frontiers | Frontiers in Water

TYPE Perspective
PUBLISHED 28 January 2025
DOI 10.3389/frwa.2025.1520853

OPEN ACCESS

EDITED BY
Murugesu Sivapalan,
University of Illinois at Urbana-Champaign, United States

REVIEWED BY
Aviram Sharma,
University of Vigo, Spain
Jenia Mukherjee,
Indian Institute of Technology Kharagpur, India

*CORRESPONDENCE
Joyeeta Gupta
✉ j.gupta@uva.nl

RECEIVED 04 November 2024
ACCEPTED 07 January 2025
PUBLISHED 28 January 2025

CITATION
Gupta J, Bosch HJ and van Vliet L (2025) Water security reframed using Water System Justice and Earth system boundaries, foundations, and corridor.
Front. Water 7:1520853.
doi: 10.3389/frwa.2025.1520853

Water security reframed using Water System Justice and Earth system boundaries, foundations, and corridor

Joyeeta Gupta[1,2]*, Hilmer J. Bosch[1] and Luc van Vliet[1]

[1]Amsterdam Institute for Social Science Research, University of Amsterdam, Amsterdam, Netherlands, [2]IHE-Delft Institute for Water Education, Delft, Netherlands

In the Anthropocene, when human activity, including the overuse and over-pollution of water, is leading to the destabilization of the global hydrological cycle, the concept of water security represents both a threat to and opportunity for international cooperation on water issues. Hence, this paper asks: *How does Water System Justice redefine the content of water security in the Anthropocene?* In this perspective paper we argue that water security, when narrowly understood by states and multinationals as the need for control over water, can justify the securitization and commodification of water. This in turn can lead to practices such as water grabbing creating and perpetuating injustices for the poor and marginalized. To counter this, we propose to conceptually link water security to water justice through an operationalized framework for Water System Justice (WSJ). This framework includes ideal, recognition, and epistemic justice, as well as integrating the 3I's (Interspecies, Intergenerational and Intragenerational justice), and procedural and substantive justice. Applied quantitatively, this framework provides safe and just quantitative boundaries to water use (climate change and nutrients), and quantifies what is necessary to meet the minimum human rights of people worldwide for water (for WASH, food, energy, infrastructure) and translates this into pressures on the water system using the same units—thereby delineating a corridor of water that can be equitably shared by people. Adding our Water System Justice framework enriches water security by providing a systemic perspective of interdependence from the local to the global level.

KEYWORDS

water security, justice, Earth system boundaries, SDG 10: reduced inequalities, Water System Justice, water securitization

1 Introduction: between security of access and securitization

Despite the growth in water security literature, few papers link it to water justice. Using the Water System Justice (WSJ) framework, which builds on Earth System Justice (ESJ) (Gupta et al., 2023a, 2023b), we re-examine what water security could mean. Grey and Sadoff (2007, p. 545) define it as "the availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems and production, coupled with an acceptable level of water related risks to people, environment and economies." Water security is often seen in nexus to food, energy and health security (Pahl-Wostl et al., 2016a). While water security simply means adequate access needed by a society for all its key functions, water securitization refers to how water scarcity becomes 'securitized' through language, the military, and maps to become a threat (Fischhendler and Nathan, 2016).

Against this background, we ask: *how does Water System Justice redefine the content of water security in the Anthropocene?* We link local to global water security with WSJ to show that justice means ensuring security in a systemic context, not securitization, and requires unprecedented cooperative behavior between states and people. This perspective paper recognizes that "any operationalization of water security must be negotiated in a societal discourse" (Pahl-Wostl et al., 2016b, p. 4), but proposes conceptualizing and operationalizing water security through a Water System Justice lens.

2 Key concepts: water system justice and water security

2.1 Water System Justice (WSJ)

WSJ emerges from two traditions. First, in the water domain, water scholars generally discuss local justice issues, focusing on how technologies (e.g., dams, irrigation facilities) (Richter et al., 2010) and the financializaton (Williams, 2021) of water affect access by altering power dynamics. However, in the Anthropocene, accelerated demands on and pollution of the water system, and climate impacts on the hydrological system are exacerbating water injustices through changing the water system, which calls for WSJ. Since geologists continue to debate on the Anthropocene in terms of their definitions of epochs measured in the Earth's strata, we use the concept as Earth system scientists do (e.g., Rockström) to refer to human impacts on Earth systems and as social scientists do who call for new approaches to justice Ghosh (2024). Second, WSJ emerges from 'systemic' justice frameworks such as planetary justice (Biermann and Kalfagianni, 2020) which calls for systemic transformations to address global inequalities and environmental limits. ESJ builds on these by integrating justice into the biophysical boundaries necessary for Earth's stability.

Given this heritage, WSJ is a systemic approach to local to global water injustice. Building on the Earth Commission's conceptualization of ESJ, it states that *conservative justice* often takes existing rules as the starting point reproducing injustice; whereas *ideal justice* reconstructs these rules through procedural justice to achieve a just society (Kalfagianni and Meisch, 2020, p. 206). It uses recognition justice to prioritize the 'other' and epistemic justice to give space to plural ways of knowing. It integrates the 3I's—Interspecies justice and Earth system stability, Intergenerational justice and Intragenerational justice. Since existing theories of interspecies and multispecies justice focus on our relations with other species and the more than human world, they are difficult to operationalize and quantify. Hence, we use the knowledge and criteria of ecologists and biologists to quantify boundaries to protect ecosystems. ESJ includes procedural and substantive (distributive, corrective, restorative) justice. This is then operationalized in terms of *ends* (safe and just boundaries and ambient quality standards; meeting human rights) and *means* (addressing drivers of water system degradation and inequality; redistributing remaining resources, liability for harm caused, and responsibilities for governing the water system). Regarding power dynamics, WSJ implicitly addresses the causes of water injustice by promoting principles and instruments which can counter counter existing power imbalances and unequal power structures that exacerbate inequalities. These power dynamics often affect who has access to resources and how the remaining resources, risks/harm and responsibilities are allocated in society (Gupta et al., 2023a), thereby perpetuating inequality.

For water, the ends include: (a) living within proposed quantified *safe* (avoiding irreversibility) and *just* (avoiding significant harm) *Water* and related *Earth system boundaries* and *standards* for water quality (Rockström et al., 2023). Such quantifications aim to ensure that the water system functions as always and avoids adding significant harm to humans. We also argue that in addition to water quantity, it is critical to meet water quality standards. This incorporates respect for the full water cycle, including transboundary and green water flows and across local-to-global value chains; and (b) prioritizes the minimum access needs of people to water to fulfil their human rights to water, food, energy and infrastructure. The latter is quantified in terms of pressure on the water system using the same units as the boundaries, thereby delineating a corridor of 'remaining' water. Meeting basic water needs of the poorest increases demand by 2–5%. This additional demand is roughly equivalent to the pressures of the world's wealthiest 1–4% (Rammelt et al., 2022). Boundaries, standards, access and allocation comprehensively articulates water security.

2.2 Water security and securitisation

'Water security' is an ambivalent concept. It has become popular in academic and policymaking circles (Quiroga and Castelblanco, 2024) to advocate for acceptable levels of water quantity and quality (e.g., Grey and Sadoff, 2007). Scholars emphasize different components [e.g., basic needs (Sullivan, 2002), privatization and power (Bakker, 2003), and national security (Gleick, 1993)], but their social justice approaches are broadly consistent (Wade, 2018). Thus 'achieving' water security is shorthand for ensuring that people's water needs are met and that they are protected from water-related threats.

However, governments often invoke water security to prioritize and protect water as a national interest. They often see water through a scarcity lens leading to its securitization implying that water is framed as a security threat requiring extraordinary measures to protect it. Such measures include absolute sovereignty, hydro hegemony and/or neo-liberal privatization, financialization and marketization of water (Bosch and Gupta, 2023). Water has a long history of upstream countries demanding absolute sovereignty over their water resources; and this is institutionalized in the 2030 Agenda on the SDGs where governments agreed to recognize states' full permanent sovereignty over natural resources. Thus, water security could be invoked to reframe water from a social and sustainability problem to a national security issue (Fischhendler and Nathan, 2016; Risbey, 2008), typically deprioritizing social or environmental justice concerns, prompting scholars to integrate justice into water security (Cook and Bakker, 2012; Harris et al., 2017; Pokharel, 2023) and environmental issues more broadly (Gupta et al., 2020). Such securitization can also lead to water 'grabbing', concentrating water resources in rich hands.

Securitization is not limited to international relations but can manifest within countries. For instance, municipalities may securitize water access at the expense of rural areas, using their economic and political power to claim a disproportionate share of resources, while rural areas bear the environmental and social costs of extraction. This

Abbreviations: WSJ, Water System Justice; ESJ, Earth System Justice; ESB, Earth System Boundaries; HRWS, Human right to water and sanitation.

occurred when the Indian Sirsi Municipality decided to meet its water needs from the Kengrehalla stream by attempting to dam it, at the expense of farmers in the Kengre watershed area (SOPPECOM, 2010).

Rejecting securitization may seem ideal; however, it requires dismantling entrenched political, economic, and institutional systems that benefit from this approach. This raises critical questions about whose interests are served by securitization and how alternative frameworks, such as justice-based approaches, can challenge these. Hence, we argue for reconceptualising water security through a WSJ lens, which seeks to address the root causes of resource inequity and power imbalances while promoting inclusive governance mechanisms across scales.

2.3 Linking the two concepts together

Combining water security and WSJ brings out the relative strengths of each: avoiding the pitfalls of narrow definitions of water security that ignore justice and benefiting from the ubiquity of water security in policy circles to popularize and operationalize WSJ (see Table 1).

In the Anthropocene, integrating justice and water security in harmony with nature becomes increasingly more important (GCEW, 2024; Schoeman et al., 2014) especially as "in struggles for water security, the poor tend to lose" (Boelens et al., 2014; Escobar, 2006; Harvey, 1996; Perreault et al., 2011 – in Boelens et al., 2018b, p. 1). For example, irrigation infrastructure upgrades are a technical fix to address water and related food insecurity but often externalizes the impacts on irrigators, Indigenous Peoples and local communities and the environment, and through a rebound effect ultimately exacerbates scarcity (Owens et al., 2022). Relatedly, the water security discourse is linked to an extractive commercialized understanding of 'water-as-resource' ignoring other water ontologies (Quiroga and Castelblanco, 2024). Hence, integrating justice and water security addresses the issue of exacerbating and perpetuating inequality by expanding the meaning of water security.

TABLE 1 Conceptually linking water security to water system justice.

WSJ	Water security means…
Recognition	Recognizing and including individuals and communities, their needs, wants, claims, values, relationships – it focuses on 'nothing about us without us'.
Epistemic	Considering 'other' knowledge systems (without hierarchy); creating just water security that reflect the lived realities of the marginalized and excluded.
Interspecies	(interpreted as) Maintaining (water) ecosystems and Earth system (water) stability to allow species to flourish.
Intergenerational	(interpreted as) Avoiding significant harm to future generations and re-examining past harm to present generations through corrective/restorative justice
Intragenerational	(interpreted as) Addressing intersectional (race, gender, class, and sexuality, caste, class, religion) disparities between people communities and countries
Procedural	(implies) Enhancing access to information, decision making, civic space and courts to ensure water security including where necessary positive discrimination.
Substantive	(implies) Addressing the drivers of water security problems and inequality; ensuring minimum access and an equitable allocation of the remaining water, approaches to address water related harms (e.g. floods) (e.g., liability, insurance) and allocating responsibility for achieving water security (e.g., user and pollution permits). Includes distributive justice.

3 Global level

Since "water security problems must be tackled at different and often simultaneously at multiple scales" (Pahl-Wostl et al., 2016b, p. 8), this fits well with a WSJ approach that builds in local to global justice implications. At the global (to local) level, WSJ defines the safe and just 'corridor' for human interactions with relevant water boundaries and standards.

Operationalizing the 3I's to minimize significant harm to people, ecosystems and Earth system stability promotes a stable water system including water based ecosystems. Based on 4 years of research, the Earth Commission proposed that: (a) surface water fluctuation should not vary more than 20% in relation to the natural flow level on a monthly basis; and (b) groundwater extraction should not exceed its recharge rate (Rockström et al., 2023, p. 107). Groundwater boundaries also avoid land subsidence and saltwater intrusion (Gupta and Conti, 2017). Debates about the underlying data and methods has also been settled (Bunn et al., 2024). Both these boundaries have been crossed at local to global levels: 47% of groundwater levels are declining, and 34% of surface water bodies fluctuate more than 20% (Bunn et al., 2024), while the minimum water needs and water for food, energy and infrastructure needs were not met for the poorest (Rammelt et al., 2022). Additionally, a safe boundary for green water terrestrial precipitation, evaporation, and soil moisture—"represented by the percentage of ice-free land area on which root-zone soil moisture deviates from Holocene variability for any month of the year" (Wang-Erlandsson et al., 2022, p. 380), has also been crossed.

These boundaries are based on literature, Earth system modelling, historical data, and expert judgement and data gaps, especially in developing countries are accommodated by employing proxies like recharge rates and flow fluctuations. These quantitative boundaries are complemented with quality standards, e.g., emission, technology and ambient standards for water bodies (Rockström et al., 2023). Existing standards (WHO, EU and others) fall short of what is needed for the new chemicals (e.g., PFAS), minerals and metals. Boundaries and standards need to be contextualized for relevance and restrict water use, consumption, and pollution.

The climate boundary affects water security as climate change causes droughts, floods, changing rainfall patterns and melting glaciers. For every 1°C rise in global average temperatures, there is a 7% increase in the moisture-holding capacity of the atmosphere, exacerbating weather extremes (GCEW, 2024). The safe and just boundary for climate change is 1°C above pre-industrial levels (Gupta et al., 2024b) which exposes tens of millions of people to irreversible harm, is a threshold that has already been transgressed. Agriculture uses 70% of all blue water as well as green water, and pollutes water through N and P inputs, leading to eutrophication and health risks. This requires safe and just boundaries for nitrogen (N) and phosphorus (P) surpluses by capping nitrogen

surplus at 61 Tg N per year and phosphorus at 4.5–9.0 Tg P per year in cropland areas to prevent nutrient leaching (Rockström et al., 2023).

These quantitative and qualitative boundaries represent the upper limit. The lower limit is defined by the impacts on the water system of meeting the human right to water and sanitation (HRWS) which requires approximately 50 to 100 liters of water per person per day (WHO, 2017), although this rises to about 4,000 liters per person for a dignified life when food, domestic and industrial needs from blue and green water are considered (GCEW, 2024). These minimum needs have been calculated using the same units as the boundaries and enables the definition of a safe and just corridor (Gupta et al., 2024a).

Thus, at global level, water security can be operationalized using WSJ which reinforces the need for global cooperation (see Figure 1). The water, climate and nutrient boundaries and quality standards represent the maximum allowable pressure on the water system. The pressures of meeting the minimum needs of all is the foundation. The water within the corridor needs to be fairly allocated including responsibilities for harm and risk. Thus visualizing the hydrological, climate and nutrient cycle as a global common good and meeting minimum needs as a merit good provides additional reason to enhance multilateralism and coordination to regulate water and pollution allocation mechanisms through the polluter pays principle and the common but differentiated responsibility principle. This ensures sustainable and equitable water use, fostering international cooperation for the collective good. Moreover, trade in water and embodied water (virtual water trade) needs to be undertaken within multi-level water boundaries, standards and foundations. Finally, land and water grabbing by foreign investors (e.g., miners) needs to be avoided in line with the 'Means' of Earth System Justice (Bosch and Gupta, 2022; Rulli et al., 2013).

4 Transboundary level

Transboundary water security concerns emerge when water resources cross (sub)national boundaries. Our surface water boundary requires that water flows downstream and into the oceans, and that monthly withdrawals are in line with recharge levels while pollution needs to be within ambient standards for water. As a foundation, the needs of local people have to be met first. The remaining water in the corridor is what can be equitably shared between transboundary riparians.

These boundaries and floors challenge the existing 800 or more international, freshwater-related agreements on the 313 international river basins (Oregon State University, 2023) and require rethinking shared aquifers and account for green water flows. Upper riparians have been unwilling to share water, as demonstrated through the limited ratification of the Watercourses Convention (39 countries) and

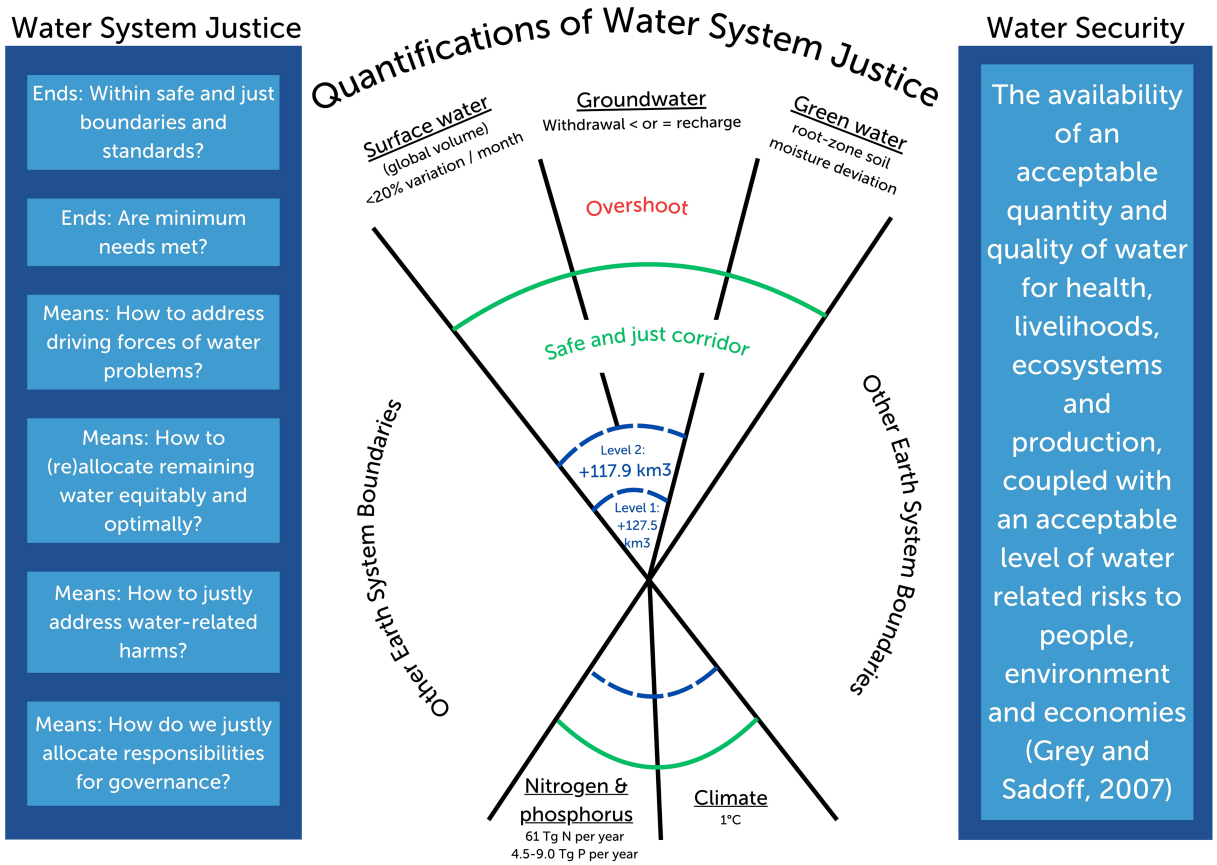

FIGURE 1
Water System Justice and water security in the context of water-relevant Earth system boundaries. Combining WSJ and water security means meeting minimum needs whilst not overshooting boundaries (i.e., remaining within the safe and just corridor) (ends) through just means.

the Water Convention (55 countries[1]) (Gupta, 2016). Where water scarcity is acute and increasing with climate change, countries are securitizing water using hardline diplomatic stances including militarization and conflict (Fischhendler, 2016). Securitization undermines social and environmental justice goals ignoring downstream communities and ecosystems (e.g., Palestinians in the West Bank) (Nathan and Fischhendler, 2015).

A WSJ approach at the transboundary level implies that water security requires meeting minimum quality and quantity standards for humans within the safe and just water and related boundaries which leaves water for nature to flourish (interspecies justice). This entails ensuring downstream countries and marginalized groups receive fair access to water resources, and that agreements account for the short and long-term sustainability of water resources (intra and intergenerational justice).

Fortunately, strategic 'realpolitik' and justice approaches are not necessarily mutually exclusive, as countries are interdependent on the hydrological, climate and nutrient cycle (GCEW, 2024) and unification behind WSJ goals can open the door to less 'zero-sum' approaches to transboundary water cooperation. While the historical reluctance of states to cooperate on blue water challenges such optimism, green water flows provide a compelling basis for more cooperation especially since nearly half of all precipitation over land originates from terrestrial sources (Petrillo et al., 2024). Atmospheric moisture flows connect regions making them highly interdependent: e.g. Brazil's Amazon rainforest recycles 36% of its own rainfall, while also exporting significant moisture to neighboring countries, thus contributing to regional/transcontinental precipitation (Smith et al., 2023). Similarly, West African evaporation contributes to rainfall in South America. These interconnections underscore shared dependency and need for cooperation.

This interdependence suggests that aligning national interests with WSJ principles could open pathways for less zero-sum approaches and reduce the adversarial nature of transboundary water negotiations (Tuinenburg et al., 2020).

5 National to local level

From the national to local levels, water security issues become more immediate and tangible with competition between different uses and users. Agriculture uses 70% of water abstractions and water utilities that provide quality water to homes and offices account for ~10%. Such water must be returned clean to nature. Indigenous groups and environmental rights activists are advocating for sustainable water governance practices including legal personhood of rivers and other water bodies (e.g., Embassy of the North Sea) (Cyrus, 2020). When such locally rooted customs are recognized at the national level, they can ensure that water bodies are treated as ecological systems, in turn shoring up water security. The 20% fluctuation rule (see 3.1) could be seen as a way to define the right of the river.

Many states use a priority of use system to guide water access and allocation, especially in times of scarcity. This can ensure that achieving minimum human (HRWS) and nature needs is made actionable, as human consumption and adequate environmental flows are afforded top priority, followed by uses such as agriculture (which itself must differentiate between vital and luxury goods, such as export crops) and industry (AI creates a new problem because of its enormous use of energy, water, and minerals/metals) (Gupta et al., 2024). The priority of use must be sensitive to local needs and could be linked to pollution permits.

At national level, increased water scarcity can lead to securitizing water by promoting full permanent sovereignty over natural resources. Water markets may lead to water hoarding (as in Chile). When water is commodified, the state/businesses may prioritize uses with higher returns (e.g., industrial over agricultural, urban over rural) at the expense of marginalized communities and ignoring sacred relations with water (Taylor et al., 2019). For example, Gaybor (2011) in Boelens et al. (2018a) found that in Ecuador the agricultural export sector represents 1% of farms while receiving concessions for 67% of the total available irrigation water. Securitization by international investors happens through land and water grabbing (Franco et al., 2013), the building of infrastructures (e.g., dams), as well as through investor-state contracts (Bosch and Gupta, 2022) and putting water as an asset on companies balance sheets. These can exacerbate local insecurity. A justice-centered approach to water security addresses inequalities, recognizes diverse relationships to water, and moves beyond a sovereign technocratic and financialization model of water securitization. Operationalizing just water security nationally requires contextualization, which involves incorporating justice-based conditionalities to contracts, concessions, permits, licences, EIAs, policies, strategies, rights, investment agreements, land planning, and Corporate Social Responsibility Programmes—putting justice front and centre.

6 Conclusion

In this perspective paper, we conclude that 'water security' can benefit from 'Water System Justice' and its operationalized quantifications as developed by the Earth Commission. This requires that water security: accounts for recognition and epistemic justice, and plural ways of knowing water (Wilson et al., 2019); incorporates the 3I's of justice—Interspecies, Intergenerational and Intragenerational justice in boundaries and standards; meets minimum needs, and holds polluters accountable, and challenges state and private interests that threaten access to clean water. It additionally supports local communities' right to procedural justice.

Such boundaries can contextualize Earth Commission boundaries and international quality standards. This forms the upper limit of the local to global level corridor. The pressure on the water system of meeting minimum needs to water, including water for food, energy, infrastructure, calculated using the same units as the boundaries provides the foundation. The remaining water in the corridor in between, then needs to be reallocated between the different uses and users in an equitable and optimal manner. Incorporating green water boundaries and the flows of atmospheric rivers adds another complex dimension to water security. Addressing power and the drivers of inequality requires justice principles. A commitment to collaborative management, rooted in WSJ principles and proposed quantifications, is essential to balance human and ecological needs for a secure and just water system. The scalar dimension of water security can be linked to the multi-level systemic justice approaches. Scale jumping, e.g., where local level values match global ones but not national ones can

1 Including the European Union.

be used to reinforce justice especially by linking key shared justice principles. The interdependence between countries reinforces the need for just cooperation for collective security.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

JG: Conceptualization, Supervision, Visualization, Writing – original draft, Writing – review & editing. HB: Investigation, Visualization, Writing – original draft, Writing – review & editing. LV: Investigation, Visualization, Writing – original draft, Writing – review & editing.

Funding

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article. This paper received funding from the Netherlands Enterprise Agency (RVO), under grant number 5000005700 and case number 31184622, and the Dutch Ministry of Infrastructure and Water Management, under grant number 5000005700 and case number 31184622. This paper also contributes to the ongoing work of the Earth Commission and the Global Commission on the Economics of Water.

Acknowledgments

This research was conducted at the Governance and Inclusive Development Programme Group (GID) at the Amsterdam Institute of Social Science Research (AISSR) of the University of Amsterdam (UvA). The authors acknowledge the support from IHE Delft Institute for Water Education and the Global Commission on the Economics of Water.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The authors declare that no Gen AI was used in the creation of this manuscript.

Publisher's note

References

Bakker, K. (2003). Archipelagos and networks: urbanization and water privatization in the south. *Geogr. J.* 169, 328–341. doi: 10.1111/j.0016-7398.2003.00097.x

Biermann, F., and Kalfagianni, A. (2020). Planetary justice: a research framework. *Earth Syst. Govern.* 6:100049. doi: 10.1016/j.esg.2020.100049

Boelens, R., Budds, J., Bury, J., Butler, C., Crow, B., Dill, B., et al. (2014). Santa cruz declaration on the global water crisis. *Water International.* 39, 246–261. doi: 10.1080/02508060.2014.886936

Boelens, R., Perreault, T., and Vos, J. (Eds.) (2018a). Water justice. *1st* Edn. Cambridge: Cambridge University Press.

Boelens, R., Vos, J., and Perreault, T. (2018b). "Introduction: The multiple challenges and layers of water justice struggles," in *Water Justice. R.* eds. T. P. Boelens and J. Vos (Cambridge: Cambridge University Press), 1–32.

Bosch, H. J., and Gupta, J. (2022). Water property rights in investor-state contracts on extractive activities, affects water governance: an empirical assessment of 80 contracts in Africa and Asia. *Rev. Eur. Commun. Int. Environ. Law* 31, 295–316. doi: 10.1111/reel.12436

Bosch, H. J., and Gupta, J. (2023). The tension between state ownership and private quasi-property rights in water. *WIREs Water.* 10:e1621. doi: 10.1002/wat2.1621

Bunn, S. E., Stewart-Koster, B., Ndehedehe, C., Gordon, C., Rockström, J., Gupta, J., et al. (2024). Reply to: concerns regarding proposed groundwater earth system boundary. *Nature* 635, E6–E8. doi: 10.1038/s41586-024-08083-8

Cook, C., and Bakker, K. (2012). Water security: debating an emerging paradigm. *Glob. Environ. Chang.* 22, 94–102. doi: 10.1016/j.gloenvcha.2011.10.011

Cyrus, R. (2020). Rights of Rivers: A global survey of the rapidly developing Rights of Nature jurisprudence pertaining to rivers. Available at: https://www.internationalrivers.org/wp-content/uploads/sites/86/2020/09/Right-of-Rivers-Report-V3-Digital-compressed.pdf

Escobar, A. (2006). Difference and conflict in the struggle over natural resources: A political ecology framework. *Develop.* 49, 6–13. doi: 10.1057/palgrave.development.1100267

Fischhendler, I. (2016). The securitization of water discourse: theoretical foundations, research gaps and objectives of the special issue. *Int. Environ. Agree. Special Issue* 15, 245–255. doi: 10.1007/s10784-015-9277-6

Fischhendler, I., and Nathan, D. (2015). The social construction of water security discourses: preliminary evidence and policy implications from the Middle East.

Fischhendler, I., and Nathan, D. (2016). "The social construction of water security discourses: preliminary evidence and policy implications from the Middle East," in *Handbook on Water Security*. eds. C. Pahl-Wostl, A. Bhaduri and J. Gupta (Cheltenham: Edward Elgar Publishing Limited).

Franco, J., Mehta, L., and Veldwisch, G. J. (2013). The global politics of water grabbing. *Third World Q.* 34, 1651–1675. doi: 10.1080/01436597.2013.843852

Gaybor, A. (2011). Acumulación en el campo y despojo del agua en el Ecuador. *Justicia hídrica: acumulación, conflictos y acción civil.* eds. R. Boelens, D. Getches and M. Zwarteveen Lima: IEP; Fondo Editorial PUCP, Justicia Hídrica), 195–208.

GCEW (2024). The economics of water: Valuing the hydrological cycle as a global common good: Global Commission on the Economics of Water.

Ghosh, R. (2024). A fond farewell to the Anthropocene. *Issues Sci. Technol.* 40, 20–22. doi: 10.58875/OUAY7538

Gleick, P. H. (1993). Water and conflict: fresh water resources and international security. *Int. Sec.* 18, 79–112. doi: 10.1162/isec.18.1.79

Grey, D., and Sadoff, C. W. (2007). Sink or swim? Water security for growth and development. *Water Policy* 9, 545–571. doi: 10.2166/wp.2007.021

Gupta, J. (2016). The watercourses convention, hydro-hegemony and transboundary water issues. *Int. Spect.* 51, 118–131. doi: 10.1080/03932729.2016.1198558

Gupta, J., Bai, X., Liverman, D. M., Rockström, J., Qin, D., Stewart-Koster, B., et al. (2024a). A just world on a safe planet: a lancet planetary health–earth commission report on earth-system boundaries, translations, and transformations. *Lancet Planet. Health.* doi: 10.1016/S2542-5196(24)00042-1

Gupta, J., Chen, Y., Mckay, D. I. A., Fezzigna, P., Gentile, G., Karg, A., et al. (2024b). Applying earth system justice to phase out fossil fuels: learning from the injustice of

adopting 1.5 °C over 1 °C. *Int. Environ. Agreem. Politics Law Econ.* 24, 233–255. doi: 10.1007/s10784-024-09628-y

Gupta, J., Bosch, H. J., and van Vliet, L. (2024). AI's excessive water consumption threatens to drown out its environmental contributions. Available at: https://theconversation.com/ais-excessive-water-consumption-threatens-to-drown-out-its-environmental-contributions-225854

Gupta, J., and Conti, K. (2017). Global climate change and global groundwater law: their independent and pluralistic evolution and potential challenges. *Water Int.* 42, 741–756. doi: 10.1080/02508060.2017.1354415

Gupta, J., Liverman, D., Prodani, K., Aldunce, P., Bai, X., Broadgate, W., et al. (2023a). Earth system justice needed to identify and live within earth system boundaries. *Nat. Sustain.* 6, 630–638. doi: 10.1038/s41893-023-01064-1

Gupta, J., Prodani, K., Bai, X., Gifford, L., Lenton, T. M., Otto, I., et al. (2023b). Earth system boundaries and earth system justice: sharing the ecospace. *Environ. Polit.* 33, 1286–1305. doi: 10.1080/09644016.2023.2234794

Gupta, J., Scholtens, J., Perch, L., Dankelman, I., Seager, J., Sánder, F., et al. (2020). Re-imagining the driver–pressure–state–impact–response framework from an equity and inclusive development perspective. *Sustain. Sci.* 15, 503–520. doi: 10.1007/s11625-019-00708-6

Harris, L. M., McKenzie, S., Rodina, L., Shah, S. H., and Wilson, N. J. (2017). "Water justice: Key concepts, debates and research agendas," in *Handbook of environmental justice*. eds. R. Hollifield, J. Chakraborty and G. Walker (New York: Routledge). 338–349.

Harvey, D. (1996). Justice, Nature and the Geography of Difference. Cambridge (MA) Blackwell Publishers Inc; Oxford, Blackwell Publishers Ltd.

Kalfagianni, A., and Meisch, S. (2020). Epistemological and ethical understandings of access and allocation in earth system governance: a 10-year review of the literature. *Int. Environ. Agreem.: Politics Law Econ.* 20, 203–221. doi: 10.1007/s10784-020-09469-5

Nathan, D., and Fischhendler, I. (2015). Triggers for securitization: a discursive examination of Israeli–Palestinian water negotiations. *Water Policy* 18, 19–38. doi: 10.2166/wp.2015.027

Oregon State University. (2023). International freshwater treaties database: Program in Water Conflict Management and Transformation. Available at: https://transboundarywaters.ceoas.oregonstate.edu/international-freshwater-treaties-database

Owens, K., Carmody, E., Grafton, Q., O'Donnell, E., Wheeler, S., Godden, L., et al. (2022). Delivering global water security: embedding water justice as a response to increased irrigation efficiency. *WIREs Water* 9:e1608. doi: 10.1002/wat2.1608

Pahl-Wostl, C., Bhaduri, A., and Gupta, J. (2016a). Handbook on water security: Edward Elgar Publishing.

Pahl-Wostl, C., Gupta, J., and Bhaduri, A. (2016b). "Water security: a popular but contested concept," in *Handbook on Water Security*. eds. C. Pahl-Wostl, A. Bhaduri and J. Gupta (Cheltenham: Edward Elgar Publishing Limited).

Perreault, T., Wraight, S., and Perreault, M. (2011). The social life of water: Histories and geographies of environmental injustice in the onondaga lake watershed. New York: Justicia Hídrica.

Petrillo, E. D., Fahrländer, S., Tuninetti, M., Andersen, L. S., Monaco, L., Ridolfi, L., et al. (2024). Reconciling tracked atmospheric water flows to close the global freshwater cycle. doi: 10.21203/rs.3.rs-4177311/v3

Pokharel, K. (2023). Understanding water security as an agenda of critical environmental justice (CEJ). *World Water Policy* 9, 503–506. doi: 10.1002/wwp2.12113

Quiroga, C., and Castelblanco, A. (2024). "Beyond water justice and water security: debates on water, women, and climate change in Latin America" in Routledge handbook of gender and water governance. (Abingdon and New York: Routledge). 372–387.

Rammelt, C. F., Gupta, J., Liverman, D., Scholtens, J., Ciobanu, D., Abrams, J. F., et al. (2022). Impacts of meeting minimum access on critical earth systems amidst the great inequality. *Nat. Sustain.* 6, 212–221. doi: 10.1038/s41893-022-00995-5

Richter, B. D., Postel, S., Revenga, C., Scudder, T., Lehner, B., Churchill, A., et al. (2010). Lost in development's shadow: the downstream human consequences of dams. *Water Altern.* 3, 14–42.

Risbey, J. S. (2008). The new climate discourse: alarmist or alarming? *Glob. Environ. Chang.* 18, 26–37. doi: 10.1016/j.gloenvcha.2007.06.003

Rockström, J., Gupta, J., Qin, D., Lade, S. J., Abrams, J. F., Andersen, L. S., et al. (2023). Safe and just earth system boundaries. *Nature* 619, 102–111. doi: 10.1038/s41586-023-06083-8

Rulli, M. C., Saviori, A., and D'Odorico, P. (2013). Global land and water grabbing. *Proc. Natl. Acad. Sci.* 110, 892–897. doi: 10.1073/pnas.1213163110

Schoeman, J., Allan, C., and Finlayson, C. M. (2014). A new paradigm for water? A comparative review of integrated, adaptive and ecosystem-based water management in the Anthropocene. *Int. J. Water Resour. Dev.* 30, 377–390. doi: 10.1080/07900627.2014.907087

Smith, C., Baker, J. C. A., and Spracklen, D. V. (2023). Tropical deforestation causes large reductions in observed precipitation. *Nature* 615, 270–275. doi: 10.1038/s41586-022-05690-1

SOPPECOM. (2010). Study of social movements on water in India. Society for Promoting Participative Eco-system Management. Available at: https://www.soppecom.org/pdf/report-study-of-social-movements-on-water-in-India.pdf

Sullivan, C. (2002). Calculating a water poverty index. *World Dev.* 30, 1195–1210. doi: 10.1016/S0305-750X(02)00035-9

Taylor, K. S., Longboat, S., and Grafton, R. Q. (2019). Whose rules? A water justice critique of the OECD's 12 principles on water governance. *Water* 11:809. doi: 10.3390/w11040809

Tuinenburg, O. A., Theeuwen, J. J., and Staal, A. (2020). High-resolution global atmospheric moisture connections from evaporation to precipitation. *Earth Syst. Sci. Data* 12, 3177–3188. doi: 10.5194/essd-12-3177-2020

Wade, S. (2018). Is water security just? Concepts, tools and missing links. *Water Int.* 43, 1026–1039. doi: 10.1080/02508060.2018.1543750

Wang-Erlandsson, L., Tobian, A., van der Ent, R. J., Fetzer, I., te Wierik, S., Porkka, M., et al. (2022). A planetary boundary for green water. *Nat. Rev. Earth Environ.* 3, 380–392. doi: 10.1038/s43017-022-00287-8

WHO (2017). Guidelines for drinking-water quality. Geneva: World Health Organization.

Williams, J. (2021). "Money is not the problem": the slow Financialisation of Kenya's water sector. *Antipode* 53, 1873–1894. doi: 10.1111/anti.12755

Wilson, N. J., Harris, L. M., Nelson, J., and Shah, S. H. (2019). Re-theorizing politics in water governance. *Water* 11:470. doi: 10.3390/w11071470