Heterodox Thinking on Water Economics, Values and Governance

by

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Abstract

Global water crises are, finally, near the top of the agendas at the United Nations and multi-lateral initiatives and organizations. A social sciences and humanities informed emerging literature, we call 'Heterodox Thinking', offers alternatives to much of the current decision-making on water. Rooted in water economics, values and governance, Heterodox Thinking comprises developments in non-market valuation, systems thinking, risk assessments and mitigation, infrastructure investments, and understanding injustices and relationality. It is characterized by the Three P's: People (e.g., who has voice and power and who does not); Place (e.g., locally informed and justice-based); and Planet (e.g., systems interconnections, risks, ecological and non-human considerations). At its best, Heterodox Thinking is informed by on-the-ground evidence and multiple disciplines/knowledge and seeks to value water, expose power imbalances, support human rights/well-being, and mitigate system risks. If effectively operationalized, it delivers more equitable, risk-mitigated and sustainable responses to the many different and localized water crises.

1. INTRODUCTION

The United Nations (UN) 2023 Water Conference, and its successor scheduled for December 2026, mark high points in terms of the attention paid to water by political leaders (1). According to the then President of the UN General Assembly, Csaba Kőrösi, a key message of the 2023 Water Conference was that "the global water cycle is a global common good", (2, p.1), signifying that water is a shared resource that provides multiple benefits to many people. Treating water as a global common good originated in Interactive Dialogue 5 of the Water Conference. This UN Dialogue highlighted that the global water cycle is currently out of balance, prioritized the benefits of mobilization of finance, especially for infrastructure, and stressed the importance of pricing and valuing water correctly.

Commonly, water is characterized as a local public good, and as a global public good when in the atmosphere (3) because it is non-exclusive and non-rival. Water, however, can also be a private good (e.g., captured in water storages, bottled water) and a common-pool resource (e.g., rivers and aquifers) where its use is rivalrous and exclusion difficult and/or costly. A growing literature emphasizes that a lack of safe access (4) and degradation of water sources (e.g., catchments) are primarily a result of relational and governance failures (5).

An emerging social sciences and humanities informed literature on water economics, values and governance, that we label 'Heterodox Thinking', provides diagnoses and responses to 'too much, too little and too dirty' water (6) different from much of the current practices and decision-making on water (7). We contend that Heterodox Thinking provides valuable insights about the causes and sustainable responses to the many water crises. It comprises perspectives on preferred socio-economic-outcomes, water governance, and the values and valuation of water in support of pathways to achieve Sustainable Development Goal (SDG) 6 targets, including 'Clean Water and Sanitation for All'.

Heterodox Thinking highlights that there is no singular (e.g., global water cycle out of balance) world water crisis. There are, in truth, multiple crises of different magnitudes with various causes that manifest in many ways across numerous places. That is, water crises play out primarily at the local scale (e.g., catchment level) with responses and feedbacks across multiple scales. When global considerations matter, at least for the present, they are dominated by virtual water, chiefly food trade (8), rather than changes to the global water cycle.

We first review values and the valuation of water. This framing supports an understanding of the systems and risks around water, and how some risks can be managed with grey (built) infrastructure such as urban drainage systems, desalination plants, irrigation canals, and green (natural) infrastructure, such as floodplains and wetlands (9). Our review also focuses upon two neglected but important areas of Heterodox Thinking: justice and well-being; and relationality, or how we connect via relationships and diverse values with people, place, and planetary considerations of water (see **Figure 1**). We conclude with key messages that highlight emerging insights on water economics, values and governance.

2. VALUES AND VALUING WATER

As water crises intensify globally—manifested through scarcity, pollution and inequitable access, as well as extreme floods, storms and droughts—more nuanced, transparent and inclusive approaches are required to understand, measure, govern, manage and communicate water's diverse values (10, 11).

Today's water valuation methods were founded in economics—governed by concepts such as utility maximization—but have since broadened to multi-disciplinary framings that put water values and water valuation at the intersection of economics, governance and ethics (12). Recent practical developments in water valuation include more sophisticated stated and revealed preference methods, advanced spatial and temporal data analysis, the valuation of damages and losses, the growing use of natural capital accounting, and an alignment with the broader sustainable development agenda (13, 14, 15).

Heterodox Thinking highlights challenges in embedding plural values into policy, responding to inequities, and integrating valuation tools with the complex socio-political realities of water governance (16). While valuation research initiatives are becoming more technically sophisticated, their perceived high cost, time, and complexities raise concerns over their usefulness in practical decision-making (17), as do inadequate resources to support research uptake by policymakers (18).

2.1. Defining Values

Debates around water values are central to the UN 2021 World Water Development Report (19) which built upon The Bellagio Principles for Valuing Water (20). These principles describe five distinct, but interconnected aspects of valuing water: sources, infrastructure, services, productive inputs, and socio-cultural attributes.

Notwithstanding these principles, diverse views remain around ‘water values’ — some of which are contested across different socio-cultural and disciplinary contexts (11).

A common misunderstanding is that price and value are equivalent. Price is what needs to be paid or exchanged to access water and/or water services where, all else equal, the higher the price the less is demanded. Value, by comparison is not about exchange but, instead, encompasses the intrinsic, not necessarily monetizable, water benefits and/or services embedded in multiple individual and societal values, both tangible and intangible (21). This is an important distinction and is consistent with the view that the process of valuing water should be shaped by societal, historical, religious, aesthetic and cultural values.

Decisions about water are influenced by water-related values including underlying personal and governance-related convictions (22). Exploring these perceptions, a study (23) adopted a sociological lens to show that people’s engagement with water (e.g., through hydration, hygiene, comfort, and care) influences their ‘value’, and that tension and trade-offs arise between functional (e.g., meeting one’s needs) and ethical considerations (e.g., caring for others’ needs and the environment).

Heterogeneities in water were highlighted in a study (24) across gender, class, and ethnicity—underscoring the need for representative justice and to value pluralism in water policy (25), especially with respect to long-standing Indigenous values. ‘Relational values’ have become increasingly prominent in the published literature, although uptake by decision-makers has been low. Relationality recognizes connections that humans have with nature, and with each other, that are largely separate from instrumental value (not substitutable) and are embedded in ethical frameworks (26), history, lived experiences, place-based identities, Indigenous ontologies and collective responsibilities (25, 27, 28, 29). Alongside, relational value framings, environmental and water justice perspectives are becoming more prominent, highlighting how disparities in water distribution, processes and recognition shape how water is considered and who and what are prioritized (5, 30).

2.2. Monetary Valuation of Water

The 1989 Exxon Valdez oil spill led to the US National Oceanic and Atmospheric Administration's (NOAA) 'Blue Ribbon' Panel that provided guidelines about the practice of stated preferences approaches (31). The 'stated preferences' literature investigates preferences for hypothetical improvements. A different body of work examines valuation using 'revealed preferences' methods, including 'averting behaviour', and methods employed in 'damage assessment' (32). Valuation methods include the public willingness-to-pay to repair or avoid environmental damages (33). Damage estimates can also be framed as 'willingness-to-accept' a certain payment to compensate for a reduction in utility from a given change, relative to the status quo (34). For example, a landmark study of the BP oil spill in the Gulf of Mexico quantified the injuries to natural assets at US$17.2 billion (35).

Key recent developments in water valuation include a focus on ensuring clean water access for human wellbeing. This includes a study of the preferences of Australian residents for a program to improve drinking water quality for up to 260,000 Australians in remote communities (36). The study found a willingness to pay of AU$5.4 to AU$33.2 billion for better water quality over 10 years by the entire Australian population, highlighting strong public support for mitigating inequities in safe drinking water access among underprivileged and historically underserved communities. A different Australian study estimated that households would be willing to pay an aggregate of AU$74.5 million for a modest (5%) reallocation of irrigation water to Aboriginal communities for environmental, cultural and agribusiness purposes in the Murray-Darling Basin (37). In another study (38), it was estimated that over three-quarters of households in the United States (US) would be willing to pay upwards of US$22 per household to finance a water pipeline that would allow the Hopi Tribe to maintain their traditional culture and way of life. A positive willingness to pay for improved water services for the disadvantaged has also been estimated in Bangladesh (39), among other countries.

Valuation studies increasingly account for characteristics of service provision, especially aspects related to the reliability and performance of water delivery systems (40). It was found that residents in Canada would be willing-to-pay between CA$46-$71 annually to halve their risk of short-term water outages (41). In Guatemala, it was estimated (42) that rental prices decreased by 0.7% with every day of water supply interruptions—while home units equipped with water storage infrastructure attracted a 10% higher rental price. Other hedonic price studies have found positive associations between real estate prices and the quality and access to freshwater bodies and aquifers (43, 44, 45).

Besides drinking water access, water valuation is applied to water changes in the natural environment (e.g., rivers or lakes) for non-consumptive purposes—recreation, cultural practices, or support for water-dependent ecosystems (46). As an example, the value of ecosystem services in the Yellow River Basin, China, was assessed to be circa US$266 billion in 2020, and it was estimated that US$18 billion in ecological compensation could be allocated to upstream areas with high ecological values but lower economic capacity (47). In Jakarta, Indonesia, urban riparian (green) corridors for a river were valued using multiple approaches, including stated preferences methods (48). The study found low-income residents valued river services that were at risk of being lost from proposed policy changes around restricted access to green corridors.

Valuation studies can help identify public priorities for specific waterbody improvements. In a recent study from Aotearoa New Zealand (49), a choice experiment was used to assess preferences for improvements of nutrient levels, clarity, and bacterial contamination of river waters. The study found an overall value of NZ$115 million annually for a national policy delivering moderate improvements in river water quality. Similarly, at a local scale, Melbourne (Australia) residents were willing to pay up to AU$37 million for a 10% reduction in the number of urban waterways in poor ecological and amenity conditions (50). In the US, the Environmental Protection Agency supported a substantial body of work to estimate the benefits of the US Clean Water Act. This research has valued improved water quality using multiple methods, especially stated preference methods and benefit transfer approaches (51).

The estimation of losses and damages is crucial to support effective responses to floods, droughts, or infrastructure failures, and for evaluating the value of adaptation strategies—such as insurance schemes—to reduce vulnerability and build resilience (52, 53). One study (54) found that wetland losses significantly increased property damages from flooding and a rise in claims to the US National Flood Insurance Program. The authors estimated the cost to society from one hectare of lost wetland to be US$1,840 on average, and up to US$8,000 in high-density areas. Such assessments are important in the context of climate change and environmental degradation, including cases where long-term damages are incurred by future generations (55).

2.3. Water Accounting

Growing interest in water and natural capital accounting (NCA) reflects a recognition that sustainability, in part, requires an understanding of the links between environmental change and the market economy (56). Such links are formalized in the System of Environmental Economic Accounting – Ecosystem Accounting (SEEA-EA) framework that provides standardized guidelines to connect environmental assets and services with economic activities (57). Many SEEA-EA applications involve water accounts. Water accounting, which seeks to represent the stocks and flows of water within and between the hydrological system and the economy (56), highlights the dependencies of economic activities on ecosystems (58).

The concept of water accounting was advanced in a study (59) that demonstrated how sustainable use of groundwater resources can increase the long-term wealth of a region through increased agricultural productivity. Building on this work, data from Panama was used to examine the complementarity between natural and produced capital, challenging the long-standing notion that the various forms of capital are substitutes for each other (60).

Water accounting is not without challenges, such as standardization of measures, and suffers from limited integration of NCA into policy and decision-making (61). A practical limitation of water accounting lies in its handling of non-market values (56). Nevertheless, a proposed set of indicators has been developed to represent the spiritual and relational values that First Nations peoples associate with land and water (62)—

values that cannot be integrated into standard national accounts but can be used alongside them.

Recent advances have sought to bridge the gap between accounting and valuation to support more robust water accounting (63). In one study (64), the zonal travel cost method estimated the monetary value of nature-based recreation by linking potential visits to high-quality recreational areas with travel costs. Given that travel costs are observable, these can be used as a proxy for the exchange value of recreation and then be included in SEEA-EA tables of monetary flows as a replacement cost approach based on actual costs. New approaches show how stated preference techniques can be used to provide simulated exchange values (65). In sum, while water accounting and valuation serve different purposes, both offer practical ways to value water (66).

3. UNDERSTANDING SYSTEMS AND RESPONDING TO RISKS

Water resources systems, including stormwater management, flood protection and water security measures, are connected components of surrounding complex systems such as the biosphere, society, economy, climate and geopolitics. Climate change and population growth are increasing the complexity of the multiple scale interactions and feedbacks between water resources and surrounding systems (67).

Key, recent contributions to systems thinking highlight both the challenges and opportunities hitherto hidden by mainstream and, typically, siloed thinking. At its best, systems thinking and methods explicitly consider cumulative spatial and temporal effects of current and alternative policy pathways. In this context, 'top down and mean-focused' analyses have been shown to frequently misinform (68), while generalized, rather than fit-for-purpose, assessments constrain what is considered important and what may be excluded, thereby jeopardizing the effectiveness of proposed solutions (67). For instance, heuristic and short-term focused responses to flooding or droughts—based on long-term historical experiences or data—may result in ineffective and less than robust actions to dynamic and system-wide changes (68).

Key identified risks for water include governance challenges, hydro-political tensions, socio-economic inequalities, and climatic changes, all of which can affect billions of people. One risk that needs effective mitigation is the decline in terrestrial water storage in multiple and important food-producing regions due to overextraction and, increasingly, climate change (69). This decline is expected to increase both the frequency and severity of water stress episodes (70). A second key risk is the intensification of extreme precipitation and floods within the seasonal cycle of water availability (71).

Global water demand continues to rise, driven primarily by agriculture and industrial consumption despite large regional variations. Irrigated agricultural land has been expanding by nearly 1% each year, much of it in already water-stressed countries such as India and China, thereby intensifying unsustainable freshwater use and food security risks (72). Increases in urban water demand are projected to result in over a quarter of the world's major cities confronting water deficits, including 'Day Zero Events' when water becomes severely rationed and/or unavailable from conventional sources, with hotspots in the Mediterranean, Southern Africa and Western North America (73). Human interventions—including some land-use changes—can alleviate scarcity in particular upstream areas but potentially at the expense of exacerbating water shortages downstream (74). Overall, current trends, including the increasing use of water for cooling (e.g., AI data centres) underscore the growing pressures on water systems (75), and the importance of regionally tailored strategies to balance competing water demands.

3.1. Increasing Risks: Scarcity, Extreme Quantity and Poor Water Quality

High-resolution monthly analyses reveal that nearly two-thirds of the world's population—half of them in regions in China and India— experience severe water scarcity for at least one month each year, while about half a billion people face such scarcity year-round (76). Global water demand is increasing (77) and projections from multiple climate models suggest that by 2050 between 0.5 and 3.1 billion people could be newly exposed to water scarcity due to climate change, with uncertainties especially pronounced in South and East Asia (78). Probabilistic analyses further indicate that both the median severity of water scarcity and the range of uncertainty are increasing globally, posing serious threats to biodiversity, food security, and human wellbeing (79).

Changes in atmospheric moisture fluxes amplify both wet and dry events, driving an intensification of precipitation extremes and increasing the risk of short-term water quantity crises (80). Drought, understood in mainstream thinking as primarily a deficit in precipitation, soil moisture, or water storages, must now be conceptualized as a multidimensional process embedded within coupled human–water systems (81). Heterodox Thinking on anthropogenic droughts emphasizes the interplay of natural variability, climate change, and water extractions on water management outcomes (82).

Earth system model simulations suggest that extreme droughts, more than mild or moderate events, will increasingly disrupt global vegetation productivity and the carbon cycle, with projections indicating a tripling of drought-related impacts on gross primary production by the late twenty-first century, compared to historical baselines (83).

Similarly, declines in terrestrial water storage increase the land area and population exposed to exceptional drought conditions. These projections underscore the urgent need for a radical reassessment of climate change mitigation and the critical importance of adaptive water management (70).

Common responses to poor water quality episodes include substitution with alternative water sources, but this may increase risks of chemical and microbiological contamination (84). Water quality risks, however, are no longer limited to traditional pollutants but increasingly are viewed as being caused by uses of modern pharmaceutical and lifestyle compounds. Fertilizers, pesticides, pharmaceutical residues, and industrial byproducts have degraded water quality in many places (85) and are increasingly a global-scale concern. Contaminants, such as endocrine disrupting chemicals like per- and polyfluoroalkyl substances or PFAS (86) and microplastics, create new uncertainties and challenges whose associated health risks are only now emerging (87).

3.2. Responding to Water Security Risks

Growing pressures from climate change, rapid urbanization, and environmental degradation are intensifying risks to ‘Water Security’, defined here as the capacity of humans to have sustainable and safe access to water to achieve their full potential. Thus, climate-smart and adaptive strategies are essential for ensuring safe and reliable drinking water. A review of over 9,000 studies highlights that water security and resilience must be central to policy and practice (88). Adaptive measures — including stormwater management, wastewater reuse, water pricing, and public awareness campaigns — offer context-specific pathways to improve water management, augment supplies, and reduce demand. Wastewater reuse, including in agriculture (89) and when embedded within a circular economy, may expand the life cycle of water use and enhance water availability but needs strengthening with effective regulatory frameworks (90).

Heterodox Thinking about adaptation measures and further investments shows that risk rankings and the use of simple, purely financially motivated benefit-cost ratios across alternatives are inappropriate, by themselves, in an uncertain and dynamic world. That is, and contrary to mainstream thinking, what matters is the mitigation of risks and/or increased benefits from additional investments, and who actually receives those benefits, or who bears the costs, and not a purely financial static ranking of options based on the greatest 'bang-for-the-buck' (91)

Integrated, climate-smart approaches include multi-hazard frameworks and consider the interactions between different types of risks (e.g., integrating flood and disaster risks). They can support resilience and sustainable development, while safeguarding public health and limiting the effects of climate change and water-related risks (92). Nature-based solutions (NBS)—otherwise known as green infrastructure (wetlands, forests and aquifers used for managed recharge)—complement and possibly substitute for grey infrastructure (e.g., levees) for flood risk management. For example, coastal wetlands, if given sufficient accommodation space and sediment supply, can mitigate some of the consequences of sea-level rise and safeguard ecosystem services (93). At their best, NBS foster synergies between nature, society, and the economy, support greener urban development, and enhance resilience (94, 95).

Effective management of irrigation water is essential to respond to water risks because this sector accounts for about 70% of global freshwater withdrawals (77).

Increased irrigation efficiency is often promoted as a solution, yet a compilation of evidence from multiple studies (96) shows that higher efficiency rarely reduces overall water use unless it is paired with basin-scale water accounting, caps on extractions, and robust monitoring of irrigators' behavior (97). Without additional measures, efficiency gains can, paradoxically, result in greater water consumption as return flows decline when beneficial crop transpiration increases, and may result in rebound effects from substitution to more water intensive crops, and an increase in the irrigated areas (98).

By incorporating regulation, pricing mechanisms, and conservation measures alongside efficiency improvements, decision-makers can help to ensure that limited freshwater resources are used more productively, reallocated to urban and environmental needs, and managed in ways that enhance resilience to droughts and climate variability (99). Ultimately, integrated management approaches that recognize trade-offs, assess uncertainties, and account for irrigators' incentives are critical for mitigating water scarcity while seeking stable and profitable agricultural production systems (100).

While infrastructure (grey and green) investment is important in dealing with increased water risks, effectively responding to these challenges requires governance reform. Demand management through conservation, compliance, pricing, and behavioral change is essential to complement supply-side measures, and in many regions, formal and informal water markets can play a useful role (101). While some cities lack basic water and wastewater services, and others have well-developed infrastructure with potable water and universal access, all require long-term, integrated planning and cooperative learning systems that strengthen governance (102) and raise public awareness. Ultimately, reframing urban water governance to emphasize both.demand-side efficiency and supply-side resilience is critical to safeguarding freshwater, reducing environmental costs, and enhancing cities' adaptive capacity.

Responding to water risks must go well beyond prices and markets to include local, regional, and basin-level caps on water consumption, compliance enforcement, equitable allocation mechanisms for shared freshwater resources, and technological innovations (103). In this context, the reframing of water primarily as a financial risk is problematic because it reduces consideration of benefits from risk mitigation to prioritize quantitative measures, especially return on investment. By contrast, Heterodox Thinking highlights the benefits of multiple approaches, including experiential knowledge, to inform a comprehensive consideration of risks across multiple communities of knowledge (104). In the infrastructure that supports water markets in many countries, further beneficial innovations, if supported by effective regulatory frameworks, may include forward and option contracts, online trading platforms, and blockchain development to track water trade (103).

Remote sensing has already transformed the monitoring of evapotranspiration, a critical component of the water cycle, enabling large-scale, cost-effective estimations of water uses and consumption. Advances in data fusion, assimilation, and multi-sensor integration are further refining accuracy and reducing uncertainties (105). Global and continental-scale flood forecasting has progressed through the coupling of meteorological and hydrological models, enhanced by ensemble prediction systems and early warning soil moisture monitoring. When integrated into cloud-based platforms like Google Earth Engine, these innovations can provide cost-effective detection of soil moisture and improve the forecasting of hydrological risks (106). In sum, while mainstream thinking has helped to mitigate risks, cumulative and systemic risks are increasing, especially for the poor and already disadvantaged, which requires Heterodox Thinking.

4. CONNECTING INFRASTRUCTURES TO SOCIO-ECONOMIC OUTCOMES

Debates around the value of grey (built) water infrastructure frequently focus on financing gaps. International agencies and financiers have developed estimates of this 'gap', with the World Water Council and the OECD (107) suggesting that the financing needs in water-related infrastructure globally could be US$6.7 trillion by 2030 and US$22.6 trillion by 2050. Yet a surprising proportion of allocated funds go unspent (108).

While financial gap analysis contributes to awareness of water-related challenges, it frames the value of infrastructure as a question of providing inputs (e.g., investment) to deliver outputs (e.g., irrigation canals, water treatment plants). Such framing, however, misses the multiple outcomes that are enabled when infrastructure choices and investments are informed by Heterodox Thinking around water values (109).

4.1. Different Approaches

Water infrastructure has traditionally been viewed as consisting of built solutions – dams, pipelines and other infrastructure systems to store, desalinate, clean or distribute water. The last decade has seen a substantial increase in interest around NBS (110). This has encouraged stakeholders to broaden their view of water infrastructure, its benefits and, therefore, its value.

Heterodox Thinking has highlighted the multiple freshwater ecosystem services that green infrastructure provides for water. An increasing number of economic studies have estimated the economic benefits of, and willingness to pay for, green/natural water infrastructure projects and NBS (e.g., 111, 112, 113, 114, 115).

Notwithstanding championed projects and programs, the enthusiasm of environmental organizations, multilateral development banks, and academics for NBS, natural/green infrastructure has not yet led to a commensurate increase in, for example, waterway naturalization and catchment rehabilitation globally. This may be explained by the characteristics of NBS: the diffuse, long-term and public nature of benefits, missing markets and lack of economic valuation, knowledge gaps, governance challenges, and unequal power relations (9, 95). There are also important unanswered questions regarding the performance of NBS under increasing extreme climatic conditions (116).

Options for 'new' grey and green water infrastructure emphasize funding innovations (117). The most feasible, lower-cost options, however, involve adapting and/or reinvesting in existing water infrastructure by 're-adapting' to meet evolving needs, and climate challenges (118). These options include: (i) reoperate to generate new benefits or meet new demands, adapt to climate change, or respond to hydro-ecological shocks; (ii) rehabilitate to meet new, or to retain, desired water service requirements, reduce resource consumption; and (iii) retrofit to enable new uses of facilities, or utilization of new technologies (e.g., wastewater treatment). Valuation of existing assets can also lead to their removal. While there is growing interest in water infrastructure removal, notably dams, there is limited evidence to date on the social, environmental, and economic outcomes arising from such decisions (119).

Insufficient attention to the potential value of infrastructure upgrades or operational adjustments includes a failure to adequately consider the broader hydrological and ecological systems to which large water infrastructure projects are connected. This is surprising given the persistent popularity of approaches like Integrated Water Resources Management and Nexus thinking. More importantly, a lack of systems thinking poses serious risks to water security where investments in water-use efficiency or new water supply do not account for rebound effects (97, 98) in water demand, and where they lead to increased vulnerability from concentrating demands on a single water source (67, 120, 121).

4.2. Appraisal Frameworks to Value Water Infrastructure

Approaches connecting infrastructure to a broad range of socio-economic outcomes have evolved in the last decade. From a focus on least-cost, single-objective planning of water infrastructure, improved analytical approaches include Heterodox Thinking on quantifying costs and benefits to different water users of alternative infrastructure options, and the robustness of infrastructure investments, under alternative scenarios (122). Over the past decade, water infrastructure evaluations have evolved to better encompass equity and ecological outcomes, and to apply non-market valuation methods.

A focus on the disadvantaged in terms of access and affordability of water is increasingly being included in water system planning models—and is important for water infrastructure planning (123), as is ensuring 'Free, Prior and Informed Consent' —too often ignored with top-down decision-making. For example, in a study (124) a water resource system model was designed that fused information on Santa Cruz's (California) water infrastructure with behavioral and regulatory features. This model has been used to assess the impacts of tariff rate design on household water affordability (124).

Ecological outcomes and services are increasingly being incorporated into a range of quantitative models. For instance, a new decision framework, called eco-engineering decision scaling, compares outcomes across ‘traditional’ water infrastructure performance metrics (e.g., water supply reliability) and ecological outcomes (e.g., flow recession rates) under uncertainty (125). This practical approach connects infrastructure performance to broader societal outcomes.

A study (126) has shown how framing water management problems can impede decision-makers’ capacity to evaluate trade-offs between environmental outcomes and economic benefits. The authors highlight the benefit of a multiple-objective robust optimization framework that allows for improved identification of trade-offs under uncertainty. Others have developed computational frameworks to inform infrastructure selection under climate change (127) and deliver adaptive environmental flows—a form of green infrastructure investment—to prepare for and manage multi-year periods of water stress.

Standard valuation methods applied to water infrastructure valuation (e.g., stated and revealed preference) (111) are increasingly being accompanied by qualitative and narrative evidence on the relationship between humans, from the individual to the collective, and water. For example, Heterodox Thinking includes the use of water diaries (128), while experiential water insecurity scales (129) are being piloted in decision-making about water infrastructure investments (130). In sum, multiple approaches and Heterodox Thinking are required to ensure investments in infrastructure (grey and green), new and existing, appropriately meet the needs of the disadvantaged, effectively mitigate risks and are fit for place and purpose.

5. PROMOTING JUSTICE AND WELL-BEING

Justice is a multidimensional concept that has evolved across cultural, historical, and institutional contexts. It concerns who gets water and who does not (e.g., distributive and redistributive justice) (131, 132), and who gets to participate in decisions, and how (e.g., procedural and representation justice) (133, 134). It encompasses how past harms—particularly colonial and racialized exclusions—are acknowledged and responded to (e.g., recognition and restorative justice) (135, 136). Justice must also consider whose knowledge matters and how knowledge is included in water governance (e.g., epistemic and relational justice) (29, 137), and who is recognized (138).

Well-being is much more than a measure of absolute living standards. It depends on measures of relative affluence, material sufficiency and what opportunities are available to the disadvantaged. Well-being also includes dignity, health, cultural integrity, and ecological viability for both human and non-human communities (29, 139, 140). These conceptions challenge mainstream thinking that has not, typically, used broad-based measures of well-being for water-related decision-making (136).

Justice and well-being are not abstract ideals but practical imperatives that shape how water is accessed, managed, and valued. Three interrelated areas affect how justice and well-being are operationalized: one, efficiency-equity trade-offs in resource allocation; two, how social norms influence water-related practices; and three, the existence, or not, of just and inclusive decision-making that respects and draws from diverse knowledge systems and effectively responds to historical exclusions.

5.1. Efficiency-Equity Trade-offs in Resource Allocation

Efficiency is too often misconstrued as a neutral or apolitical principle. It is neither. Actions intended to optimize resource use—such as water markets and conservation pricing—can inadvertently deepen inequality when equity is not structurally embedded in regulatory design. Equity considerations matter and decision-making requires valuation frameworks that evaluate what happens to whom, who benefits, and who loses. To illustrate, formal and informal water markets play important roles in many countries in sharing water, increasing productivity and efficiency, aiding climate adaptation and increasing access to water. Nevertheless, formal water markets require sophisticated governance structures and many pre-conditions to achieve societal goals. Consequently, without proper oversight, they may fail to achieve economic efficiency goals while compromising equity or environmental sustainability (141).

Conservation pricing introduces another layer of complexity, especially when not implemented with lump-sum subsidies, progressive rebates or a free ‘basic’ water allowance to disadvantaged and impoverished stakeholders (103). That is, higher water prices reduce demand but if not properly implemented can easily reduce the well-being of the least well-off. For example, higher volumetric water tariffs have imposed a disproportionately greater burden on lower-income households and communities of color in Las Vegas (142). In Barcelona, demand reduction policies curbed water use the most among the poorest households (143).

Technological solutions to resolve water access are also not neutral in terms of supporting equitable outcomes. For instance, some technologies (e.g., solar-powered groundwater pumps), when embedded in unequal socio-political systems and without a systems perspective of land, water and energy uses, risk discriminating against the impoverished and reinforcing structural inequalities (144).

5.2. Cultural Drivers of Just, Inclusive Decision-making

Justice in water governance emerges not solely through legal frameworks or policy instruments, but through culturally embedded logics of reciprocity, proportionality, and collective responsibility. In Italy, for example, Catholic engagement in social activism against privatization of water services reframes water as a moral right and a public good (140). In Namibia, proportional fairness became a legitimate basis for cost-sharing, but only when supported by State institutions—revealing how moral norms and formal authority can support and co-produce legitimacy (145).

Multiple studies emphasize that communities play an active role in maintaining justice by shaping water governance through moral economies—shared norms, expectations, and informal sanctions that regulate behaviors and influence how water is valued and accessed (140, 146). Such norms function both independently and in conjunction with established legal frameworks. They can be especially important where governmental systems are inconsistent or lack effectiveness.

Just, inclusive decision-making, including dialogues (147), allows for relational and negotiated processes that center equity, legitimacy, and plural worldviews. It can reveal how water governance needs to be redesigned to accommodate distributive outcomes and promote deliberative justice (136). An example from China suggests that equitable water allocation does not have to compromise future economic performance (148).

Similarly, equity-weighted approaches to tourism and conservation might reconfigure spatial priorities, mitigating the exclusion of rural and ecologically sensitive communities from water-intensive development (149). Further, cooperative game theory can align with social justice principles to support cost-sharing mechanisms with stakeholder perceptions of fairness, such as with river basin adaptation planning (150). Such models show that justice and negotiated fairness are not simply external constraints on efficiency, but necessary conditions for its legitimacy.

Heterodox Thinking emphasizes that dialogue and ontological pluralism are not procedural add-ons for governance but transformative practices. Relational ethics also offer prescriptive values for water justice grounded in humility, reciprocity, and respect (135). Embedding diversity, equity, inclusion, and justice into water dialogues requires spaces where marginalized voices shape decisions (147, 151). In sum, to incorporate justice in water decision-making, decision-makers need to hold multiple understandings of water—as resource, relative, or Sacred Being—especially in settler colonial contexts (137) and where there is long-standing exclusion or discrimination against some groups.

6. RETHINKING RELATIONALITY

Heterodox Thinking on relationality asks what forms of human and non-human flourishing water governance should enable, and it evaluates institutions by their capacity to maintain 'living' relationships over time. The relationality literature provides practical design guidance and seeks to pluralize law and knowledge and put decision-making in People (e.g., who has voice and power and who does not), Place (e.g., locally informed and justice-based decision-making), and Planet (e.g., interconnections, non-human considerations, systemic risks).

6.1. Motivation: Should We Adopt Relational Thinking?

Worldviews (e.g., economic growth as the policy priority) that situate humans as separate from the world around them have undoubtedly contributed to improvements in average living standards. Yet they have also contributed to unsustainable trajectories (152). Heterodox Thinking, including water ecological economics perspectives grounded in complex coupled systems (5), seeks to conceptualize humans and nature as fundamentally interconnected, prioritizing multispecies–ecosystem justice (153) and operationalizing more just and sustainable outcomes.

Heterodox Thinking on relationality does not denote a singular framework but signals a broader intellectual shift spanning multiple disciplines. At its core, this shift reconceives ‘objects’, such as humans, waters, trees, and rocks, not as fixed substances or entities, but as temporary ‘events’ within ongoing flows of dynamic relationships that encompass what are conventionally distinguished as human and natural dimensions (154). That is, Heterodox Thinking on relationality inverts substantialist assumptions common in systems approaches: entities do not precede relations but rather emerge through them (155).

Relationality literature draws from several overlapping traditions. An increasing body of evidence documents that the environmental ethical frameworks of Indigenous Peoples are critical to maintaining and restoring ecosystems. These ethical frameworks are grounded in a “relational accountability through the basis of four core relational values prominent across numerous cultural contexts: integrity, respect, humility and reciprocity” (26). Here, integrity refers to honoring Indigenous laws and ethics related to stewarding ecosystems across the spectrum of relationships. Respect involves a commitment to the health and well-being of those relationships, past, present, and future. Humility is rooted in an ontology where humans and their welfare are not superior to that of others. Reciprocity is an ethic of putting back what one takes out, to ensure intergenerational sustainability for human and non-human communities.

Indigenous relational ontologies have long articulated water as kin, relative, or being. Relationality includes mutual caretaking among people through access to safe, sufficient, and culturally meaningful water (156), and reciprocity with land, waters, and all living beings, codified in governance norms, legal concepts, and ceremony (157). Feminist and post-humanist scholars emphasize how water flows across and destabilizes boundaries (body/environment; human/non-human; material/spiritual). They highlight that water is not merely a substrate but a connective medium through which multispecies life is constituted (158).

Hydrosocial scholarship advances the view that water is made and remade with infrastructures, laws, and power relations that affect who gets water and where (159, 160, 161). Decolonial aspects of this literature insist that water governance must be responsive to place-specific ecologies, and to Indigenous sovereignties, ontologies and rights. As with multispecies justice claims, these approaches frequently collide with resource-extractive imperatives (162).

6.2. Operationalization: How Might Relational Thinking be Put into Practice?

In Canada, the Anishinaabe Nibi.Inaakonigewin assert jurisdiction over water that goes far beyond colonial legal structures to revitalize ceremonial relationships, even as state recognition and resources remain limited (163). Colombia's Constitutional Court recognized the Atrato River as a rights-bearing entity and mandated co-governance with Indigenous and Afro-Colombian communities complemented by a comprehensive restoration of the river. Nevertheless, implementation has been uneven, extractive industries persist, and river defenders face ongoing threats from non-state actors (164). Further, and in general, substantial funding and state-controlled infrastructure raises the risk of symbolic recognition of relationality in the absence of more distributed power governance (165).

Broader syntheses (166) suggest that more relational governance could be legally, socially, and ecologically transformative. That is, relational governance must be meaningfully implemented, resourced, and empowered if it is to reshape power and practices. While legal reform is vital, it is insufficient, by itself, to deliver relational governance. Statutory changes are often undercut when they are not embedded in supportive socio-political and institutional contexts (167). Operationalizing relationality, thus, requires aligning epistemologies, institutions, and power with relational values in four ways.

First, ontological and epistemological shifts are necessary (168). Governance arrangements that recognize multiple ontologies must value stories, oral histories, land-based knowledge, and ceremonies alongside modern science. This is more than 'including local voices'; it is about reshaping hierarchies of evidence and remaking what counts as authoritative knowledge in decision-making. Recent reviews highlight a growing discourse of ‘water relationality’ that runs counter to, and may conflict with, rights-based and market-based framings (166). In practice, this can mean seating knowledge-keepers and ceremonial authorities within decision fora, and treating practices, such as water walks, offerings, or seasonal rites, as legally and institutionally meaningful forms of governance (169).

Second, transforming governance means redesigning the institutions through which water is governed. Recent work on hydrosocial territories underscores that authority over waterscapes is always claimed and contested; institutional design should, therefore, anticipate and respond to these contestations rather than depoliticize them (170). Moving from centralized decision-making to include local-based and expert-based actors, possibly within watershed councils and community guardianship, helps to ground decision-making in place and relation. These bodies would include Elders, women, youth, and knowledge-keepers in decision-making roles, and should promote more-than-human interests through appointed Guardians. Emerging policy instruments and initiatives include cultural flow allocations, guardianship networks (such as the recently launched River Guardian Network across the Thames catchment in the UK), relational monitoring protocols tied to ceremony and seasonal indicators (171), and public-facing decision support tools that enable communities to directly engage with scientific model outputs (172).

Third, legal and institutional pluralism must entail a redistribution of powers and resources. Legal personhood for rivers or lakes can be an entry point, but without power sharing and enforcement powers it risks remaining symbolic. Recent comparative analyses document both opportunities and pitfalls: where guardianship bodies have resources, clear mandates, and accountability to local communities, personhood provisions can recalibrate power and bolster restoration; where they do not, they can stall or be co-opted (173).

Fourth, in an increasingly urbanized world, scaling relational water governance to complex and urban settings is both possible and necessary. Urban design is being reconceptualized as a constellation of small-scale practices which catalyze socio-ecological processes that advance a just transition from extractive toward regenerative economies, promoting the Rights of Nature. One example is the rapidly urbanizing territory of Chiang Mai in Thailand, where forest remnants, traditional villages, and emerging subdivisions intersect within a landscape mosaic structured around river-fed weirs, canals, and rice paddies (174). Crucially, and in general, water governance reform can do much more than to ‘add’ relationality to existing architectures; what is required is reconstituting governance structures around care, reciprocity, and place-based responsibility.

6.3. Reflection: Challenges and Possibilities of Relational Approaches

Relational approaches face large impediments in implementation. First, resistance from state and corporate actors can be very difficult to overcome. This is because relational governance unsettles entrenched political economies of extraction, decision-making and infrastructure. Even where courts or legislatures adopt relational instruments, implementation frequently lags and struggles to align ministries, budgets, and enforcement with newly recognized obligations (164, 173). Second, tokenism emerges when symbolic recognition proceeds without a supportive institutional framework which includes a redistribution of authority and resources. Personhood provisions that lack guardianship budgets, monitoring powers, or community accountability can entrench the status quo under the guise of innovation. Third, co-optation threatens non-Western knowledge systems and governance forms when they are translated into state categories without respect for sovereignty and self-determination. Recent syntheses caution that relational discourses can be mobilized rhetorically while decision-making remains technocratic and growth-oriented (166, 170).

Against these challenges, Heterodox Thinking shows that transformative change is possible. Empirical studies indicate that relational designs can help navigate ‘nested conflicts’ by institutionalizing practices that maintain relationships amid disagreement (175). Climate–water scholarship demonstrates that relational, spatial, and political lenses produce more just and workable interventions than biophysically isolated fixes (161). Reviews in sustainability and environmental governance document a steady shift toward pluralist, place-based, and justice-centered paradigms, especially where Indigenous governance is upheld (171, 176). The jurisprudence and policy experimentation around the Rights of Nature and legal personhood for rivers highlight the importance of pairing legal recognition with guardianship bodies that have decision-making authority and restoration mandates (173).

The broader implication of Heterodox Thinking is that relational thinking is neither a new concept nor a buzzword. Rather, relationality is a coherent call for reorientation of water governance: from allocation to obligation, from efficiency to reciprocity, and from abstract universals to situated, place-based responsibilities. In this, relational water governance must be led by communities, adequately resourced, and enabled to reshape power relations. To effect the required changes, as reviewed in Heterodox Thinking and especially in terms of relationality, there must be change in the practices of high-level decision-making. Practical design guidance for such transformational change includes: employing plural forms of law and knowledge; basing decision-making in place and relation; allocating resources to Nature guardianship and restoration; and measuring success in terms of ecological-cultural integrity and distributional justice. In sum, we contend that when and where these elements align, relational approaches can produce legally robust, socially legitimate, and ecologically (re)generative responses to the world's many local water crises. When and where they do not, relationality risks becoming a label for business-as-usual.

7. CONCLUSIONS

Sustainable Development Goal 6, on Clean Water and Sanitation, provides priorities for actions and measures to assess whether targets are being achieved, or not. While substantial progress has been made since 2015, none of the key SDG 6 targets will be close to being delivered by 2030. In part, this is because of the scale of the challenges. We contend that another key impediment is misplaced diagnoses, policies and priorities that arise from inadequate attention to an emerging literature and heterodox evidence and frameworks about how to respond to the many local water crises.

Our review characterizes Heterodox Thinking in water economics, values and governance by the Three P's: People (e.g., who has voice and power and who does not); Place (e.g., locally informed and justice-based decision-making); and Planet (e.g., relationality and strengthening of interconnections between People, Place and Planet in ways that integrate non-human considerations, systems thinking and systemic risks). By contrast, more dominant policies and practices on water tend to prioritize single issue and highly targeted interventions with quantifiable metrics and/or key performance indicators; promote water-use efficiency and pricing as the primary instruments to resolve water insecurity; and spotlight the mobilization of funds, such as through public-private partnerships, to invest in new grey infrastructure.

Both Heterodox Thinking and mainstream approaches can, and have, contributed to positive water outcomes. Nevertheless, deficiencies in much of current decision-making are impeding more effective, equitable and sustainable responses to the world's many water crises. These deficiencies, in the extreme, include: a focus on financial returns while either ignoring or making a lower-order priority social, environmental and relational values which, typically, have the biggest impact on the well-being of the most disadvantaged; a framing of the global water crisis that fails to recognize that water insecurities are primarily experienced at a local scale, and are principally determined by local drivers and conditions; a priority focus on building grey infrastructure that obscures the important interconnections across existing (grey and green) infrastructures that need to be fit for purpose and place; single-goal missions that frequently fail to deliver systems solutions to systemic problems; and top-down governance that either misses or undervalues the insights and knowledge of local communities and ignores the power imbalances around who gets what water, when, how and why.

In sum, Heterodox Thinking in water economics, values and governance that has emerged over the past decade or so offers an alternative vision and practices to business-as-usual decision-making. In our view, decision-making informed by Heterodox Thinking is essential if the world is to develop the sustainable and effective responses needed to overcome the systemic problems of 'too much, too little and too dirty' water.

SUMMARY POINTS

1. Global water crises of 'too much, too little and too dirty' water are, essentially, local and require place and context-based responses.
2. Mainstream priorities and solutions for water insecurity need to go beyond prices and markets, efficiency, and mobilization of finance to fully encompass considerations people and place, and planet.
3. Multiple emerging and/or too often neglected or ignored approaches and methods are available to value water, identify injustices, understand power relationships and analyses, and mitigate risks.
4. On-the-ground evidence and 'Heterodox Thinking' across multiple disciplines, especially in the humanities and social sciences, offer justice-based and more equitable and sustainable solutions to the world's many local water crises.

FUTURE ISSUES

1. Integration of standard methods of analysis with justice, place-based and relational approaches supports more equitable and sustainable outcomes for water and people.
2. Relational thinking promotes the delivery of 'Clean Water and Sanitation for All' and, if it is to be implemented effectively, will need to be embedded within

decision-making, and especially around infrastructure, mitigation of risks, and remedies for injustices.

3. Systematic bottom-up and top-down collection and sharing of data with results and analyses, including lived experiences, are needed to better understand existing and emerging water risks, and to evaluate the effectiveness of current and alternative responses to local water crises.
4. Valuing and respecting community, traditional and ecological knowledge creates opportunities to improve decision-making processes and to promote more equitable and sustainable outcomes for humans within Nature.

DISCLOSURE STATEMENT

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AUTHOR CONTRIBUTIONS

R.Q.G conceived the study; R.Q.G, E.B., L.C, P.C., S.F., D.H.M., P.K., S.L., A.M., W.N., J.S., S.W., P.W., were the lead co-authors of key sections of the report (alphabetical by last name after the first author); R.Q.G., E.B., L.C, P.C., S.F., D.H.M., P.K., S.L., A.M., W.N., J.S., S.W., P.W., W.A., S.A., A.B., R.B., L.D., J.H., T.K., L.L, R.M., S.M., N-M.N., C.R., J. T-J., D.T., C.T., J.W. wrote and reviewed the article (alphabetical by last name after the lead co-authors).

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Figure 1

People, Place and Planet: The Do and the Don't based on 'Heterodox Thinking' on Water Economics, Values and Governance

Themes	**Do**	**Don't**
Values	Prioritize local-scale and place-based values, and where possible, measure cultural, spiritual, non-material and shared values	Assume values are always material, immutable or individualistic
Valuation Methods	Review and/or measure all values whenever possible, employ best practice methods and 'triangulate' across methods	Only prioritize market values and efficiency measures or ignore non-market values
Systems Thinking	Adopt systems thinking (e.g. elements, functions and interconnections) and actively adapt to actual and projected changes	Adopt single-goal missions to resolve systemic failures or use 'generalized and mean-based' assessments
Risk Assessments	Document boundaries, feedbacks and dynamic behaviors, consider who bears the risks, and effectively evaluate systemic and cumulative risks	Assume a business-as-usual trajectory or use risk methods inappropriate for complex, dynamic systems
Infrastructures	Ensure infrastructures (grey and green) are fit for 'purpose, place, and people' and evaluate spatial and temporal interconnections across infrastructures	Make the mobilization of funds invested on infrastructure as the key performance indicator
Water Justice	Identify injustices (e.g. distributive, procedural, epistemic, restorative) and prioritize remedies to the disadvantaged and disempowered	Prioritize global and/or top-down approaches or focus on documentation of injustice at the expense of practical responses

Rights of Nature	Recognize Indigenous rights and customary practices while effectively supporting legal person guardianship with institutional arrangements	Implement tokenistic rights or ignore or trivialize the power dynamics over how water gets allocated/reallocated
Relationality	Integrate relational values (e.g. integrity, respect, humility, reciprocity) into decision-making and adopt 'places and people and relations' thinking	Trivialize power relationships or fail to document historical failures and institutional weaknesses or ignore the wellbeing of non-humans
Just, Inclusive decision-making	Adopt and support inclusive decision-making processes (e.g. dialogues, deliberative processes) and actively ensure all voices are heard	Prioritize efficiency at the expense of basic human rights and needs or ignore the institutional structures that determine who get what water and when
Water Governance	Integrate local-scale and place-based knowledges, experiences and priorities within existing or improved decision-making processes	Focus only on returns on investment and efficiency and exclude, undermine or ignore bottom-up decision-making
Economic Evaluation	Conduct benefit-cost analyses that follow best practice guidelines, quantify wider social, environmental and cultural values, highlight (e.g. Monte Carlo Methods) a range of possible outcomes, identify who benefits and loses, and complement analyses with relevant qualitative and/or experiential assessments	Conduct static financial or only market value analyses, provide a single Benefit-Cost Ratio, or its equivalent, fail to properly assess risks and uncertainties, or ignore broader and non-material values (e.g. socio-cultural) and measures of well-being

Source: the authors

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