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Ancestral sociohydrology: Transforming water research by learning from multiple ways of knowing, relating to, and governing water

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Abstract

The contemporary scientific concept of the hydrological cycle emerged within a positivist paradigm, historically serving the interests of state-led development and colonial expansion. This legacy positioned water primarily as a resource to be measured, extracted, and controlled – an ontology that has contributed, directly and indirectly, to the planetary crises of climate change and environmental degradation. While sociohydrology has advanced the field by including human and cultural dimensions, it remains largely rooted in positivist onto-epistemology that separate humans from nature. To achieve a sustainable and just coexistence on a living planet, we critically examine the colonial foundations of hydrological knowledge and embrace onto-epistemological pluralism, as a more transformative concept toward equitable relationships with and benefit from water. Drawing from place-based onto-epistemologies and their practices of ancestral hydro-technologies, we propose new ways to re-imagine our understanding of hydrology based on an onto-epistemological pluralism, incorporating multiple values, cultural norms, and identities. With this work, we launch an open reflection to pluralize narratives and corresponding illustrative archetypes of how human-water feedback are conceived, portrayed and known. The goal of this discussion is to develop the foundation for co-creating a more suitable concept of the sociohydrological cycle, which builds on a plurality of ways of understanding and relating to water.

1. Introduction

At the heart of modern hydrology lies the concept of the hydrological cycle: a water circulation paradigm first proposed by European naturalists in the XVII century based on what was becoming "Western" Science [1,2]. The water cycle describes the balance and regularity of evaporation, precipitation, infiltration and runoff dynamics, focusing on cyclicity and constancy in water flows. This epistemological view, having historically situated roots [3,4], has informed both theoretical and practical hydrological applications worldwide. As a result, a kind of stigmatization of non-temperate, non-European water patterns developed within the scientific community, which could be termed "hydrological orientalism" [5]. This ideological attitude sees especially drylands (and the people who inhabit them) as flawed by chronic scarcity of water in the form of surface flow or accumulation. This view fails torecognize that water dynamics function according to the specific characteristics and ecologies of each place, and peoples' relationship with water depends on adapting to local hydrological dynamics, not disconnected ideas of what water availability "should" be. This imposed view legitimates the need of engineering interventions that "fix" the local riotous hydrology (and civilize the technical-social context) (Linton, 2008).

Such intellectual posturing has important repercussions for the actual infrastructure and management policies adopted by governments. It is linked to a particular way of knowing and understanding water that constrains the material and cultural fluidity of the element to an abstract, therefore socio-politically neutral, comparable and interchangeable quantity across ecological and cultural landscapes.

In response to this reductionist understanding of water, sociohydrology has emerged over the past decade as an interdisciplinary field seeking to understand the dynamic interactions between human societies and the hydrological cycle [6,7]. Its central premise is that hydrological processes cannot be understood in isolation from human behaviour, institutions, and decision-making, which in turn are shaped by and react to hydrological variability.

By coupling human-water systems, sociohydrology aims to identify mechanisms of mutual influence and adaptation across scales. However, despite this integrative ambition, sociohydrology remains largely confined within the philosophical assumptions inherited from Western hydrology, from which it originated [8]. Most modelling-based researchcontinue to treat human actions as quantifiable variables external to the hydrological system, rather than as expressions of culturally and historically situated relationships with water. As noted by Lane (2014), this creates a paradox in which society is reintroduced into hydrology yet remains objectified as a measurable input rather than a knowing and meaning-making agent [9]. Similarly, Pande and Sivapalan (2017) highlighted that sociohydrological frameworks often fail to capture the political and ethical dimensions of water management, thereby risking the depoliticization of inherently contested processes [10]. This positivist framing, while enabling formal coupling between social and physical processes, tends to obscure the diversity of worldviews, values, and moral economies that shape water relations across societies. As Rusca and Di Baldassarre (2019) argue, even participatory sociohydrological approaches often reproduce technocratic hierarchies, privileging

scientific rationality over local experience [11]. Consequently, the discipline risks reproducing, rather than challenging, the same epistemic hierarchies that underpin unsustainable and unjust water governance, and perhaps neglecting adaptive opportunities for resillience.

To advance as a truly plural and reflexive science, sociohydrology must interrogate the historical, ontological, and epistemological premises on which it rests. Here, ontology refers to assumptions about what water is (for example, resource, relation, or living being), while *epistemology refers to how water can be known*, measured, or governed. These dimensions are deeply intertwined: ways of knowing water shape ways of being with water, and vice versa. In relational and post-human scholarship, this co-constitution is often described as an onto-epistemology, highlighting that ways of knowing water and ways of relating to water evolve together [12]. In this sense, recent literature has raised the attention to a more situated and contextualised sociohydrology, such as the concept of "Grounded Sociohydrology" [13], revisiting and proposing radical changes to the approach to the discipline.

In this paper, to reinforce this call, we deliberately engage the conceptual vocabulary of sociohydrology to ensure accessibility for readers trained in positivist hydrology, while critically examining its onto-epistemological assumptions. This translational approach aims to open dialogue across disciplinary traditions rather than presupposing a shared conceptual framework. In the following sections, we examine how hydrology evolved from a colonial science of control into a capitalist science of extraction, and how this trajectory marginalised place-based water knowledges. By revisiting these pre-colonial and/or non-Western onto-epistemologies and their material expressions in ancestral hydro-technologies and livelihoods, we set the stage for re-imagining hydrology through onto-epistemological pluralism and for articulating the foundations of what we term Ancestral Sociohydrology.

2. From colonial to capitalist hydrology

Throughout history, different kinds of colonial ambitions to control people and resources gradually shifted and assumed more recognizably "modern" and "positivist" characters. One among many examples of this is the change in water laws in the Andes, from Imperial Spain's legislation that largely granted water as a public good and generally respected community water rights, to post-independence legislations that sought private control of land and water sources by creole elites [14,15]. At least since the 19th century, the universality of Western hydrological knowledge underwrote nation-building projects and often travelled with colonial expansion, legitimising large infrastructure and managerial control in the name of progress. In fact, colonialism was not only territorial, but also epistemic. Through the imposition of Western scientific paradigms, colonial powers redefined how water and land were to be understood, used, and governed [16]. Epistemological colonialism enforced a worldview in which water exists solely as a resource to be owned, measured, and controlled, rather than as a living, relational being, limiting legitimate knowledge to that produced through Western science. Together, these forms of coloniality universalised Western concepts of water and rendered other water realities invisible. For example, colonial powers replaced adaptive and mobile ways of living among pastoral and nomadic societies with fixed infrastructures and irrigation systems that aligned with state control, disrupting traditional livelihoods and ecological balance [17,18].

This epistemic colonisation continued under post-colonial nation states and potentially under contemporary development and cooperation projects, whether intentionally or not, often disguised by the language of modernisation, participation, or resilience. For example, Piemontese et al. (2024) showed how interventions designed to alleviate extreme droughts to pastoral livelihoods in Southern Angola, through small water infrastructures, might erode traditional mobility systems which support the continuation of local water and ecological knowledge. Simultaneously, interventions may concentrate grazing and land use near structures, drive ecological degradation, deteriorate the local water cycle and drive unsustainable water use [19]. Such interventions, despite being scientifically sound within a positivist paradigm, might reproduce the colonial logic of fixity and control. These can be a mismatch for local social and ecological realities, resulting in resource scarcity and deterioration. Such interventions exemplify how even well-intentioned adaptation strategies can perpetuate the same epistemological hierarchies that caused vulnerability in the first place. Epistemic colonisation

thus persists not necessarily through coercion, but through the (often) unquestioned authority of Western hydrological knowledge.

Recent works call to decolonise hydrology, tracing how colonial and post-colonial regimes continue to shape methods, curricula, and governance, and urging plural, justice-oriented alternatives [20]. Such works focus on the need of restoring an epistemic justice, primarily by acknowledging the historical role of colonization on the disruption of place-basedwater knowledge systems, and addressing the presence of neo-colonial dynamics and entities, with a reflexive approach [21,22].

Recio (2024) describes this way of conceiving water as resources as "monetised epistemology", which sees water as something that can be spent, saved, invested and wasted [23]. Such epistemological view of water is deeply embedded in modern governance frameworks and continues to shape the global water agenda promoted by institutions such as the World Bank and United Nations. Within this logic, sustainability is often equated with optimization, financialisation and market regulation of the water resource [24,25]. The monetised epistemology drives the view of water as an abstract, universal substance – modern H_2O – divorced from its relational, cultural, and ecological dimensions [26].

By contrast, non-monetised water epistemologies – often rooted in place-based knowledge systems – conceive water as relational, communal, and moral, thus socially constructed [3,23]. In these frameworks, water is not an object of ownership but a member of the community, a being that coexists with humans, animals, spirits, and landscapes. Studies in political ecology and hydrosocial theories have shown that such epistemologies are grounded in reciprocity, responsibility, and collective well-being [27,28]. They articulate what might be called a hydrology of belonging, in which knowing water means recognising the relationships that constitute life itself. Knowledge is not control but coexistence, not measurement but care.

3. Ancestral, place-based water knowledge

Water knowledge paradigms are as numerous and varied as the peoples and cultural milieus that express them. Nonetheless, based on the historical-epistemological processes outlined above, some considerations can be made on how to group and assess them. For example, Linton (2010) makes a distinction between *modern water* and *traditional waters* [26]. The former is the hydrological substance rooted in Western positivist science and its political and managerial corollaries, it is thought of and represented more as "a fixed thing rather than a principle or process out of which things occur" (ivi: 4) and rests on the assumption that all water can be reduced to an abstract quantity of fluid, hence conceivable and manageable apart from its socio-ecological context and relations (ivi: 13). To the abstraction of this kind of water, one can oppose the inescapably relational and dialectical character of *traditional waters*, which do not correspond to mere H_2O units but to entire sociopolitical arrangements that allow water to assume all the values a societyassigns to it. From this perspective, society and water are seen as relationally forging each other. In terms of political praxis, this latter understanding of waters implies the necessity of people's bodily engagement with and participatory decision-making regarding their waters, as opposed to leaving watery matters in the hands of technicians and bureaucrats (ivi: 236).A semantic caveat is needed here: the use of the terms "traditional" and "ancestral" should not suggest that these sets of knowledge and practices are static or necessarily ancient. What constitutes "tradition" is a matter of debate within academic disciplines and among the wider public, but despite its vulgar, face-value connotations it can be argued that a key attribute of traditions is their redefinition, adaptation and even re-invention over time [29,30]. What we mean by characterizing practices and knowledge as "ancestral" is tying them to the relationships communities build with their landscapes and livelihoods, hence our preference for the term "place-based" knowledges, to subsume other related notions. Such relationships and the knowledge that emerges from them are passed through generations and their content changes according to transforming needs, opportunities, and aspirations. In the case of water knowledge, practices, and systems, their "traditional" or "ancestral" character is based on the fact that they are rooted in a dialogical relationship with the past, the land and the people inhabiting it, as opposed to conventional hydrology and water engineering that sees water as a mere, a-political and a-relational resource.

Across diverse cultural contexts, place-based knowledge systems articulate principles that resonate with contemporary ecological thought based on relational ontologies, which sees relationships between entities more important than their own existence [31]. For example, in different African cultures, Ubuntu expresses an ethic of interdependence (*I am because we are)* linking human existence to social and ecological harmony, and a relationship of reciprocity, not only between people, but also between people and the rest of nature [32,33].

In Canada, kinship ecology as developed by many First Nations communities frames all beings – humans, animals, waters, ancestors – as relatives bound by reciprocal obligations [28]. Several Andean ethnohistorical and ethnographical accounts depict a "circulatory cosmos" in which water represents the principal conduit of vitality but where all beings (humans, animals, plants, landscape features) partake, through living and dying, to the accumulation and dispersal of the universal flow [34]. Rituals such as communal drinking and the "feeding" of mountains and other non-humans materialize and reinstate the recognition that reciprocity links all things and those social dynamics - hence human agency and actions - are also an essential part in the circulation of water/life [35]. These and other traditions articulate a relational ontology where the distinction between nature and culture dissolves, and reciprocity generates shared benefits for people and ecosystems alike [36].

These examples are presented as cross-cultural illustrations of relational water onto-epistemologies and do not imply equivalence across diverse place-based knowledge systems. Place-based water onto-epistemologies are grounded in specific territories, governance structures, and knowledge protocols, and cannot be generalised or abstracted from their cultural and political contexts.

Sociohydrology aims to capture these relations through holistically conceiving and sometimes modelling humans as integral parts of nature in a linked human-water system. Yet, despite its interdisciplinary ambition, it often remains anchored in positivist epistemologies that treat social behaviour external variables as interacting with hydrological processes [22]. Incorporating place-based water onto-epistemologies, such as Ubuntu or kinship ethics into sociohydrological study, the interactions and relationships between water and people can be understood in a more complete rather than reductionistic way. We name this Ancestral Sociohydrology. Such an approach allows for a fuller understanding of dynamics and more appropriate approaches to water governance. Water would no longer be a parameter but a participant – a being that co-produces social organisation and environmental symphonic complexity.

4. Inherited ways of knowing and being, water technologies and livelihoods based on dialogue with water

Contemporary water governance frameworks increasingly acknowledge place-based knowledge systems, yet they often remain constrained by rational–colonial perspectives. Place-based views are often included as data sources or consultation inputs, while the underlying onto-epistemological assumptions of governance – water as resource, humans as managers – remain intact. This instrumental inclusion risks reinforcing the very hierarchies it seeks to overcome [37].

Integrating place-based knowledge within sociohydrology thus requires rethinking what "systems" mean. For example, in many place-based ecologies, systems are not mechanistic but moral. Water is not seen as a resource to be exploited and managed but an element that sustains life – a social norm in which individuals contribute to and benefit from cooperation, accountability and mutual responsibility [38]. Recognizing that economies are not always transactional but can also be moral and creating the opportunity to embedperspectives into sociohydrological frameworks could transform them from predictive tools into spaces of dialogue between scientific and place-based worldviews – more integrated and accurate understandings of water and human-water dynamics can emerge. A principle common to many place-based onto-epistemologies is the notion of respecting water and the landscape around it, recognizing the relationship between the two. This ontological stand is seen in continued traditional practices and land uses, which translates into hydro-technologies, and the shaping of waterscapes, deeply integrated into local ecologies. As described by Maddrell and Terry (2019), such respect is not a metaphor but a design principle: infrastructures are built to cooperate with natural processes,

not to dominate them [39]. Such approaches create a virtuous cycle, minimising drought and flood extremes, supporting ecosystem function, and, consequently, benefit the humans that have implemented them [38].

Ancestral hydro-technologies – *tapes*, *jessour, acequia, amuna* systems, to name a few – embody this relational design [40,41]. They enhance groundwater recharge, prevent erosion, and sustain livelihoods without isolating water from its landscape. These systems are hydrologically efficient and ecologically regenerative, precisely because they arise from a worldview that does not commodify water [42,43]. For instance, the *jessour* system in Tunisia is created with a series of small dams built across an ephemeral riverbed, which generates a succession of terraces that can retain ephemeral water flows and sediments, fostering sustainable agricultural niches that also foster local biodiversity [44,45]. Such structures are deeply rooted in the local traditions, based on the use of non-perennial flows, traditional building knowledge, locally available materials, and the concentration of runoff to restore ecological niches in the landscape. Remarkably, in Tunisia, these techniques were also at the core of the political activity of leftist politician and activist Slaheddine El Amami, that focused on traditional knowledge [46].

Another example comes from the Zapotec of Oaxaca, Mexico, showing how cultural values of reciprocity can facilitate sustained collective action to address emerging water hazards, even when the interventions used are novel. For the Zapotec, reciprocity is woven into daily life with cooperative shared work, collective efforts for celebrations, and governance in which all families directly participate [47]. As in other ancestral cultures, there is an understanding that if the people take care of the water, the water takes care of the people [47]. Facing extended drought conditions, 26 Zapotec communities self-organized into two unrelated civil society associations (respectively located in the middle and lower areas of the catchment) to recharge depleted groundwater. There were legends (and archaeological indications) that their ancestors had once done something similar, however there was no modern precedent of using such interventions [47]. Each association took a different approach to finding a solution. In one association, leaders visited the Museo del Agua in the neighbouring state of Puebla to learn about possible interventions. The other association integrated environmental engineering and watershed restoration principles into local landcare. The solution that both groups found was low-tech, low-cost, and ecologically-regenerative small-scale managed aquifer recharge (s-MAR), which slows overland flows to increase infiltration, effectively mitigating soil and hydrological drought. Increased hydrological flows have been sustained through community-level action, based in community values of reciprocity, for two decades: water is understood to not be for individual extractive gain, but for shared benefit for the community, for upcoming generations, and to help the river to flow, now and in the future. These considerations apply more broadly where land uses and dwelling patterns are adapted to local hydrology. In contrast to an onto-epistemology of control, people collectively work with water, as an act of reciprocity between water and people, and between people, having learned to move and change their livelihoods according to the availability, absence, and temporality of water sources. Such hydro-dialogical strategies include both landscapes that periodically undergo an excess of water, e.g., through heavy rainfall and inundation, and those experiencing acute drought and water sources scarcity [48].

5. Re-imagining hydrology through onto-epistemological pluralism

While knowledge co-creation and transdisciplinarity are often presented as inherently progressive, critical scholarship reminds us that they may also reproduce the same dynamics that produced the problem in the first place [49]. Co-creation can become a technology of inclusion without transformation [37], or even an epistemic extension of colonial governance [50]. In the context of hydrology, unless place-based knowledge systems are allowed to reshape the epistemic premises of water science – rather than being subsumed within them – the risk is to perpetuate the positivist and extractive rationalities we seek to transcend.

True pluralism requires more than participatory procedures; it demands onto-epistemological dialogue – recognising that place-based, non-positivist and positivist scientific perspectives arise from different understandings, experiences, and values, not just different opinions [51]. Governance, therefore, should not aim to merge these knowledge paradigms into a single framework, but to create interfaces where they can coexist and negotiate without erasure.

This shift entails institutional humility: accepting that there is no single, universal water but many waters [52]. Each carries its own meanings, temporalities, and responsibilities. Onto-epistemological pluralism thus becomes not a theoretical luxury but a practical necessity for just and adaptive water governance. It opens space for new alliances between communities, scientists, and policymakers – alliances grounded in respect rather than assimilation.

One relevant case with which we have extensive experience is the formation of the Arctic co-management paradigm [53], and its next iteration, "Adaptive Co-management" [54].The exploitation of natural gas at Prudhoe Bay, Alaska, in 1949 fundamentally changed the relationship between Indigenous Peoples and national governments throughout the Arctic Circumpolar Region, and arguably, beyond, including contributing to constitutional protection for Indigenous rights to lands and waters in northern Canada. While gas fields and pipelines appeared to serve military and southern markets in 1949, local people had no access to the gas for their own use. One of the local Inupiat witnessing this inequity was Eben Hopson, then a young person in his 20s. By Hopson's account, it took until 1963 for local Inupiat to get approval to connect to the pipelines. Hopson's response was strategic: changing the oppressive system, giving rise to the land claims movement in Alaska, and sharing the purpose and mission of native land claims across North America - giving recognition of rights to lands and waters. Outcomes in Alaska included The Alaska Native Claims Settlement, the creation of the North Slope Borough, and the creation of the Inuit Circumpolar Conference (now the Inuit Circumpolar Council), or I.C.C., through an initial meeting in 1975 in Alaska and the first international meeting in 1980 in Nuuk, Greenland. This organization was the vehicle intended to carry Hopson's vision for an Inuit homeland into international affairs, and included elements such as demilitarization, economic and social cooperation, and indigenous rights and environmental protection through self-determination [55]. From community experience, it became clear that "culture" required a distinct voice in the formation of these knowledge and practice paradigms. Inserting culture to create social-cultural-ecological systems and drive adaptation and innovation expands resilience from local to regional scales [56].

This experience has reinforced the idea that not only is "culture" a matter of tradition and identity, it is also an evolutionary-scale force co-creating new worlds, potentially at a faster rate than formal social elements, governments, and economic systems: indeed it may be the channel most available to accessible co-creation practices for fostering social learning and transitions in scientific paradigms as well [57].

6. From place-based water knowledge to Ancestral Sociohydrology

Moving from the recognition of place-based water knowledge to the development of an ancestral sociohydrology implies a profound epistemic transformation within the discipline itself. Hydrology, as conventionally practiced, is rooted in the positivist pursuit of universal laws and predictive precision. On the other hand, ancestral sociohydrology proposes that the discipline evolve from a descriptive and predictive science into a co-creative and relational practice. It should engage multiple epistemologies to co-produce understanding and solutions that are both hydrologically sound and culturally grounded. For instance, inspired by the work on Ancestral futures by Krenak (2025), which draws from South American pre-Columbian oral traditions [58], Mendiondo et al (2025) suggest that ancestral water knowledge can be related to the co-evolution of place-based human–water models and used to better understand the feedbacks and unintended consequences of human interventions over long periods of time, called Ancestral Human–Water Feedbacks (AHWF – 54,55). Modelling AHWF could involve variables such as collective memory, ritual timing, taboos, and social reciprocity, which influence water use and resilience. These are not "soft factors" but hydrosocial drivers with measurable effects on hydrological processes. By coupling hydrological models with participatory mapping, oral histories, and narrative modelling, researchers can capture the dynamic interplay between memory, ethics, and flow [59].

Such transformation would realign hydrology with the ethics of reciprocity long embedded in ancestral practices. It would shift the discipline's purpose – from predicting to listening, from controlling to supporting [60], from extraction to regeneration. In this plural form, hydrology becomes not only a science of water but a practice of care, working with and

not against both people and landscapes. It also reminds us that we are embarked upon a continuum of learning/re-learning, and that reworking the foundational ethics of our dominant knowledge systems is a slow process.

Supporting such a transformation, within westernized systems the dichotomy of people versus nature is gradually creating space for understanding people as part of nature, and the "personhood" of specific entities in nature. This shift in paradigm is often informed by place-based knowledges of particular peoples in specific places supported by cultural practices. In Western legal thinking the acknowledgement of rights of nature has a long, poorly articulated history that has come into sharper focus at key moments since WWII. Recognition of rights and/or personhood as a pathway to rights, has been argued by diverse voices, including a U.S. Supreme Court Justice, speaking of trees [61], the New Zealand Legislature, in recognition of a Māori mountain ancestor [62], and in Canada, protecting a river, the Mutuhekau Shipu (Magpie River) by recognizing its legal personhood, a move initiated by the Innu Council of Ekuanitshit and Minganie Regional County Municipality in 2021 [63], to recognize but a few. The Supreme Court of Colombia's recognition of the legal rights of the Amazon is an example of a different order in terms of scale and complexity [64].

In these examples, we begin to see the slow emergence in Western thought of a bridging recognition that the old human/nature dichotomy is fading, and a renewal of the deep sense of continuum and interconnectivity is occurring that there is a growing understanding that water flows within us, just as our actions certainly flow within water [65].

Moreover, although we are only beginning - through the critical support of emergent conceptual models informing AHWF and its convergent flows of information - within Western thought a suspicion awakes that water itself has "agency" - that water is "alive", although perhaps operating with scales and logics and feedback less familiar to our ordinary methods and apparatus. However, if we are prepared to entertain the possibility of culture as an evolutionary force, as a dynamic and living process outside of standard command and control models, here we can perhaps find space to recognize both the diversity and unity of life beyond and including the human, and also the possibility of understanding water not as "subaltern" in Said's sense of this term [66], but rather as a co-creator of our collective future, with agency and identity? As the backbone of the continuum of life?

Being open to emergent possibilities will remain a necessary and fruitful path for visioning alternative 'water centred' futures - including a fundamental shift in Western understanding of right relationships with water and with nature as a whole.

7. A Call to Plural action

We advance a strategic call to reimagine and pluralize the scientific understanding of the hydrological cycle by integrating non-positivist, place-based knowledge systemsalongside positivist science as an open, evolving, complex system. Such an approach exemplifies "two-eyed seeing" as presented by Mi'kmaw Elder Murdena Marshall and Elder Albert Marshall [67]: Place-based and Western sciences see the same reality through two different eyes. Instead of diluting place-based knowledge by incorporating it into Western science, "two-eyed seeing" recognises and weaves together these different views of the same challenges and paths toward solutions [33]. While we critique the limitations of thecapital-driven and colonially-rooted hydrological paradigm, highlighting its roots in nation-building and its contribution to unsustainable water exploitation and environmental degradation, we also draw from a rich body of indigenous research and literature to propose "ancestral sociohydrology" as a constructivist, value-oriented framework that recognizes water as an agent with its own vitality, value, history, and wisdom [52,68,69]. This shift challenges the anthropocentric and utilitarian paradigms - particularly those shaped by colonial and technocratic worldviews - that falsely separate people from nature and have long defined water management. Within such frameworks, water has been rendered passive – an inert resource awaiting human control and optimization.

Recognizing water as an agent reframes hydrology as a relational and ethical science that acknowledges the reciprocal interactions between human and non-human actors. Thus, allowing hydrology to make space for ancestral place-based cosmologies as well as contemporary systems of values and beliefs which view water as a living being that sustains,

communicates and remembers. Such perspectives decentre Western hierarchies of knowledge and open pathways for intercultural dialogue in water governance. Relationships grounded in reciprocity rather than extraction, and in humility rather than domination. It marks an ontological turn in hydrological thought, positioning culture and ethics as essential currents in the ongoing remaking of our shared water futures.

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References

1. Jarwar MA, Dumontet S, Pasquale V. The Natural World in Western Thought. Challenges. 2024;15(1):17. https://doi.org/10.3390/challe15010017
2. Sillitoe P. Local Science Vs Global Science: Approaches to Indigenous Knowledge in International Development. 1st ed. Berghahn Books. 2009. https://doi.org/10.2307/j.ctt9qdfbm
3. Linton J. Is the Hydrologic Cycle Sustainable? A Historical–Geographical Critique of a Modern Concept. Annals of the Association of American Geographers. 2008;98(3):630–49. https://doi.org/10.1080/00045600802046619
4. Nagheeby M, Mason O, Dajani M, Hussein H. Decolonizing water diplomacy for justice: Conceptual reflections and policy implications. Environ Secur. 2025;3(4):610–22. https://doi.org/10.1177/27538796251362284
5. Clifford J. Review of Orientalism. Hist Theory. 1980;19(2):204–23. https://doi.org/10.2307/2504800
6. Herrera-Franco G, Montalván-Burbano N, Carrión-Mero P, Bravo-Montero L. Worldwide research on socio-hydrology: A bibliometric analysis. Water. 2021;13(9):1283. https://doi.org/10.3390/w13091283
7. Sivapalan M, Savenije HHG, Blöschl G. Socio-hydrology: A new science of people and water. Hydrol Process. 2012;26(8):1270–6. https://doi.org/10.1002/hyp.8426
8. Sivapalan M, Konar M, Srinivasan V, Chhatre A, Wutich A, Scott CA, et al. Socio-hydrology: Use-inspired water sustainability science for the Anthropocene. Earth's Future. 2014;2(4):225–30. https://doi.org/10.1002/2013ef000164
9. Lane SN. Acting, predicting and intervening in a socio-hydrological world. Hydrol Earth Syst Sci. 2014;18(3):927–52. https://doi.org/10.5194/hess-18-927-2014
10. Pande S, Sivapalan M. Progress in socio-hydrology: a meta-analysis of challenges and opportunities. WIREs Water. 2016;4(4). https://doi.org/10.1002/wat2.1193
11. Rusca M, Di Baldassarre G. Interdisciplinary critical geographies of water: capturing the mutual shaping of society and hydrological flows. Water. 2019;11(10):10. https://doi.org/10.3390/w11101973
12. Franklin A, editor. The Routledge International Handbook of More-than-Human Studies. London: Routledge; 2023. 486 https://doi.org/10.4324/9781003262619
13. Zwarteveen M, Barreteau O, Ogilvie A, Kuper M, Venot JP. A situated proposal for a grounded approach to socio-hydrology. J Hydrol. 2026;667:134828. https://doi.org/10.1016/j.jhydrol.2025.134828
14. Chipana Rivera R. La cultura del agua y riego en la Bolivia prehispánica y el legado indeleble del reino de España: una mirada desde el Sur. Bol Real Acad Córdoba Cienc Bellas Let Nobles Artes. 2021;100(170):367–410.
15. Hines ST. Water for All: Community, Property, and Revolution in Modern Bolivia. 1st ed. University of California Press. 2022. https://doi.org/10.2307/j.ctv2j6xf3d

16. Hommes L, Hoogesteger J, Boelens R. (Re)making hydrosocial territories: Materializing and contesting imaginaries and subjectivities through hydraulic infrastructure. Polit Geogr. 2022;97:102698. https://doi.org/10.1016/j.polgeo.2022.102698
17. Juul K. Tubes, tenure and turbulence: The effects of drought related migration on tenure issues and resource management in northern Senegal. Münster: LIT Verlag. 2005.
18. Little PD. Social differentiation and pastoralist sedentarization in northern Kenya. Africa. 1985;55(3):243–61. https://doi.org/10.2307/1160579
19. Piemontese L, Terzi S, Di Baldassarre G, Menestrey Schwieger DA, Castelli G, Bresci E. Over-reliance on water infrastructure can hinder climate resilience in pastoral drylands. Nat Clim Chang. 2024;14(3):267–74. https://doi.org/10.1038/s41558-024-01929-z
20. Octavianti T, Chun KP, Bradford L, Reeves M, Nagheeby M, Olusola AO, et al. Decolonising hydrology: reflecting on positionalities for sustainable and fair futures. In: SSRN Scholarly Paper, 2025. https://doi.org/10.2139/ssrn.5238761
21. Hartwig LD, Jackson S, Markham F, Osborne N. Water colonialism and Indigenous water justice in south-eastern Australia. International Journal of Water Resources Development. 2021;:1–34. https://doi.org/10.1080/07900627.2020.1868980
22. Castelli G, Howard BC, Adyel TM, AghaKouchak A, Agramont A, Aksoy H, et al. Co-creating water knowledge: a community perspective. Hydrol Sci J. 2025;70(16):2899–919. https://doi.org/10.1080/02626667.2025.2571065
23. Recio AM. Aesthetic-epistemological contradiction in the concept of water: a necessary reformulation for life. Etikk Praksis - Nord J Appl Ethics. 2024;18(1):1. https://doi.org/10.5324/eip.v18i1.5590
24. Menga F. Thirst: The global quest to solve the water crisis. https://aisberg.unibg.it/handle/10446/304305 2025. 2026 January 13.
25. Nagheeby M, Mdee A, Amezaga J, Heller L, Nicol A, Pena-Varon MR, et al. Escaping the Capitalist Black Hole: dethroning Mammon and liberating water. Third World Quarterly. 2026;47(3):614–28. https://doi.org/10.1080/01436597.2025.2592658
26. Linton J. What is water?: The history of a modern abstraction. University of British Columbia Press. 2023. https://doi.org/10.59962/9780774817035
27. Boelens R, Perreault T, Vos J. Water justice. Cambridge: Cambridge University Press. 2018. https://doi.org/10.1017/9781316831847
28. Wilson NJ, Inkster J. Respecting water: Indigenous water governance, ontologies, and the politics of kinship on the ground. Environment and Planning E: Nature and Space. 2018;1(4):516–38. https://doi.org/10.1177/2514848618789378
29. Hobsbawm E, Ranger T. The invention of tradition. Cambridge: Cambridge University Press. 2012. https://doi.org/10.1017/CBO9781107295636
30. Sahlins M. On the anthropology of modernity; or, some triumphs of culture over despondency theory. 2008. https://doi.org/10.22459/CSDP.04.2005.03
31. West S, Haider LJ, Hertz T, Mancilla Garcia M, Moore M-L. Relational approaches to sustainability transformations: walking together in a world of many worlds. Ecosystems and People. 2024;20(1). https://doi.org/10.1080/26395916.2024.2370539
32. Mabele MB, Krauss JE, Kiwango W. Going back to the roots: Ubuntu and just conservation in southern Africa. Conserv Soc. 2022;20(2):92–102.
33. Diver S, Vaughan M, Baker-Médard M, Lukacs H. Recognizing "reciprocal relations" to restore community access to land and water. Int J Commons. 2019;13(1). https://doi.org/10.18352/ijc.881
34. Gose P. The Andean circulatory cosmos. The Andean World. Routledge. 2018.
35. Jennings J. Drinking together: continuity and change in the Andean world. The Andean World. Routledge. 2018.
36. Mehltretter S, Bradford A, Longboat S, Luby B. In a good way: Braiding indigenous and western knowledge systems to understand and restore freshwater systems. Water. 2024;16(7):934. https://doi.org/10.3390/w16070934
37. Turnhout E, Metze T, Wyborn C, Klenk N, Louder E. The politics of co-production: participation, power, and transformation. Curr Opin Environ Sustain. 2020;42:15–21. https://doi.org/10.1016/j.cosust.2019.11.009
38. Basel B, Aslekar U, Hernández Quiroz N, Kulkarni H, Piemontese L, Velasco Herrera R, et al. How humans bend the hydrograph: experiences in mitigating drought through small-scale managed aquifer recharge. International Journal of Water Resources Development. 2026;:1–32. https://doi.org/10.1080/07900627.2025.2602533
39. Maddrell A. Mapping the visible and invisible topographies of place and landscape through sacred mobilities.The psychology of religion and place: Emerging perspectives. Cham: Springer International Publishing. 2019. p. 131–44. https://doi.org/10.1007/978-3-030-28848-8_7
40. Ochoa-Tocachi BF, Bardales JD, Antiporta J, Pérez K, Acosta L, Mao F. Potential contributions of pre-Inca infiltration infrastructure to Andean water security. Nature Sustainability. 2019;2(7):584–93. https://doi.org/10.1038/s41893-019-0307-1
41. Carrión P, Briones J, Herrera G, Sánchez C, Limón J. Practical Adaptations Of Ancestral Knowledge For Groundwater Artificial Recharge Management Of Manglaralto Coastal Aquifer, Ecuador. In: WIT Transactions on Ecology and the Environment, 2018. https://doi.org/10.2495/sdp180341
42. Ancient Water Technologies. SpringerLink. https://link.springer.com/book/10.1007/978-90-481-8632-7 2026 January 13.
43. Saidani M, Aslekar U, Kuper M, Kemerink-Seyoum J. Sharing difficult waters: Community-based groundwater recharge and use in Algeria and India. Water Altern. 2023;16:108–33.
44. Piras F, Zanzana A, Costa Pinto LM, Fiore B, Venturi M. The role of the jessour system for agrobiodiversity preservation in Southern Tunisia. Biodivers Conserv. 2022;31(10):2479–94. https://doi.org/10.1007/s10531-021-02286-5
45. Castelli G, Oliveira LAA, Abdelli F, Dhaou H, Bresci E, Ouessar M. Effect of traditional check dams (jessour) on soil and olive trees water status in Tunisia. Sci Total Environ. 2019;690:226–36. https://doi.org/10.1016/j.scitotenv.2019.06.514 PMID: 31288114

46. Ajl M. Auto-centered development and indigenous technics: Slaheddine el-Amami and Tunisian delinking. The Journal of Peasant Studies. 2018;46(6):1240–63. https://doi.org/10.1080/03066150.2018.1468320
47. Basel B, Hernández Quiroz N, Velasco Herrera R, Santiago Alonso C, Hoogesteger J. Bee mietii rak rkabni nis (The people know how to seed water): A Zapotec experience in adapting to water scarcity and drought. Clim Dev. 2021;13(9):792–806. https://doi.org/10.1080/17565529.2020.1855100
48. Semplici G, Campbell T. The revival of the drylands: re-learning resilience to climate change from pastoral livelihoods in East Africa. Clim Dev. 2023;15(9):779–92. https://doi.org/10.1080/17565529.2022.2160197
49. Swedlow B. Cultural coproduction of four states of knowledge. Sci Technol Hum Values. 2012;37(3):151–79. https://doi.org/10.1177/0162243911405345
50. Tuck E, Yang KW. Decolonization is not a metaphor. Decolonization Indig Educ Soc. 2012;1(1).
51. Nakamura S, Kreibich H, Haeffner M, Mukherjee J, Di Baldassarre G, Sakamoto M, et al. Expanding and mainstreaming sociohydrology toward transdisciplinary praxis. Front Water. 2025;7. https://doi.org/10.3389/frwa.2025.1629905
52. Linton J, Budds J. The hydrosocial cycle: Defining and mobilizing a relational-dialectical approach to water. Geoforum. 2014;57:170–80. https://doi.org/10.1016/j.geoforum.2013.10.008
53. Doubleday NC. Co-management provisions of the Inuvialuit Final Agreement. Co-operative management of local fisheries: New directions for improved management and community development. University of British Columbia Press. 1989. 209–27.
54. Armitage DR, Plummer R, Berkes F, Arthur RI, Charles AT, Davidson-Hunt IJ. Adaptive co-management for social–ecological complexity. Front Ecol Environ. 2009;7(2):95–102. https://doi.org/10.1890/070089
55. Weeks N. Northern Development Political Change. In: Byers RB, Slack M. Strategy and the Arctic. Toronto: Canadian Institute of Strategic Studies. 1986.
56. Armitage D, Berkes F, Doubleday N. Adaptive co-management: Collaboration, learning, and multi-level governance. Vancouver: UBC Press. 2007.
57. Boschman R, Trono M. Culture as Vector: (Re)Locating Agency in Social-Ecological Systems Change. On Active Grounds: Agency and Time in the Environmental Humanities. Waterloo: Wilfrid Laurier University Press. 2019. 327–47. https://doi.org/https://doi.org/10.51644/9781771123402-016
58. Krenak A. Ancestral future. Cambridge: Polity Press. 2024.
59. Piemontese L, Castelli G, Limones N, Grazio A, Bresci E. Large-scale siting of sand dams: A participatory approach and application in Angolan drylands. Land Degrad Dev. 2022;34(3):844–58. https://doi.org/10.1002/ldr.4500
60. Zwarteveen M, Domínguez-Guzmán C, Kuper M, Saidani A, Kemerink-Seyoum J, Cleaver F. International Journal of the Commons. 2024;18(1). https://doi.org/10.5334/ijc.1350
61. Should Trees Have Standing? Law, Morality, and the Environment. Environment & Society Portal. https://www.environmentandsociety.org/mml/should-trees-have-standing-law-morality-and-environment 2015. 2026 January 13.
62. A New Zealand mountain is granted personhood, recognizing it as sacred for Māori. https://apnews.com/article/mountain-zealand-personhood-maori-taranak-590fca0f3d648cc0bf86d970782e954c 2025. 2026 January 13.
63. This Canadian river is now legally a person. It's not the only one. https://www.nationalgeographic.com/travel/article/these-rivers-are-now-considered-people-what-does-that-mean-for-travelers 2026 January 13.
64. International Union for Conservation of Nature. Colombian Supreme Court Recognizes Rights of the Amazon River Ecosystem. https://iucn.org/news/world-commission-environmental-law/201804/colombian-supreme-court-recognizes-rights-amazon-river-ecosystem 2018. 2026 January 13.
65. Fox CA, Reo NJ, Turner DA, Cook J, Dituri F, Fessell B. The river is us; the river is in our veins: re-defining river restoration in three Indigenous communities. Sustain Sci. 2017;12(4):521–33. https://doi.org/10.1007/s11625-016-0421-1
66. Said EW. Orientalism. London: Routledge and Kegan Paul. 1978.
67. Wright AL, Gabel C, Ballantyne M, Jack SM, Wahoush O. Using two-eyed seeing in research with Indigenous people: An integrative review. Int J Qual Methods. 2019;18:1609406919869695. https://doi.org/10.1177/1609406919869695
68. Barad K. Meeting the universe halfway: Quantum physics and the entanglement of matter and meaning. Duke University Press. 2007. https://doi.org/10.2307/j.ctv12101zq
69. Bennett J. Vibrant Matter: A Political Ecology of Things. Duke University Press. 2020. https://doi.org/10.1515/9780822391623