Toolkits and Methods	Developed a global toolkit for researchers and practitioners, including templates, training materials, and case studies to support effective communication in inter- and transdisciplinary projects.	(Laursen et al., 2024)
	Design-Based Interventions in Transdisciplinary Research	Highlighted how conceptual design and prototyping can serve as integration tools. Tangible design artifacts were used to connect diverse perspectives and foster knowledge co-creation.	(Peukert and Vilsmaier, 2021)
	Collaborative Adaptive Management (CAM)	Engaged stakeholders (e.g., ranchers, conservationists, agencies) in iterative management using co-monitoring, planning workshops, and decision cycles. Fostered social learning, reduced conflicts, and supported ecological resilience.	(Wilmer et al., 2025)
	Transdisciplinary Urban Water Management	Used panels, workshops, and cloud platforms to share hydrological data. Knowledge exchange between researchers and managers supported the design of sustainable urban water solutions.	(Mukherjee, Sundberg and Schütt, 2021)
Science communication	Transdisciplinary Research Communications Set-up	Developed by the Center for Open Science, this setup provides structured steps for launching transdisciplinary projects, including detailed guidance on communication planning from the initial phase.	(Robasky et al., 2020)
	Transdisciplinary Learning Cohort (TLC) –Graduate STEM Researchers	Combined seminars, collaborative writing, symposia, and informal talks to develop shared vocabulary and metacognitive strategies, including mentor-mentee exchanges across disciplines.	(O'Neill et al., 2019)
	Global Food Security and Ecosystem Research (GFE)	Created communication guidelines to help integrate knowledge between scientists from diverse disciplines and non-scientific participants, with a focus on addressing complex issues related to global food security and ecosystem sustainability.	(Herrera, Callenius and Knierim, 2023)
	Transdisciplinary Networks for Sustainability Science	Used interactive workshops, digital platforms, and face-to-face meetings to foster co-production of knowledge among scientists, policymakers, and civil society.	(Jahn, Bergmann and Keil, 2012)
	Collaborative Water Governance in the Katari River Basin	Applied transdisciplinarity to integrate knowledge through meetings, interviews, and observations, improving communication between scientists, managers, and communities.	(Akiyama et al., 2022)
	Participatory Mapping and Photovoice in Marine Ecosystem Management	Engaged communities in co-producing knowledge on ecosystem services using Photovoice and participatory mapping, fostering dialogue and informing adaptive marine management.	(Lim et al., 2021)
	Transdisciplinary Science for Sustainable Land Management – Brazil	Integrated scientific and local knowledge in Brazil's semiarid region through workshops, digital platforms, and participatory decision-making.	(Siegmund-Schultze, Köppel and Sobral, 2018)
Share a common language	Transdisciplinary Transformative Change Initiatives	Identified two key challenges: (1) difficulty creating a common language and shared understanding; (2) barriers to pluralizing knowledge within transdisciplinary collaborations focused on global change and biodiversity loss.	(Deutsch et al., 2023)
	INTREPID Project – World Café Method	Participants emphasized the lack of a shared language and communication protocol as critical barriers. Members agreed that developing a common language is essential to sustaining transdisciplinary collaboration and connection.	(Von Wehrden et al., 2019)
	European Performing Science Night 2021	Analysed art-science collaborations and social learning dynamics. Results showed that interrelational skills and group dynamics significantly influenced the development of shared understanding.	(Gallois et al., 2024)
	False friends across languages and scientific domains	Highlighted two main risks to communication: (1) medical eponyms functioning as "false friends" across languages; and (2) the cultural inappropriateness of storytelling for science education in certain contexts. Also noted disciplinary differences in terms like "model" and "significance."	(1) (Brdar and Brdar-Szabó, 2024); (2) (Heering, 2010)
	Common Language in Water Governance: Bridging Science and Policy	Investigated how actors in water governance build shared language using focus groups, interdisciplinary interviews, and discourse analysis to support transdisciplinary decisions.	(Akiyama et al., 2022)
Building empathy	Transdisciplinary educational experience	Explored how educational activities can foster empathy in technology students. Found that empathy development requires vulnerability, perspective-taking, and safe environments that promote trust and openness.	(Gray et al., 2016)
	Perspective-Taking Strategies in Empathy Development	Explored how past experiences affect ease of perspective-taking using vignettes and self-assessment, emphasizing reflective processes in empathy development.	(Gerace et al., 2015)
	Narratives and Storytelling for Empathy in Science Communication	Narratives and storytelling foster empathy in science communication by linking research to human experience through interviews, visual stories, and interactive formats.	(Dahlstrom, 2014)
	Virtual Reality (VR) for Enhancing Empathy in Transdisciplinary Education	VR simulations were used to foster empathy in students by immersing them in social and environmental challenges, promoting deeper understanding and collaborative engagement.	(Shin, 2018)

(*continued on next page*)

Table 2 (*continued*)

Domains	Designation	Tools	Reference
	Sustainability Transitions and Stakeholder Engagement in Urban Planning	Applied participatory mapping, future visioning, and storytelling to include diverse perspectives and foster empathy in sustainable urban planning.	(Pereira et al., 2020)
	Participatory Vulnerability and Risk Assessment – Southern Africa	Utilized assessments, maps, focus groups, and impact chains to engage communities in identifying vulnerabilities and co-developing solutions.	(Morchain et al., 2019)

Table 3
Comparison Between Traditional and Transdisciplinary Engineering – Adapted from Lattanzio, et al. (2021).

	Traditional Engineering	Transdisciplinary Engineering
Approach	Emphasizes specialization within a single discipline, often producing limited solutions to isolated problems.	Involves collaboration among experts from diverse fields to address complex, interconnected challenges.
Knowledge Integration	Integrates knowledge from related disciplines using established theories and methods.	Combines academic and non-academic knowledge, including local and experiential insights, to co-develop solutions.
Complexity and Systems	It focuses on understanding the interconnection and dynamics of these systems.	Transdisciplinary problems often involve complex systems that span multiple domains of knowledge.
Holistic Solutions	While traditional engineering often focuses on specific solutions to isolated problems.	Transdisciplinary engineering seeks holistic solutions that consider impacts across different domains and stakeholders.
Interdisciplinary Collaboration	It is usually conducted by experts in a single discipline.	It promotes collaboration between professionals from diverse domains, including social sciences, arts, humanities, and natural sciences.
Synthesis	Oriented toward technical efficiency and discipline-specific outcomes.	Aims for broad, integrated responses that incorporate diverse knowledge systems and foster co-learning.

mechanisms for engaging community knowledge, weakening their transformative potential.

A few emblematic cases suggest promising directions. Initiatives 13, 27, and 35 show strong commitment to integrating popular knowledge and advancing social justice. Brazil's river basin committees (61), represent a rare example of tripartite governance balancing technical expertise, political interests, and civil society participation, though limited by operational and political constraints.

Overall, the initiatives analysed indicate that while transdisciplinarity is increasingly present in global discourses and policy agendas, it remains more aspirational than operational. The absence of mechanisms ensuring epistemic equity, genuine engagement of local actors, and coherence across governance scales continues to hinder its effectiveness. For transdisciplinarity to become a guiding paradigm, it must evolve beyond conceptual rhetoric and consolidate as the ethical, methodological, and political foundation of water governance.

Building on this analysis, we identify key strategic priorities to turn transdisciplinary intent into concrete practice:

- Establish knowledge co-production as an organizing principle, with deliberative mechanisms from project conception to implementation;
- Value situated knowledge and foster dialogue between diverse epistemologies, particularly in contexts of conflict, scarcity, and vulnerability;
- Link funding and institutional recognition to participatory equity through social audits, water justice indicators, and representative governance bodies.

The analysed cases reinforce the theoretical arguments presented in this article while providing operational insights for advancing transdisciplinarity as a transformative practice. These comparative findings underscore that overcoming barriers to effective water governance requires not only technical innovation but a fundamental ethical reorientation grounded in inclusion, epistemic equity, and sustainability. Only through such transformation can transdisciplinarity evolve from a normative ideal into a concrete framework for action.

Across governance scales, water initiatives depend less on institutional design than on the ethical quality of participation. Without genuine engagement, even sophisticated projects risk becoming top-down and socially disconnected.

4. Conclusion

This systematic review examined how transdisciplinarity has been conceptualized and implemented in water resources management, analysing 61 international initiatives across diverse governance scales and institutional contexts. The comparative evidence reveals both significant advances and persistent limitations in translating transdisciplinary discourse into concrete practice. Although the concept has gained visibility in academic and policy arenas, its operationalization often remains partial, with many initiatives struggling to achieve genuine knowledge co-production, participatory equity, and the integration of local perspectives into decision-making.

Despite notable scientific and technological progress in water capture, treatment, and distribution, billions of people still face shortages of water, food, and sanitation. This paradox demonstrates that innovation alone, when detached from ethical and social principles, cannot ensure sustainability. Projects that exclude the voices of affected communities tend to reproduce institutional hierarchies and generate technically sound but socially ineffective outcomes. The initiatives examined in this study reinforce that sustainability depends as much on the ethical quality of participation as on the sophistication of technology.

Transdisciplinarity challenges the assumption of technical neutrality that often underpins scientific and managerial practices. It calls for a transition from formulating answers to co-formulating questions, from intervening in territories to engaging with them. The 61 initiatives collectively show that where participatory mechanisms are authentic—valuing situated knowledge, confronting power asymmetries, and embedding co-decision—results tend to be more legitimate, adaptive, and lasting. Conversely, where such principles remain rhetorical, the

Table 4
Transdisciplinary engineering. International initiatives.

Designation	Description	Reference
Alliance For Social-Ecological Resilience	Promotes transdisciplinary approaches to managing complex adaptive systems through theory, field research, and resilience policy tools. Publishes Ecology & Society.	(Resilience Alliance, n.d)
Engineering For Change (E4C)	Connects engineers, designers, and innovators to co-create sustainable, scalable solutions in areas like poverty, clean water, and infrastructure. Founded in partnership with ASME and IEEE.	(Engineering For Change, 2025)
Future Earth (FE)	Global platform connecting researchers and communities through Knowledge-Action Networks (KANs) to co-develop sustainability solutions.	(Future Earth, 2025)
Global Research Council (GRC)	Coordinates national research councils and promotes funding models for transdisciplinary solutions to global problems.	(Global Research Council, 2025)
International Conference on Transdisciplinarity (ITD)	Biennial event uniting professionals and researchers across fields to share case studies, tools, and theoretical advances in transdisciplinarity.	(Global Alliance for Inter- and Transdisciplinarity, 2025)
International Conference on Transdisciplinary Engineering (ISTE)	Originated from ICCE in the 1990s; renamed ICTE in 2015 to emphasize cross-disciplinary collaboration on *"wicked problems"*. Brings together engineers, scientists, and policymakers.	(International Society for Transdisciplinary Engineering, n.d)
International Council of Science (ICSU / ISC)	Part of the International Science Council; promotes standards for interdisciplinary and transdisciplinary collaboration.	(International Science Council, n.d)
International Sustainable Campuses Network (ISCN)	Mobilizes universities to implement sustainability initiatives and promote transdisciplinary research and learning environments.	(International Sustainable Campus Network, 2021)
MIT Solve Initiative	MIT platform hosting innovation challenges for transdisciplinary, cross-sector solutions to global issues.	(MIT Solve, n.d)
Santa Fe Institute – Complexity Science Hub	Research hub focused on complexity science, uniting engineers and scientists to tackle systemic global problems.	(Santa Fe Institute, 2024)
Transdisciplinary Research Network (Td-Net)	Swiss network offering training, tools, and events to advance transdisciplinary research.	(td-net, 2025)
UNESCO Engineering Initiative for Sustainable Development	Promotes transdisciplinary engineering to meet SDGs. Works with academia, governments, and industries to develop integrated solutions for environmental and social challenges.	(UNESCO, n.d a)
Woods Institute for the Environment (Stanford)	Integrates engineering, social sciences, and policy for sustainability through transdisciplinary approaches.	(Stanford Woods Institute for the Environment, n.d)
World Federation of Engineering Organizations (WFEO)	Encourages sustainable engineering through transdisciplinary partnerships. Provides guidelines on equity, resilience, and sustainability practices.	(World Federation of Engineering Organizations, 2025)
Zurich Transdisciplinary Laboratory (TdLab)	Integrates social sciences with engineering in teaching and research to address sustainability challenges through cross-sector collaboration.	(ETH Zürich Transdisciplinarity Lab, 2025)
International Institute for Applied Systems Analysis (IIASA)	Specializes in transdisciplinary research on global change, including energy transitions, biodiversity, and climate modeling.	(International Institute for Applied Systems Analysis, 2025)
IUGS – Working Group on Geosciences and Society	Applies transdisciplinary methods in geosciences by linking policy, engineering, and social sciences to address environmental issues.	(International Union of Geological Sciences, 2025)
Belmont Forum	International funding partnership for inter- and transdisciplinary research in sustainability.	(Belmont Forum, 2017)
Engineering X – Royal Academy of Engineering	International initiative that promotes inclusive innovation and transdisciplinary engineering solutions for global challenges.	(Royal Academy of Engineering, n.d)

social reach of innovation is diminished.

For transdisciplinarity to realize its transformative potential, it must be consolidated as an ethical, methodological, and political foundation for water governance. This requires institutional openness, shared authority, and a commitment to cognitive and social justice. Professionals in engineering and technical sciences play a pivotal role in this transition, as their decisions shape hydrosocial systems and determine whether science can act as a bridge rather than a boundary. Adopting a transdisciplinary stance therefore entails integrating scientific and local knowledge while cultivating communicative competencies that enable meaningful dialogue with communities and recognition of their priorities.

Ultimately, the future of water governance will depend less on institutional architecture than on the quality of relationships among actors and with the ecosystems that sustain them. Building effective and lasting policies demands continuous cooperation between science, management, and society, grounded in mutual trust and shared responsibility. By integrating empirical evidence with conceptual reflection, this study contributes to advancing transdisciplinarity from a normative paradigm to an actionable framework for ethical co-production—offering a pathway toward more just, inclusive, and sustainable water governance in the twenty-first century.

CRediT authorship contribution statement

Ana Paulade Carvalho Silva: Writing – original draft,

Table 5
Transdisciplinary Aspects in International Water Management Initiatives.

Nº	Initiatives	Objective	Transdisciplinary Aspects	Reference
1	African Ministers' Council on Water (AMCOW)	Strengthens cooperation among African countries to promote sustainable water management through policy support, shared agendas, and institutional partnerships.	Emphasizes regional collaborative governance; integrates scientific research with public policy; faces challenges in incorporating local knowledge and community participation.	(African Ministers' Council on Water, 2022)
2	Alliance for Global Water Adaptation	Promotes climate resilience in water management by integrating science, policy, and finance; develops tools supporting governments, businesses, and communities facing climate change.	Combines diverse sectors and knowledge systems to design adaptive strategies; facilitates collaboration among scientists, policymakers, and communities; faces challenges in effective territorial co-production.	(Alliance for Global Water Adaptation, 2025)
3	Alliance for Water Stewardship (AWS)	Promotes responsible water use via a global standard for businesses, governments, and communities; balances economic, social, and environmental needs aligned with the Sustainable Development Goals.	Facilitates dialogue among productive sectors, civil society, and regulators; applies technical and ethical tools; potential for co-production exists, though implementation prioritizes metrics and certification.	(Alliance for Water Stewardship, 2023)
4	Aqueduct by WRI (Water Resources Institute)	Provides a global water risk platform to support corporate and regional decision-making, informing policies, investments, and strategies under scarcity and vulnerability contexts.	Combines data science, strategic planning, and public policy; fosters cross-sector dialogue; remains largely technical and corporate, with limited local knowledge and community engagement.	(World Resources Institute, 2025)
5	Blue Peace Initiative	Promotes cross-border cooperation in water management as a peacebuilding tool; develops diplomatic mediation and case studies to prevent conflicts over water scarcity and mismanagement.	Integrates diplomacy, science, and public policy around water as a common good; fosters collaboration between countries; local community involvement remains limited, restricting full co-production.	(Blue Peace, n.d)
6	Circle of Blue — where Water Speaks	Connects journalism, science, and policy to raise public awareness about the global water crisis; convenes experts to produce reports, analyses, and accessible narratives.	Bridges communication, science, and society; translates complex data into accessible language, fostering engagement; while not co-productive, it broadens access and understanding of water issues.	(Circle of Blue, 2025)
7	Community Water Management for a Livable London	Engage local communities in sustainable urban water management, promoting environmental restoration, education, and participatory monitoring in London.	Promotes community participation and environmental education; connects citizen science with local policy; exemplifies co-production despite scale and institutional challenges.	(Thames21, n.d)
8	Delta Alliance	Promotes sustainable management of vulnerable river deltas via international cooperation, applied research, and experience exchange among regions confronting sea level rise and urban pressures.	Integrates scientific knowledge, spatial planning, and local wisdom in vulnerable contexts; fosters international collaboration; challenges persist in aligning global frameworks with local solutions.	(Delta Alliance, n.d)
9	Dŵr Uisce	Promotes water sustainability and energy efficiency through innovation and Ireland–Wales cooperation in research, training, and development.	Integrates engineering, policy, and development for sustainability; connects institutions and communities; continues building pathways for direct social participation.	(Dŵr Uisce Project, n.d)
10	EcoAdapt — Water & Climate Resilience Program	Strengthens climate-water resilience through nature-based solutions and participatory governance; promotes community adaptation and environmental conservation in vulnerable regions.	Integrates ecology, land management, and participation; prioritizes local solutions and traditional knowledge; advances governance focused on co-production and social embedding.	(EcoAdapt, n.d)
11	UNESCO – International Cooperation on Water	Fosters water security through IHP and WWAP, promoting scientific research, governance, and sustainability via global reports, centres, chairs, and expert networks.	Unites programmes bridging science, policy, and society; consolidates international efforts via cooperation, resource assessment, and sustainable policy frameworks.	(United Nations Educational, Scientific and Cultural Organization, n.d)
12	EU Water Research & Innovation (European Commission)	European Commission platform addressing global water challenges via research, innovation, and funding; connects science, sectors, civil society, and international cooperation on key water issues.	Articulates Horizon Europe, LIFE, Water4All, PRIMA, and JPI Water programs to advance applied knowledge and innovation; faces challenges translating science into local impact and fostering active participation.	(European Commission, 2025a)
13	Freshwater Action Network (FAN)	Connects NGOs and local communities to advocate for the right to water and sustainable sanitation; influences global policies based on experiences and needs of vulnerable populations.	Bridges community knowledge, activism, and international policy; elevates marginalized voices in policymaking; exemplifies rooted transdisciplinarity despite scale and funding challenges.	(Public World, 2025)
14	Global Water Futures (GWF)	Develops science-based solutions addressing climate change impacts on water, focusing on cold regions; combines advanced modeling, adaptive management, and end-user engagement.	Integrates climate science, engineering, and policy with user participation; fosters collaboration but remains expert-driven with limited horizontal co-production and hierarchical structures.	(Global Water Futures, 2025)
15	Global Water Partnership (GWP)	Promotes integrated water resources management by uniting governments, international organizations, and civil society to implement sustainable practices at global, regional, and local levels.	Fosters collaboration among diverse actors and governance levels; promotes participatory, systemic planning; despite inclusive language, challenges remain in ensuring equitable decision-making involvement.	(Global Water Partnership, n.d)
16	Global Water Security & Sanitation Partnership (GWSP)	Enhances water security and sanitation in low- and middle-income countries by supporting equitable public policies, sustainable investments, and institutional strengthening.	Integrates technical knowledge, social policy, and development economics; prioritizes social justice and inclusion; co-production with local communities remains limited or sporadic.	(World Bank, 2025)

(*continued on next page*)

Table 5 (*continued*)

Nº	Initiatives	Objective	Transdisciplinary Aspects	Reference
17	H_2Oliva	Optimizes water management in agriculture via monitoring technologies in olive groves; promotes sustainable practices, knowledge transfer, and technical training with farmers.	Integrates applied science, technological innovation, and local agricultural knowledge; fosters co-production with farmers and institutions; exemplifies territorialized transdisciplinarity with replication potential.	(Directorate-General for Agriculture and Rural Development, n.d)
18	Hydro Nation (Scotland)	Aims to establish Scotland as a leader in water innovation by linking science, economy, and public policy to promote sustainability and strengthen its international role in water governance.	Integrates scientific research, public governance, and economic development; fosters sustainability-driven innovation; strong institutional networks but lacks consistent citizen participation mechanisms.	(Hydro Nation International Centre, n.d)
19	Integrated Water Resources Management (IWRM)	Promotes integrated water management by addressing technical, social, economic, and environmental dimensions, emphasizing sustainability and stakeholder participation.	Incorporates diverse knowledge systems and water dimensions; advocates a systemic, participatory approach; faces challenges in operationalizing equitable community inclusion and translating principles into local practice.	(IWRM Action Hub, 2025)
20	Interdital Melides	Protects the Melides Lagoon by conserving biodiversity and promoting sustainable development, actively engaging the local community in environmental management and territorial stewardship.	Highlights local ecological knowledge and community participation; bridges science, culture, and sustainable practices; exemplifies rooted transdisciplinarity with strong territorial focus.	(Intertidal Melides, 2023)
21	International Center for Water Cooperation (ICWC)	Promotes international cooperation for managing shared water resources, supporting sustainable policies and conflict reduction through knowledge generation and dissemination.	Integrates science, governance, and diplomacy on transboundary water; fosters connections between technical knowledge and policy; institutional but with potential for greater local inclusion.	(Stockholm International Water Institute, 2025a)
22	International Commission on Irrigation and Drainage (ICID)	Supports development of efficient irrigation and drainage systems, promoting sustainable agricultural water use through technical guidelines, capacity building, and international knowledge exchange.	Integrates agricultural engineering, water management, and food policies; fosters international cooperation and knowledge sharing; lacks co-production mechanisms with farmers and local communities.	(International Commission on Irrigation and Drainage, 2022)
23	Ecohydrology Web Platform	UNESCO-IHP demo site network (since 2011) applying ecohydrology in river basins to restore ecosystem services, enhance resilience, and integrate technical, social, and ecological knowledge in water management.	Integrates transdisciplinary theory and practice through locally guided projects; connects science, policy, and communities; requires increased visibility, funding, and links to territorial and innovation networks.	(International Hydrological Programme, 2015)
24	International Water Management Institute (IWMI)	Develops evidence-based strategies to improve water management, focusing on agriculture, water security, and climate adaptation, especially in developing countries.	Combines applied science, agricultural innovation, and policy; pursues integrated solutions for vulnerable contexts; faces challenges in institutionalizing community participation.	(International Water Management Institute, 2025)
25	International Water Resources Association	Promotes global water research and governance by connecting experts, policymakers, and stakeholders to enhance sustainable water management.	Facilitates dialogue among science, policy, and practice; organizes events integrating diverse knowledge fields; co-production with local actors remains limited despite cross-sector collaboration.	(International Water Resources Association, 2019)
26	International WaterCentre (IWC)	Trains global leaders in integrated water management via education, applied research, and capacity building in interdisciplinary and international settings.	Integrates education, research, and practice toward sustainability; fosters cross-sector dialogue; co-production remains emergent despite strong educational focus.	(International WaterCentre, 2025)
27	Living Lakes Network	Conserves lakes and wetlands globally via nature-based solutions, knowledge exchange, and engagement of local communities and youth leaders.	Links conservation, education, and participation; values local knowledge and interculturality; promotes co-production and rooted solutions with socioecological impact.	(Living Lakes Network, 2022)
28	National Agreement for Human Rights for Water and Sustainability	Establishes commitments between government and private sector to guarantee drinking water rights and promote sustainable irrigation and infrastructure practices.	Integrates policy, productive sectors, and rights; advocates water as a common good; faces challenges in equitable civil society participation in decision-making.	(Gobierno de México, n.d)
29	One Water Summit	Unites governments, private sector, scientists, and civil society to integrate water into public policies and advance global governance, with emphasis on SDGs and sustainable innovation.	Fosters intersectoral and interdisciplinary dialogue; encourages innovative solutions through global collaboration; citizen participation remains largely consultative rather than co-decisional.	(One Planet Summit, 2024)
30	Pacific Institute Water Program	Develops evidence-based public policies to ensure water security, emphasizing equity, efficiency, and human rights protection.	Integrates science, policy, and socio-environmental justice; fosters cross-sector dialogue; co-production remains inconsistent despite strong ethical commitment.	(Pacific Institute, 2025)
31	Pacific Islands Water	Promotes sustainable water management in small Pacific islands by addressing climate and geographic challenges via research, advocacy, and cooperation among governments, communities, and international organizations.	Integrates climatology, environmental engineering, and local knowledge to address island vulnerabilities; connects science with rights-based advocacy in collaborative contexts; exemplifies territorially adapted transdisciplinarity.	(USGS, n.d)
32	Partnerships for Water Sustainability In British Columbia	Strengthens water sustainability through intergovernmental partnerships, green infrastructure promotion, and integrated land and water management.	Connects urban policy, environmental engineering, and collaborative planning; facilitates systemic change via cross-sector integration; citizen participation depends on local initiatives.	(Water Bucket, 2025)
33	Project Omega	Supports hydro-agricultural reservoir management via a digital platform with real-time data to enhance water efficiency and promote sustainable decision-making.	Bridges technology, agricultural management, and public policy; aids data-informed decisions with farmer participation; expanding interface with local knowledge and cultural practices.	(Empreendedor, 2023)

(*continued on next page*)

Table 5 (*continued*)

Nº	Initiatives	Objective	Transdisciplinary Aspects	Reference
34	Ramsar Convention on Wetlands	Promotes global wetland conservation and wise use through local actions, national policies, and international cooperation, emphasizing biodiversity and water resource protection.	Integrates environmental conservation, policy, and education; fosters participatory and intercultural methods; challenges persist in including local communities effectively in governance and implementation.	(Ramsar Convention Secretariat, 2025)
35	REACH: Improving Water Security for the Poor	Enhances water security for vulnerable populations through risk-based research, fostering collaboration among science, policy, and practice, with emphasis on poverty reduction and social justice.	Combines applied science, public policy, and social needs; promotes multisector partnerships focused on equity; strong transdisciplinary approach, yet faces challenges sustaining long-term participation.	(REACH Programme, 2024)
36	Stockholm International Water Institute (SIWI)	International NGO transforming water understanding, valuation, and management; operates globally through projects, research, training, and platforms to strengthen governance, cooperation, and justice aligned with the 2030 Agenda.	Employs a multi-scale, transdisciplinary approach integrating science, policy, diplomacy, and inclusion; provides training, advice, and advocacy; co-production effectiveness depends on regional integration and community engagement.	(Stockholm International Water Institute, 2025b)
37	Sustainable Sanitation Alliance (SuSanA)	Promotes sustainable sanitation solutions to improve water access and health in underserved communities, focusing on education, infrastructure, and public policy.	Integrates environmental, social, and health issues; fosters community participation; promotes local solutions but struggles with policy implementation.	(Sustainable Sanitation Alliance - SuSanA, n.d)
38	The European Water Framework Directive (WFD)	Establishes a framework for integrated water management in the EU, promoting sustainability and protection of inland and coastal waters, emphasizing water quality and public participation.	Integrates environmental, economic, and social dimensions; fosters public participation; faces challenges in local application and regional adaptation.	(European Commission, 2025b)
39	The Global Environment Facility (GEF)	Supports global environmental conservation projects, including water resource management, emphasizing sustainability and the integration of science, policy, and economic development.	Integrates environmental science, policy, and economics to promote sustainable solutions; collaborates with diverse stakeholders; local-level knowledge co-production remains limited	(Global Environment Facility, 2025)
40	The Water Diplomacy Program at Tufts University	Trains interdisciplinary professionals in sustainable water management by combining research, diplomacy, and innovation to tackle global water challenges.	Integrates research, diplomacy, and innovation; fosters academic–governmental collaboration; co-produced solutions depend on field implementation.	(Tufts Institute of the Environment, 2025)
41	The Water Institute At UNC	Develops research and public policies for sustainable water management, emphasizing climate change adaptation, water security, and socio-economic impact.	Integrates scientific research, policy, and socio-economic dimensions; promotes sustainability in vulnerable communities; integration with local managers and populations still faces barriers.	(UNC Water Institute, n.d)
42	The Water Project	Provides access to clean and safe water in sub-Saharan African communities while promoting education on sustainable water practices.	Integrates engineering, education, and community empowerment; operates locally with focus on sustainability and participation; faces challenges in scaling impact.	(The Water Project, 2025)
43	The World Water Forum	Brings together experts, organizations, and citizens to address global water challenges, promoting governance, participation, and sustainable development.	Creates dialogue across sectors and cultures; integrates technical knowledge, social demands, and public policy; inclusion of marginalized voices remains a challenge.	(World Water Council, 2021)
44	Transboundary Water Management	Promotes cooperation among countries sharing river basins, aiming at sustainable management and peaceful resolution of water-related conflicts.	Integrates international policy, diplomacy, and environmental management; fosters collaborative approaches, yet implementation across nations and cultures remains challenging.	(United Nations, 2024)
45	Un Water	Coordinates United Nations actions related to water governance, management, and policy to promote sustainability and ensure universal water access.	Integrates global governance, environmental policy, and water management; fosters multisectoral cooperation and transnational justice for equitable, context-sensitive solutions.	(United Nations, n.d)
46	UNESCO's International Center for Water Hazard and Risk Management (ICHARM)	Improves water risk management by addressing natural disaster impacts and climate adaptation, emphasizing early warning and integrated risk strategies.	Integrates climate science, disaster management, and policy for adaptation; fosters collaboration among governments, NGOs, and communities; struggles to adapt technologies and include vulnerable groups in decisions.	(Associated Programme on Flood Management, 2020)
47	TerAgua (DGT - Direção Geral do Território, Portugal)	Develops a collaborative platform to support integrated water and land use planning in the Castelo do Bode watershed, aiming to improve management efficiency and territorial sustainability.	Integrates statistics, information systems, land and water planning; fosters cross-institutional collaboration, including analog-to-digital conversion, data validation, and stakeholder engagement in platform updates.	(Direção-Geral do Território, 2025)
48	Water Education Program	Trains professionals to develop sustainable water management approaches through education focused on conservation and responsible use.	Integrates education, water management, and sustainability; fosters knowledge exchange between academia and professionals; implementation remains difficult in areas with limited infrastructure.	(UNESCO, n.d b)
49	Water Governance Initiative	Improves water governance by sharing good practices and policy guidelines, promoting stakeholder engagement and strengthening global dialogue on water policies.	Integrates governance, public policy, and social participation; encourages exchange across sectors and countries; faces challenges in local adaptation and fostering co-production.	(Organisation for Economic Co-operation and Development, n.d)
50	Water Integrity Network (WIN)	Prevents corruption in water management by promoting good practices, transparency, and accountable governance, fostering collaboration among public, private, and civil society actors.	Integrates governance, transparency, and social responsibility; encourages cross-sector collaboration for equitable water use; struggles to embed a culture of integrity at the local level.	(Water Integrity Network, n.d)

(*continued on next page*)

Table 5 (*continued*)

Nº	Initiatives	Objective	Transdisciplinary Aspects	Reference
51	Water Resilience Coalition	Seeks to mitigate the global water crisis and its link to climate change, aiming to provide clean water, sanitation, and hygiene to 300 million people by 2050 through public-private partnerships.	Links cross-sector efforts among businesses, governments, and NGOs; promotes sustainable innovation; faces challenges in ensuring equitable community inclusion in implementation.	(Water Resilience Coalition, n. d)
52	Water Resources Group (WRG)	Supports governments and organizations in improving water management through public-private partnerships, focusing on innovative solutions for water security and sustainable use.	Fosters public–private partnerships by integrating science, technology, and management; promotes collaborative solutions; faces challenges in implementing sustainability amid socio-economic disparities.	(2030 2030 2030 Water Resources Group, 2025)
53	Water, Peace and Security Partnership (WPS)	Develops tools to identify and mitigate water-related security risks, aiming to prevent conflicts and promote peace through participatory analysis and dialogue in vulnerable regions.	Integrates technology, risk management, and diplomacy for conflict resolution; fosters collaboration, though co-production is constrained by complex local and conflict dynamics.	(Water, Peace and Security, n.d)
54	Water, Sanitation and Hygiene (WASH)	Promotes universal access to drinking water, sanitation, and hygiene as a human right by integrating public health, education, engineering, and policy.	Combines health, education, infrastructure, and rights-based approaches; supports inclusive, sustainable solutions; implementation remains difficult in contexts of high social and economic vulnerability.	(World Health Organization, 2025)
55	Joint Monitoring Programme (JMP)	Monitors global progress in access to drinking water, sanitation, and hygiene under the SDGs, emphasizing disaggregated data and inclusion of vulnerable groups.	Integrates data monitoring, policy, and inclusion; fosters collaboration among agencies, governments, and NGOs; challenges persist in applying data effectively for disadvantaged communities.	(World Health Organization and United Nations Children's Fund, n.d)
56	Global Analysis and Assessment of Sanitation and Drinking-Water (GLAAS)	Assesses national system capacities to deliver water and sanitation services, supporting the development of evidence-based policies and targeted investments.	Integrates technical, governance, and financial dimensions; promotes collaboration between governments and international organizations; faces challenges in tailoring policies to local realities and addressing water inequalities.	(UN-Water GLAAS, 2025)
57	Wateraid	Promotes universal access to clean water and sanitation in impoverished communities, emphasizing local empowerment and sustainable, community-driven solutions.	Integrates education, health, and infrastructure with strong community participation; fosters local empowerment, yet struggles to scale impact in socially unequal contexts.	(WaterAid, n.d)
58	World Bank's Water Sector	Supports global water management projects focused on infrastructure, governance, and sustainability to enhance access and efficient resource use.	Integrates investment, policy, and resource management; fosters collaboration among governments, private sector, and NGOs; faces challenges in adapting solutions and incorporating community knowledge.	(World Bank Group, 2025)
59	World Water Council	Promotes global initiatives and public policies for water security, engaging governments, international organizations, and experts to prioritize water in sustainable development.	Integrates policy, diplomacy, and water management to advance hydrodiplomacy; encourages international participation and decentralization to ensure policy impact at local and community levels.	(World Water Council, 2025)
60	WWAP - Un World Water Assessment Program	Assesses the global status of water resources and provides critical information to support SDG implementation, focusing on equitable access and efficient water management.	Integrates scientific data, public policy, and water management for sustainability; promotes international collaboration; challenges remain in applying solutions locally.	(World Water Assessment Programme, n.d)
61	River Basin Committees (Law nº 9.433/1997, Brazil)	Implements integrated water management through tripartite governance involving government, users, and civil society; applied in river basins like Guandu, Guanabara, Dois Rios, São João, and Piabanha; expanded nationwide.	Fosters dialogue among institutional, social, and technical actors; integrates scientific, traditional, and political knowledge; supported by water agencies for planning and financing; challenges persist in autonomy, equity, and conflict resolution.	(Presidência da República, Casa Civil, and Subchefia para Assuntos Jurídicos, 1997)

Note: This table summarizes selected international initiatives based on their objectives, transdisciplinary aspects, and governance context. Sources are listed in the Reference section.

Conceptualization. **Margarida Ribau Teixeira:** Writing – review & editing. **Luís Miguel Nunes:** Writing – review & editing, Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors are unable or have chosen not to specify which data has been used.

References

2030 Water Resources Group (2025) *About Us.*(Accessed: 20 May 2025)⟨https://www.2030wrg.org/about-wrg⟩.

African Ministers' Council on Water, 2022. AMBome, AMCOW(Accessed: 17 May 2025)⟨https://amcow-online.org/amcow/⟩.

Aicardi, C., Reinsborough, M., Rose, N., 2018. The integrated ethics and society programme of the Human Brain Project: reflecting on an ongoing experience. J. Responsible. Innov. 5 (1), 13–37. https://doi.org/10.1080/23299460.2017.1331101.

Akhtar, N., et al., 2021. Modification of the water quality index (WQI) process for simple calculation using the multi-criteria decision-making (MCDM) method: a review. Water 13 (7), 905. https://doi.org/10.3390/w13070905.

Akiyama, A.A., et al., 2022. Framing water policies: a transdisciplinary study of collaborative governance; the Katari River Basin (Bolivia. Water 14 (22), 3750. https://doi.org/10.3390/w14223750.

Alliance for Global Water Adaptation (2025) *AGWA.*(Accessed: 17 May 2025)⟨https://www.alliance4water.org⟩.

Alliance for Water Stewardship (2023) About AWS'.(Accessed: 17 May 2025)⟨https://a4ws.org/about/⟩.

Associated Programme on Flood Management (2020) 'About'(Accessed: 20 May 2025)⟨https://www.floodmanagement.info/about-apfm/⟩.

Belmont Forum (2017) 'About', 30 March.(Accessed: 17 May 2025)⟨https://belmontforum.org/about⟩.

Blue Peace (n.d) *Water Diplomacy and Mediation.*(Accessed: 17 May 2025)⟨https://www.thebluepeace.org/water-diplomacy⟩.

Brandt, P., et al., 2013. A review of transdisciplinary research in sustainability science. Ecol. Econ. 92, 1–15. https://doi.org/10.1016/j.ecolecon.2013.04.008.

Brdar, M., Brdar-Szabó, R., 2024. When medical eponyms become false friends, and how to deal with them. Engl. Specif. Purp. 73, 75–94. https://doi.org/10.1016/j.esp.2023.10.005.
Brennan, M., et al., 2021. Conceptualising global water challenges: a transdisciplinary approach for understanding different discourses in sustainable development. J. Environ. Manag. 298, 113361. https://doi.org/10.1016/j.jenvman.2021.113361.
Callaos, N. (2022) 'Trans-Disciplinary Communication, Education, and Meta-Education', in *International Institute of Informatics and Systemics - IIIS*. USA.
Choi, B.C.K., Pak, A.W.P., 2006. Multidisciplinarity, interdisciplinarity and transdisciplinarity in health research, services, education and policy: 1. Definitions, objectives, and evidence of effectiveness'. Clin. Invest. Med. 29 (6), 351–364.
Circle of Blue (2025) 'About Circle of Blue'.(Accessed: 17 May 2025)⟨http://www.circleofblue.org/about/⟩.
Cortes Arevalo, V.J., et al., 2023. Drivers and barriers to knowledge exchange through an envisioned online platform for transdisciplinary research projects. Environ. Sci. Policy 147, 201–214. https://doi.org/10.1016/j.envsci.2023.06.009.
Dahlstrom, M.F., 2014. Using narratives and storytelling to communicate science with nonexpert audiences. Proc. Natl. Acad. Sci. 111 (ement_4), 13614–13620. https://doi.org/10.1073/pnas.1320645111.
Delta Alliance (n.d) *About*.(Accessed: 17 May 2025)⟨http://www.delta-alliance.org/about-delta-alliance⟩.
Deutsch, S., et al., 2023. Transdisciplinary transformative change: an analysis of some best practices and barriers, and the potential of critical social science in getting us there. Biodivers. Conserv. 32 (11), 3569–3594. https://doi.org/10.1007/s10531-023-02576-0.
Direção-Geral do Território (2025) *TER-AGUA - Planeamento integrado | DGT*, *dgTerritório*.(Accessed: 20 May 2025).⟨https://www.dgterritorio.gov.pt/investigacao/projetos/TER-AGUA⟩ .
Directorate-General for Agriculture and Rural Development (n.d) *H2Oliva, Innovation for Agriculture*.(Accessed: 17 May 2025)⟨https://inovacao.rederural.gov.pt/26-alteracoes-climaticas-riaac-agri/1857-h2oliva⟩.
Dreyer-Gibney, K., et al., 2024. Responding to the UN sustainability goals in transdisciplinary partnership through network action learning. Environ. Dev. Sustain. 26 (12), 31757–31788. https://doi.org/10.1007/s10668-024-04664-9.
Dŵr Uisce Project (n.d) *Dŵr Uisce Home*, DWR.(Accessed: 17 May 2025)⟨https://www.dwr-uisce.eu/home-1⟩.
EcoAdapt (n.d) *Resources*.(Accessed: 17 May 2025)⟨https://www.ecoadapt.org/resources⟩.
Empreendedor (2023) 'Direção-Geral de Agricultura apoia inovação na gestão de recursos hídricos', 2 January.(Accessed: 20 May 2025)⟨https://www.empreendedor.com/direcao-geral-de-agricultura-apoia-inovacao-na-gestao-de-recursos-hidricos/⟩.
Engineering For Change (2025) 'About E4C'.(Accessed: 17 May 2025)⟨http://www.engineeringforchange.org/about/⟩.
ETH Zürich Transdisciplinarity Lab (2025) *About Us*, *USYS TdLab*(Accessed: 17 May 2025)⟨https://tdlab.usys.ethz.ch/about.html⟩.
European Commission (2025a) *Water*, *Water Research and Innovation*.(Accessed: 17 May 2025)⟨https://research-and-innovation.ec.europa.eu/research-area/environment/water_en⟩.
European Commission (2025b) *Water Framework Directive*.(Accessed: 20 May 2025)⟨https://environment.ec.europa.eu/topics/water/water-framework-directive_en⟩.
Felt, U., et al., 2016. Transdisciplinary Sustainability Research in Practice: Between Imaginaries of Collective Experimentation and Entrenched Academic Value Orders. Science technology & human values.
Fischer, C., et al., 2024. Communication tools and their support for integration in transdisciplinary research projects. Humanit. Soc. Sci. Commun. 11 (1), 120. https://doi.org/10.1057/s41599-024-02607-3.
Fleming, A., et al., 2021. Reflections on integrated research from community engagement in peatland restoration. Humanit. Soc. Sci. Commun. 8 (1), 1–11. https://doi.org/10.1057/s41599-021-00878-8.
Future Earth (2025) 'Open Call: Finance and Economics Knowledge-Action Network (KAN)'. ⟨https://futureearth.org/2020/05/26/open-call-finance-and-economics-knowledge-action-network-kan/⟩ (Accessed: 17 May 2025).
Gallois, S., et al., 2024. Learning to collaborate within transdisciplinarity: internal barriers and strengths of an art–science encounter. Sustain. Sci. 19 (4), 1345–1358. https://doi.org/10.1007/s11625-024-01495-5.
General Assembly, 2015. Transforming our world: The 2030 Agenda for Sustainable Development. United Nations. ⟨https://undocs.org/en/A/RES/70/1⟩. Accessed: 16 May 2015).
Gerace, A., et al., 2015. Perspective taking and empathy: does having similar past experience to another person make it easier to take their perspective? J. Relatsh. Res. 6, e10. https://doi.org/10.1017/jrr.2015.6.
Global Alliance for Inter- and Transdisciplinarity (2025) *ITD-Alliance*, *Home*.(Accessed: 17 May 2025)⟨https://itd-alliance.org/⟩.
Global Environment Facility (2025) *Home | GEF*, *The GEF*.(Accessed: 20 May 2025)⟨https://www.thegef.org/⟩.
Global Research Council (2025) *2023 Meeting | GRC*, *2023 Annual Meeting*.(Accessed: 17 May 2025)⟨https://globalresearchcouncil.org/meetings/annual-meetings/2023-meeting/⟩.
Global Water Futures (2025) *Global Water Futures*, *Global Water Futures*.(Accessed: 17 May 2025)⟨https://gwftest.usask.ca/index.php⟩.
Global Water Partnership (n.d) *GWPO GWP*, *Global Transformation Agenda on Water Investments*.(Accessed: 17 May 2025)⟨https://gwpo-gwp.org/⟩.
Gobierno de México (n.d) *Infografi_a_Compromisos_por_el_agua*, *Acuerdo Nacional por el Derecho Humano al Agua y la Sustentabilidad*.(Accessed: 20 May 2025)⟨https://www.gob.mx/cms/uploads/attachment/file/960137/Infografi_a_Compromisos_por_el_agua.pdf⟩.
Gray, C.M. *et al.* (2016) 'Instructional Strategies for Incorporating Empathy in Transdisciplinary Technology Education', in. ASEE's 123rd Annual Conference & Exposition, New Orleans, LA, June 26-29., New Orleans, La: American Society for Engineering Education., p. Paper ID #14934.
Grzybowski, C., 2010. For an integrative theory for understanding the reality. Psychol. Study 15, 373–379. https://doi.org/10.1590/S1413-73722010000200016.
Hartel, T., et al., 2019. Mainstreaming human and large carnivore coexistence through institutional collaboration. Conserv. Biol. 1256–1265, 6th edn.
Heering, P., 2010. False friends: what makes a story inadequate for science teaching? Interchange 41 (4), 323–333. https://doi.org/10.1007/s10780-010-9133-0.
Herrera, B., Callenius, C., Knierim, A., 2023. Transdisciplinary research projects approach in GFE: concepts and tools. Research Centre for Global Food Security and Ecosystems, Stuttgart, Germany, p. 128.
Hirsch, G.B., Levine, R., Miller, R.L., 2007. Using system dynamics modelling to understand the impact of social change initiatives. Am. J. Community Psychol. 39 (3–4), 239–253. https://doi.org/10.1007/s10464-007-9114-3.
Hoffmann-Riem, H., 2008. Idea of the Handbook. In: Hadorn, G.H. (Ed.), Handbook of Transdisciplinary Research. Springer, Bern, Switzerland, pp. 3–17.
Hydro Nation International Centre (n.d) *Hydro Nation Scholars Programme*, *Hydro Nation Scholars Programme*. ⟨https://www.hydronationscholars.scot/scotland-hydro-nation⟩ (Accessed: 17 May 2025).
International Commission on Irrigation and Drainage (2022) *Home (ICID)*, *International Commission on Irrigation & Drainage*. ⟨https://icid-ciid.org/home⟩ (Accessed: 20 May 2025).
International Hydrological Programme, 2015. *Ecohydrology Web Platform*, *Ecohydrology Demonstration Sites, IHP UNESCO*. ⟨http://www.ecohydrology-ihp.org/demosites/#about-eh-platform⟩. Accessed: 20 May 2025).
International Institute for Applied Systems Analysis (2025) *IIASA*, *IIASA - International Institute for Applied Systems Analysis*. ⟨http://iiasa.ac.at/⟩ (Accessed: 17 May 2025).
International Science Council (n.d) 'What is transdisciplinary science?', *Transdisciplinary Science*. ⟨https://council.science/theme/transdisciplinary-science/⟩ (Accessed: 17 May 2025).
International Society for Transdisciplinary Engineering (n.d) 'Past Conferences', ISTE. ⟨https://intsoctransde.org/past-conferences/⟩ (Accessed: 17 May 2025).
International Sustainable Campus Network, 2021. Charter - ISCN, Charter 2018Accessed: 17 May 2025)⟨https://international-sustainable-campus-network.org/charter/⟩.
International Union of Geological Sciences, 2025. What is IUGS?IUGS(Accessed: 20 May 2025)⟨https://www.iugs.org/history⟩.
International Water Management Institute (2025) *IWMI: Home Page*, *International Water Management Institute (IWMI)*. ⟨https://www.iwmi.org/⟩ (Accessed: 20 May 2025).
International Water Resources Association, 2019. IWRA Home. International Water Resources Association. ⟨https://www.iwra.org/⟩. Accessed: 20 May 2025.
International WaterCentre (2025) *Homepage*, *International WaterCentre*. ⟨https://watercentre.org/⟩ (Accessed: 20 May 2025).
Intertidal Melides (2023) 'Projetos', *Intertidal Melides*. ⟨https://intertidalmelides.org/projetos/⟩ (Accessed: 20 May 2025).
IWRM Action Hub (2025) 'Explained', *IWRM Action Hub*. ⟨https://iwrmactionhub.org/about/iwrm-explained⟩ (Accessed: 20 May 2025).
Jahn, T., Bergmann, M., Keil, F., 2012. Transdisciplinarity: Between mainstreaming and marginalization. Ecol. Econ. 1–10.
Jiang, J.-Q., 2018. Occurrence of microplastics and its pollution in the environment: a review. Sustain. Prod. Consum. 13, 16–23. https://doi.org/10.1016/j.spc.2017.11.003.
Khatriÿ, N., Tyagi, S., 2015. Influences of natural and anthropogenic factors on surface and groundwater quality in ruraland urban areas'. Front. Life Sci. 8 (1), 22–39.
Khorram-Manesh, A., Burkle Jr, F.M., Goniewicz, K., 2024. Pandemics: past, present, and future: multitasking challenges in need of cross-disciplinary, transdisciplinary, and multidisciplinary collaborative solutions. Osong. Public Health Res. Perspect. 15 (4), 267–285. https://doi.org/10.24171/j.phrp.2023.0372.
Klein, J.T., 2008. Evaluation of interdisciplinary and transdisciplinary research. Am. J. Prev. Med. 35 (2), S116–S123. https://doi.org/10.1016/j.amepre.2008.05.010.
Lang, D.J., et al., 2012. Transdisciplinary research in sustainability science: practice, principles, and challenges. Sustainability Sci. 7 (1), 25–43.
Laursen, B., et al., 2024. Toolkitting: an unrecognized form of expertise for overcoming fragmentation in inter- and transdisciplinarity. Humanit. Soc. Sci. Commun. 11 (1), 1–10. https://doi.org/10.1057/s41599-024-03279-9.
Lencastre, M.P.A., 2008. Transdisciplinarity and Good Science: Bruno Latour's Contribution to a New Understanding of the Links between Science. Knowledge and Society 146–155.
Lim, V.-C., , 2021. 'Eliciting local knowledge of ecosystem services using participatory mapping and Photovoice: a case study of Tun Mustapha Park, Malaysia'Villamayor-TomasS.PLOS ONE16e025374010.1371/journal.pone.0253740.
Living Lakes Network (2022) 'Home - Living Lakes Network', *Living Lakes*, 11 November. ⟨https://livinglakes.org/⟩(Accessed: 20 May 2025).
Messerli, B., Messerli, P., 2008. 'From Local Projects in the Alps to Global Change Programmes in the Mountains of the World: Milestones in Transdisciplinary Research. In: Hadorn, G.H., et al. (Eds.), Handbook of Transdisciplinary Research. Dordrecht. Springer, Netherlands, pp. 43–62. https://doi.org/10.1007/978-1-4020-6699-3_3.
Misra, S., Lotrecchiano, G.R., 2018. Transdisciplinary communication: introduction to the special issue. Informing Sci. Inter. J. Emerg. Trans. 21, 41–50.
Mistry, Ayalaxshmi, Berardi, A., 2016. Bridging Indigenous and scientific knowledge. Am. Assoc Adv. Sci. 1274–1275. https://doi.org/10.1126/science.aaf1160.
MIT Solve (n.d) *Scalable Social Impact Solutions & Grassroots Innovation for Global Challeng, Solve*. ⟨https://solve.mit.edu/impact⟩ (Accessed: 17 May 2025).

Morchain, D., et al., 2019. Building transformative capacity in southern Africa: surfacing knowledge and challenging structures through participatory vulnerability and risk assessments. Action Res. 17 (1), 19–41. https://doi.org/10.1177/1476750319829205.
Mukherjee, S., Sundberg, T., Schütt, B., 2021. Issues, Dimensions and Approaches of Assessing Urban Water Security in Developing and Emerging Countries: An Inclusive Perspective. In: Sikdar, P.K. (Ed.), Environmental Management: Issues and Concerns in Developing Countries. Springer International Publishing, Cham, pp. 151–184. https://doi.org/10.1007/978-3-030-62529-0_9.
Nicolescu, B., 1996. La Transdisciplinarité: Manifeste. Édition du Rocher, Monaco.
Nicolescu, B., 1997. The transdisciplinary evolution of the university condition for sustainable development'. International Congress. Universities' Responsabilities to Society. Responsabilities to Society, Chulalongkorn University. International Association of Universities, Bangkok, Thailand.
O'Neill, M., et al., 2019. Cohort learning: supporting transdisciplinary communication and problem-solving skills in graduate STEM researchers'. Int. J. Teach. Learn. High. Educ. 31 (1), 166–175.
One Planet Summit (2024) *One Water Summit*. ⟨https://oneplanetsummit.fr/en/events-16/one-water-summit-287⟩ (Accessed: 20 May 2025).
Organisation for Economic Co-operation and Development (n.d) *OECD Water Governance Initiative*, OECD. ⟨https://www.oecd.org/en/about/programmes/oecd-water-governance-initiative.html⟩ (Accessed: 20 May 2025).
Pacific Institute, 2025. Our Approach. Pacific Institute. ⟨https://pacinst.org/our-approach/⟩. Accessed: 20 May 2025).
Pereira, L., et al., 2020. Transformative spaces in the making: key lessons from nine cases in the Global South. Sustain. Sci. 15 (1), 161–178. https://doi.org/10.1007/s11625-019-00749-x.
Peukert, D., Vilsmaier, U., 2021. Collaborative design prototyping in transdisciplinary research: an approach to heterogeneity and unknowns. Futures 132, 102808. https://doi.org/10.1016/j.futures.2021.102808.
Piaget, J., 1972. In: Berger, G., Briggs, A., Michaud, G. (Eds.), The epistemology of Interdisciplinary relationships. ERIC.
Presidência da República, Casa Civil, and Subchefia para Assuntos Jurídicos, 1997. Pol. ítica Nac. De. Recur. H. ídricos. ⟨https://www.planalto.gov.br/ccivil_03/leis/l9433.htm⟩ (Accessed: 13 May 2025.
Public World, 2025. Freshwater Action Network. Public World. ⟨https://publicworld.com/about-us/clients-partners/freshwater-action-network/⟩. Accessed: 17 May 2025).
Ramsar Convention Secretariat (2025) *Home page*, *The Convention on Wetlands, The Convention on Wetlands*. ⟨https://www.ramsar.org/⟩ (Accessed: 20 May 2025).
REACH Programme, 2024. *Home*, *REACH: Improving water security for the poor*. ⟨https://reachwater.uk/⟩. Accessed: 20 May 2025).
Resilience Alliance (n.d) *RA - About*. ⟨https://www.resalliance.org/about⟩ (Accessed: 16 May 2025).
Rittel, H.W.J., Webber, M.M., 1973. Dilemmas in a general theory of planning. Policy Sci. 4 (2), 155–169. https://doi.org/10.1007/BF01405730.
Robasky, K., et al., 2020. How to Launch Transdisciplinary Research Communication. RTI Press, Charlottesville, VA, USA, p. 7. https://doi.org/10.3768/rtipress.2020.rb.0022.2004.
Royal Academy of Engineering (n.d) *International Programmes*, *RAEng*. ⟨https://raeng.org.uk/programmes-and-prizes/programmes/international-programmes⟩ (Accessed: 17 May 2025).
Santa Fe Institute (2024) *About SFI*. ⟨https://www.santafe.edu/about/overview⟩ (Accessed: 17 May 2025).
Schroeder, M.J., 2022. Multidisciplinarity, interdisciplinarity, and transdisciplinarity: the tower of babel in the age of two cultures. Philosophies 7 (2), 26. https://doi.org/10.3390/philosophies7020026.
Shin, D., 2018. Empathy and embodied experience in virtual environment: to what extent can virtual reality stimulate empathy and embodied experience? Comput. Hum. Behav. 78, 64–73. https://doi.org/10.1016/j.chb.2017.09.012.
Siegmund-Schultze, M., Köppel, J., Sobral, M. do C., 2018. Unraveling the water and land nexus through inter- and transdisciplinary research: sustainable land management in a semi-arid watershed in Brazil's Northeast. Reg. Environ. Change 18 (7), 2005–2017. https://doi.org/10.1007/s10113-018-1302-1.
Stanford Woods Institute for the Environment (n.d) *About Us*, *Our Mission: To advance global sustainability through new knowledge and practical, fair solutions to pressing environmental challenges*. ⟨https://woods.stanford.edu/about/about-us⟩ (Accessed: 17 May 2025).
Stockholm International Water Institute (2025a) *About ICWC: International Centre for Water Cooperation*, *SIWI - Leading expert in water governance*. ⟨https://siwi.org/international-centre-for-water-cooperation/about-icwc⟩ (Accessed: 20 May 2025).
Stockholm International Water Institute (2025b) 'What we do', *SIWI - Leading expert in water governance*. ⟨https://siwi.org/what-we-do/⟩ (Accessed: 20 May 2025).
Sustainable Sanitation Alliance (n.d) *Home*, *SuSanA*. ⟨https://www.susana.org/⟩ (Accessed: 20 May 2025).
td-net (2025) *About*, *Network for Transdisciplinary Research*. ⟨https://en.transdisciplinarity.ch/about-td-net⟩ (Accessed: 17 May 2025).
Tengö, M., et al., 2014. Connecting Diverse Knowledge Systems for Enhanced Ecosystem Governance: The Multiple Evidence Base Approach. AMBIO 43 (5), 579–591. https://doi.org/10.1007/s13280-014-0501-3.
Thames21 (n.d) 'About us', *Thames21*. ⟨https://www.thames21.org.uk/about-us/⟩ (Accessed: 17 May 2025).
The Water Project (2025) *The Water Promise*, *The Water Project*. ⟨https://thewaterproject.org/water-promise⟩ (Accessed: 20 May 2025).
Tufts Institute of the Environment (2025) *Water Diplomacy Track | MS in Sustainable Water Management*, *Tufts University*. ⟨https://swm.tufts.edu/tracks-curriculum/water-diplomacy-track⟩ (Accessed: 20 May 2025).
UNC Water Institute (n.d) *Clean Water. Global Health. Powered by Science*. ⟨https://waterinstitute.unc.edu/⟩ (Accessed: 20 May 2025).
UNESCO (n.d a) *Engineering Report*. ⟨https://www.unesco.org/en/basic-sciences-engineering/report⟩ (Accessed: 17 May 2025).
UNESCO (n.d b) *Water education for sustainable development: a global synthesis*, UNESDOC Digital Library. ⟨https://unesdoc.unesco.org/ark:/48223/pf0000215884⟩ (Accessed: 20 May 2025).
United Nations (n.d) *About UN-Water*. ⟨https://www.unwater.org/about-un-water⟩ (Accessed: 20 May 2025).
United Nations (2024) *Progress on Transboundary Water Cooperation – 2024 Update*. ⟨https://www.unwater.org/publications/progress-transboundary-water-cooperation-2024-update⟩ (Accessed: 20 May 2025).
United Nations Educational, Scientific and Cultural Organization (n.d) *Water security*. ⟨https://www.unesco.org/en/water⟩ (Accessed: 17 May 2025).
UN-Water GLAAS (2025) *UN-Water Global Analysis and Assessment of Sanitation and Drinking-Water*, *WHO*. ⟨https://www.who.int/teams/environment-climate-change-and-health/water-sanitation-and-health/monitoring-and-evidence/wash-systems-monitoring/un-water-global-analysis-and-assessment-of-sanitation-and-drinking-water⟩ (Accessed: 20 May 2025).
USGS (n.d) *About | U.S. Geological Survey*. ⟨https://www.usgs.gov/centers/pacific-islands-water-science-center/about⟩ (Accessed: 20 May 2025).
Vienni-Baptista, B., Pohl, C.E., 2023. Exploring interdisciplinarity and transdisciplinarity as knowledge regimes: a heuristic tool for disentangling understandings in academia and policy. Sci. Technol. Hum. Values. https://doi.org/10.1177/01622439231216789.
Von Wehrden, H., et al., 2019. Interdisciplinary and transdisciplinary research: finding the common ground of multi-faceted concepts. Sustain. Sci. 14 (3), 875–888. https://doi.org/10.1007/s11625-018-0594-x.
Wang, J., Aenis, T., Siew, T.F., 2019. Communication processes in intercultural transdisciplinary research: framework from a group perspective. Sustain. Sci. 14 (6), 1673–1684. https://doi.org/10.1007/s11625-019-00661-4.
Water Bucket (2025) 'About Us', *The Partnership*. ⟨https://waterbucket.ca/about-us/⟩ (Accessed: 20 May 2025).
Water Integrity Network (n.d) *Home*. ⟨https://www.waterintegritynetwork.net⟩ (Accessed: 20 May 2025).
Water Resilience Coalition (n.d) 'A CEO-led initiative committed to reducing water stress by 2050'. ⟨https://ceowatermandate.org/resilience/⟩ (Accessed: 20 May 2025).
Water, Peace and Security (n.d) *About*. ⟨https://waterpeacesecurity.org/info/our-approach⟩ (Accessed: 20 May 2025).
WaterAid (n.d) *We change lives | WaterAid Global*. ⟨https://www.wateraid.org/⟩ (Accessed: 20 May 2025).
Wezel, A., et al., 2009. Agroecology as a science, a movement and a practice. A review. Agron. Sustain. Dev. 29 (4), 503–515. https://doi.org/10.1051/agro/2009004.
Wilmer, H., et al., 2025. Collaborative adaptive management in the greater yellowstone ecosystem: a rangeland living laboratory at the us sheep experiment station. Sustainability 17 (7), 3086. https://doi.org/10.3390/su17073086.
Wognum, N., et al., 2019. Transdisciplinary systems engineering: implications, challenges and research agenda. Int. J. Agil. Syst. Manag. 12 (1), 58. https://doi.org/10.1504/IJASM.2019.098728.
World Bank (2025) *Global Water Security & Sanitation Partnership*, *GWSP*. ⟨https://www.worldbank.org/en/programs/global-water-security-sanitation-partnership⟩ (Accessed: 17 May 2025).
World Bank Group (2025) *Water*. ⟨https://www.worldbank.org/en/topic/water⟩ (Accessed: 20 May 2025).
World Federation of Engineering Organizations, 2025. About us. WFEO. ⟨https://www.wfeo.org/about-us/⟩. Accessed: 17 May 2025).
World Health Organization (2025) *The WASH vision and mission*, *Water Sanition and Helth*. ⟨https://www.who.int/teams/environment-climate-change-and-health/water-sanitation-and-health/about⟩ (Accessed: 20 May 2025).
World Health Organization and United Nations Children's Fund (n.d) *About the JMP*, *Wash - Water, Sanitation and Hygiene*. ⟨https://washdata.org/how-we-work/about-jmp⟩ (Accessed: 20 May 2025).
World Health Organization and United Nations Children's Fund (2017) *Progress on drinking water, sanitation and hygiene: 2017 update and SDG baselines*. World Health Organization (WHO) and the United Nations Children's Fund (UNICEF): Anna Grojec (NLM, WA 670).
World Resources Institute, 2025. Aqueduct. ⟨https://www.wri.org/aqueduct⟩. Accessed: 17 May 2025).
World Water Assessment Programme (n.d) *About the World Water Assessment Programme*. ⟨https://www.unesco.org/en/wwap/about⟩ (Accessed: 20 May 2025).
World Water Council (2021) *A world event*. ⟨https://www.worldwatercouncil.org/en/world-event⟩ (Accessed: 20 May 2025).
World Water Council (2025) *Home*. ⟨https://www.worldwatercouncil.org/en⟩ (Accessed: 20 May 2025).