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Water woes: the institutional challenges in achieving SDG 6

Jaivime Evaristo[1*], Yusuf Jameel[2], Cecilia Tortajada[3], Raymond Yu Wang[4], James Horne[5], Howard Neukrug[6], Carlos Primo David[7], Angela Maria Fasnacht[8], Alan D. Ziegler[9,10] and Asit Biswas[11,12,13]

Abstract

Background Sustainable Development Goal (SDG) 6 envisions a future where everyone has access to clean water and sanitation. Yet, as 2030 looms closer, the complexity of achieving this target becomes apparent, with issues far surpassing basic water infrastructure and utility challenges. The underlying problems lie in broader spheres such as governance, policymaking, and financing.

Main body The global landscape of water management is marked by complexities that transcend the operational troubles of water utilities. Financial sustainability is a monumental task. And while it is true that water utilities struggle with revenue generation, the broader picture reveals systemic challenges. The true cost of water provision often extends to ecosystem services such as watershed protection. Often, these services are not internalized in the revenue models of utilities but are typically subsidized by governments or simply not considered. Balancing affordability for users with cost recovery for service providers, however, is not just an arithmetic exercise. It is also a question of equitable policies. Non-revenue water (NRW), resulting from physical losses such as leaks, theft, and inaccurate [or lack of] metering, exacerbates existing financial strain. Annual NRW losses are estimated at an astonishing 126 billion cubic meters, costing roughly USD 39 billion. But at the most fundamental level of achieving SDG 6 is misgovernance. Effective water governance demands consistent policies, coherent collaboration among diverse stakeholders, and comprehensive strategies that cater to specific regional contexts. Current models often suffer from fragmented policies, inadequate public-private partnerships, and weak engagement mechanisms. A glaring gap exists between academic advancements in water management and their practical implementation in policymaking. Moreover, international cooperation, while vital, reveals an unequal landscape in knowledge exchange. Knowledge transfer is often skewed, favoring dominant nations while sidelining voices from the Global South. This emphasizes the need for an inclusive, equitable, and context-specific global cooperation model.

Conclusion The road to realizing SDG 6 is multifaceted, and while on-the-ground solutions are essential, the real success lies in addressing the foundational challenges. This requires innovative financial solutions, reimagining water governance structures, and ensuring all voices, especially from the Global South, are heard and integrated into global policies. As 2030 nears, it is the synergy of governance, finance, and technology that will ultimately make clean water and sanitation a reality for all.

*Correspondence:
Jaivime Evaristo
j.evaristo@uu.nl
Full list of author information is available at the end of the article

Introduction

In 2015, the leaders of UN Member states united behind an audacious vision: achieving 17 Sustainable Development Goals (SDGs) aimed at ending poverty, protecting the planet and improving the lives and prospects of everyone, everywhere. Slated for completion by 2030, the stark and sobering disconnect between ambition and reality becomes apparent as we approach the halfway mark. Particularly prominent is the lack of progress on SDG 6. This goal not only prioritizes the provision of drinking water, sanitation, and hygiene (WaSH) services, but also emphasizes the sustainable management of water resources globally. The vision captures essential advancements related to water access, pollution reduction, management of water across boundaries, enhancement of water use efficiency, and curtailment of unsustainable water withdrawals.

Despite noble intentions, nearly 30% of humanity still lacks access to safely managed drinking water [1], A staggering 1.7 billion people lack basic sanitation [1]. Regardless of economic status, pollution continues to deteriorate water quality in numerous rivers across Latin America, Africa, and Asia [2]. Globally, vital and delicate wetlands are shrinking at an alarming rate of 0.2% annually [3]. Progress on transboundary cooperation has remained limited, and in some areas where hydropower is growing in importance, geopolitical tensions have increased. Approximately half of the world's population experience severe water scarcity for at least 1 month each year due to climatic extremes and land degradation, among other factors [4]. Concurrently, growing global population, along with increased industrialization, urbanization, and shifting consumption patterns, intensifies the demand for water resources worldwide [5]. These challenges are set against the backdrop of rapid global change.

In perspective: climate change, SDG 6, and institutional failures

Climate change undeniably influences the water cycle, increasing evaporation and altering precipitation patterns across regions [4]. For example, climate-induced changes in the water cycle are exacerbating water shortages in arid, semi-arid, and Mediterranean regions by inducing long-term declines in annual precipitation [6, 7] and increasing the threats posed by salinization [8, 9]. These not only make water availability less predictable but also amplify existing challenges. However, while climate change contributes to the unpredictability, it is crucial to understand that many water crises are primarily products of mismanagement and lack of political will, rather than direct outcomes of climate change.

Droughts, floods, and other hydrological phenomena have been part and parcel of our planet's history. The current observed fluctuations over the past 5 years, however, were unprecedented even by 2018's consensus [10]. But, even though climate change does aggravate these hydrological phenomena, in the context of domestic water supply, it is management and political prioritization that have a more prominent role to play. It is vital to acknowledge that a vast majority of nations use less than 10% of their total water for domestic purposes. In a well-managed system with political backing, this should, in principle, suffice to provide a significant portion of the population with clean drinking water. Sadly, this is not the case. This suggests that the core issue might lie more in governance than in climate change.

Consider the melting of non-polar glaciers, notably in the Hindu-Kush Himalayas. While their accelerated retreat due to rising air temperatures and black carbon deposition raises long-term water availability concerns, in the short-to-medium term, glacier-melt has augmented water supply for millions [11]. Such nuances emphasize the need to approach water challenges with a balanced perspective, acknowledging benefits where they arise while planning for future risks.

The 2022 flood in Pakistan provides a case in point. While it was triggered by heavy rainfall, the primary contributor to its devastating impact was the lack of disaster prevention planning and execution [12]. Similar climatic events in countries such as India and Bangladesh would likely have resulted in significantly less damage, owing to their enhanced preparedness. That is, relative to Pakistan's. Furthermore, focusing solely on flooding obscures a critical issue. Many regions in Pakistan, like several other developing Asian nations, did not have access to "safe drinking water" even before the flood. Piped water, while accessible, often requires household-level treatment before consumption.

Another case in point is the 2023 dam failure in Libya. While Storm Daniel was undoubtedly a force to reckon with, it was the long-term negligence in the design, construction, and maintenance of the Darna and Mansour dams that rendered them vulnerable. Decades of neglect and poor upkeep culminated in the disaster that ensued. Thus, attributing the dam failures solely to climate change or Storm Daniel might be an oversimplification.

Thus, while climate does play a role, it is critical to understand the multifaceted nature of water-related challenges, from systemic mismanagement to varying socio-economic realities and infrastructural disparities. Alongside addressing the tangible impacts of climate change (SDG 13), it is equally vital to tackle institutional challenges and prioritize effective water management for a holistic approach to achieving water security.

These issues extend beyond mere statistics and observations; they underline broken commitments, poor governance, and reluctance to work together in championing sustainable solutions. If we don't quadruple our current progress rate for SDG6, billions will still lack access to clean water and sanitation by 2030 [13]. Yet, there is little evidence that any acceleration in effort is occurring or emerging [14]. Why has this occurred? In this Debate contribution, we outline inter-related institutional challenges that exist in pursuing SDG 6. These challenges relate to ensuring funding to build and sustain infrastructure, committing to sustainable management of water resources, and providing stronger governance needed to evoke change.

Institutional challenges

Challenge 1: Financial disenfranchisement

Underfunding

The financial gaps for achieving SDG 6 are considerable. Estimates suggest a global need ranging from USD 30 billion to a daunting USD 1.1 trillion per year [15]. Estimates based on Integrated Assessment Models, which take into account the impacts of climate change, range between USD 445 and USD 885 billion annually [15]. Achieving universal access to WaSH services alone necessitates an annual investment of USD 28.4 billion [16]. Aiming for safely managed services would triple these costs to USD 86.9 billion. The typical funding streams – Tariffs, Taxes, and Transfers – are generally unable to cover the full costs required for ensuring the provision of adequate WaSH services, let alone capacity expansions driven by growing demand [17–19].

The funding landscape also reveals significant regional disparities among end users. Much of the Global South grapples with funding shortages for critical water projects [20]. For instance, in Southern Africa, there's a noticeable deficit in investments for WaSH services [21]. This shortfall intensifies existing access inequities and contributes to adverse health outcomes [22]. The African water sector is further hamstrung by the chronic underpricing of water. Tariffs, in principle, should help narrow the expenditure gap. But often, tariffs barely cover costs, making it challenging to fund operations and maintenance (O&M) [23]. Paradoxically, water tariffs in Africa are already relatively high, even compared to other developing regions [24]. Thus, implementing higher tariffs may exacerbate water insecurity unless buttressed with measures that combat poverty [25].

It is important to acknowledge that while many discussions in the literature focus on the commodification of water supply and wastewater treatment, viewing these services merely as commercial enterprises overlooks their essential role as public goods. Such a perspective underscores the importance of state involvement, public investment, and state capacity to address social inequalities and ensure equitable access to these vital services.

Multilateral development banks (MDBs) partially plug the funding gaps in developing regions by providing official development assistance (ODA), which is aid from donor countries aimed at fostering development in regions identified as developing by the OECD [26]. ODA is delivered either directly from a donor country or through a multilateral agency. Over the last decade, MDBs provided over USD 15 billion for WaSH infrastructure worldwide [20]. However, the reported decreasing trend in ODA, down by 12% to USD 9.8 billion between 2015 and 2021, exacerbates the uncertainty of meeting the funding needs in areas with the greatest need and limited funding [27].

Conversely, much of the developed world generally enjoys better access to safe drinking water and high financial cost-recovery rates. Cost-recovery rates in the UK, France, Germany, and the Netherlands were close to or higher than 100% [23]. However, the Global North is not without challenges. Aging infrastructure, water contamination, and regional disparities persist [28, 29]. Areas with marginalized communities still face water issues. Over 2 million people in the United States, along with indigenous populations in Australia [30] and Canada, lack access to safe drinking water, indoor plumbing, or adequate wastewater disposal facilities [31]. The Flint, Michigan crisis underscores that even wealthy countries are not immune to systemic challenges causing public health emergencies linked to water quality [32–34]. U.S. water utilities are struggling with generally fixed and rising costs, while their typically variable revenue has been on a decline [35]. Such imbalance is making it increasingly difficult to maintain financial sustainability. In some European countries, the absence of metering results in water wastage and increased wastewater treatment costs [23].

Funding inequality

Inequality in funding further exacerbates these challenges. Funding often disproportionately favors urban areas, leaving rural regions, where the need may be greater, underfunded [20]. Economic instability and high levels of national debt can make it difficult for countries to secure additional funding for water and sanitation projects. Moreover, while the water sector does provide both public and private benefits, many cannot be easily monetized, which limits potential revenue streams [36]. The current financial system, with its macro and micro disparities, is ill-equipped to sufficiently fund crucial water investments [37]. Of the three financial mechanisms for funding water projects in both developed and developing economies – public, corporate, and project finance – only the project finance model allows global capital markets to invest in countries with non-exchangeable currencies. But the investment costs often outweigh the potential profit from water projects [37]. In urban settings, investments in water distribution are more economically feasible in high-density areas. However, as population density decreases towards the outskirts, the financial viability drops. Furthermore, residents in high-density areas frequently resist any increase in their water rates, which could help subsidize the expansion of the system to the less economically viable zones.

Structural and operational inefficiencies, combined with lack of institutional capacity, limited data, analytical tools, and sector knowledge, add to the problem. Additionally, there is an evident mismatch in the supply and demand sides of finance, which discourages potential commercial investors due to high initial investment needs and extended payback periods [36].

Financial inequalities intensify these challenges. Richer areas usually have better funding, modern technology, and skilled workers. This allows for more advanced or higher-quality water systems. Meanwhile, poorer regions face outdated infrastructure, limited funds, and weak investment prospects. This growing gap does not just limit equal water access. It also blocks system upgrades and new water solutions for the most needy.

The transboundary nature of many water resources further complicates financing. There is a perceived high risk in investing in transboundary water projects, with the benefits often misunderstood or undervalued, leading to insufficient resources for water cooperation at this level [38, 39].

International aid and ODA, while useful, are not a panacea. Often, such aid brings about long-term sustainability issues, with loans carrying conditions that might not align with a nation's unique water and sanitation needs. Mismanagement, corruption, lack of political will, and intricate regulations further impede the impact of these funds, slowing project implementation and escalating costs. Ranging from high-level abuses to petty bribery, corruption also results in substandard infrastructure, and inequitable resource distribution. These challenges not only make water services unaffordable for many but also perpetuate cycles of poverty and deepen social disparities.

Challenge 2. Financial sustainability

One pervasive challenge for water utilities worldwide is financial sustainability [40]. Water utilities struggle to generate sufficient revenue to cover O&M costs [19]. The true cost of water supply also encompasses the payment for ecosystem services (PES) such as watershed protection, reforestation, stream bank protection, and increased infiltration, which are typically subsidized by governments, when implemented. The issue is compounded by the complexity of balancing affordable tariffs for consumers while ensuring cost recovery for service providers [19, 23].

It can be argued, however, that the core issue in financing water utilities is not the scarcity of funds, but the lack of sustainable financing models to cover both capital expenditure (capex) and operational expenditure (opex). Despite some utilities receiving capex funding from MDBs, without proper models, operational activities suffer in the long run. Donors are eager to provide funds for utilities with a solid financing model, as observed with Cambodia's Phnom Penh Water Supply Authority [41]. The majority of utilities, however, lack such models. Essential long-term water and sanitation services are achievable, and households should pay for these services either through tariffs or taxes, with only genuinely needy households receiving subsidies.

On balance, it can be argued that capital should be readily available for projects that are "bankable". Phnom Penh Water Supply Authority's success over 25 years with a strong governance and financial model is an example [42]. Thus, utilities lacking a credible financial model face challenges in attracting capital investment. However, this does not mean that addressing continuous and systemic waste is not essential for enhancing or at least increasing the financial sustainability of water utilities.

Non-revenue water (NRW), characterized by physical losses from leaks, water theft, inaccurate metering, etc., further contribute to the chronic financial unsustainability in the water sector. Current estimates report NRW losses of 126 billion cubic meters annually, incurring a substantial cost of USD 39 billion [43]. Globally, the median level of NRW, expressed as a percentage of system input, is estimated at 40% (IQR 15%), ranging from 4% in Singapore to 83% in Armenia (Fig. 1A). The global median NRW is 69 liters per capita per day (Fig. 1B), demonstrating that NRW losses are a globally prevalent issue. Their high rates indicate the essential need for substantial investments in water infrastructure to reduce losses and ensure the financial sustainability of the water sector worldwide. These figures underline the urgency in addressing this issue, as it reflects not only significant economic losses but also grave inefficiencies in global water resources management.

Technological innovations are crucial in reducing NRW by identifying system leaks and inaccuracies. Tools such as acoustic sensors, smart metering, and predictive analytics allow utilities to detect issues, educate consumers, and foresee potential failures. These advances lead to financial savings, improved water conservation, and reliable service.

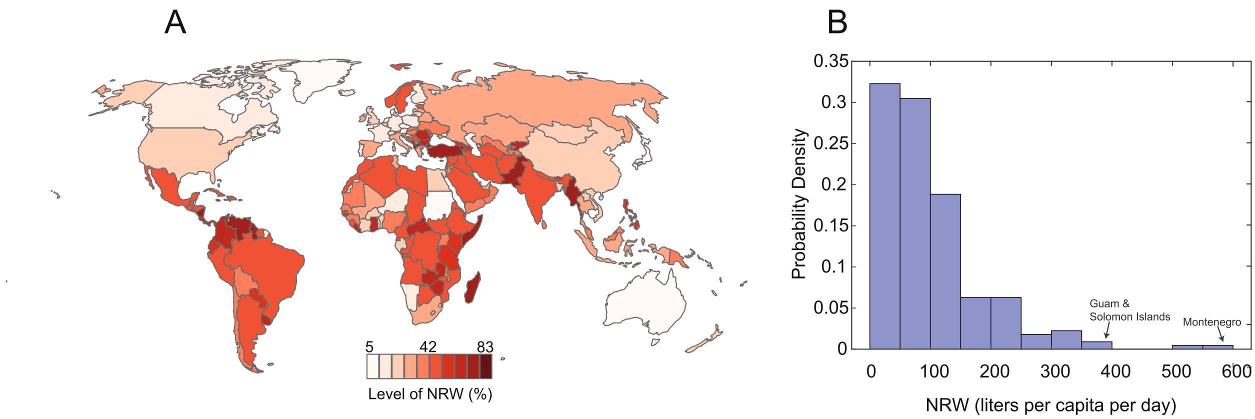

Fig. 1 Non-revenue water (NRW). **A** Global map of the level of NRW per country as a percentage of system input volume. **B** Density histogram of NRW per country in liters per capita per day. In the density histogram, the vertical axis representing 'probability density' indicates the likelihood of observing different values of NRW per capita per day within the dataset. Specifically, for any given value on the horizontal axis, the height of the histogram at that point reflects how common or frequent that particular NRW value is in the dataset. This allows for a more nuanced understanding of the distribution of NRW across countries, showing not just the number of occurrences but the relative frequency of each occurrence, standardized across the entire range of data. Source of NRW data is ref. [43]

NRW exerts significant financial strain on water utilities, amidst increasing water scarcity and aging infrastructure. NRW was the most important aspect influencing the financial sustainability of a water utility in Kenya [44]. The necessity for effective NRW reduction strategies in Malaysian water utilities was underscored to cater to the escalating water demand and bolster financial sustainability [45]. Reducing NRW has been shown to diminish environmental burdens and boost the sustainability of water supply systems in India [46]. Simply put, lost water is lost revenue. And lost revenue seriously undermines a water utility's ability to provide reliable and affordable services.

In addition to NRW, the continuous upward trend in O&M costs compounds the financial woes faced by water utilities. By 2029, O&M costs are projected to surpass capital expenditure by 1.6 times [19]. A survey of 605 utilities from developing countries showed that a mere 17% of them covered their O&M costs and achieved sufficient surpluses [47]. It is inevitable that utilities need to explore measures to reduce costs and increase efficiency in order to remain viable in the years to come.

Challenge 3. Misgovernance

Weak governance

Water governance, especially in terms of policy coherence and collaboration among governmental, private and NGO actors with asymmetric rights and responsibilities as well as differing interests and agendas [48], are recognized as crucial for managing water resources under different contexts. Paradigms such as Integrated Water Resources Management (IWRM) (SDG Target 6.5), is considered as crucial for adapting to the multifaceted challenges posed by climate change, urbanization, and shifting demographics. Yet, status quo understanding reveals a complex landscape of challenges across nations and cities, affecting both developed and developing regions that make its translation and adoption very difficult [49].

In many countries, from India to Mexico, Chief Executives of water utilities have short average tenures of about 18 months. Many lack technical or utility management backgrounds. Longer tenures of 6 years, split into two 3-year terms with specific key performance indicators, could solve around 60% of the problems faced by such countries [42]. This is even at current funding levels [42]. Cities like Dhaka and São Paulo witnessed improved utility performance after making their utilities autonomous and hiring headhunted Chief Executives. Notably, São Paulo's public sector owns the majority of utility shares, but the private sector appoints the CEO. This leads to improved water delivery and commercial financing [42].

Further, achieving SDG 6 requires strong public-private partnerships. Doing so requires leveraging private sector investments and bolstering governance, especially as the water sector is susceptible to "leakage". Corruption, for example, not only hampers environmental and social outcomes but also deters vital investments. Thus, a collaborative approach between public, private, and civil society is pivotal to ensure transparency and efficiency in water infrastructure financing.

Context matters and countries develop what can be considered as unique water management and governance models. In Latin America, Chile's market-driven model exhibits a lack of social participation due to lack of a more effective state regulation [50]. Mexico [51] and Brazil [52] seem to fare better in terms of community engagement. However, shared deficiencies across these countries emphasize concerns over financing, participatory mechanisms and gender and indigenous populations inclusivity in water governance.

Urban water governance challenges to meet SDG 6 are heightened by climate change effects. Focusing on Australia, Horne [53] emphasizes the importance of managing water demand and not simply focusing on supply. He underscores cost-effective demand reduction strategies that may be required to supplement more robust governance structures and enhanced prosecution of corruption if SDG goals are to be met.

A recent analysis on 200 cities [54], representing 95% of the global urban population, underlines the gravity of the urban water issue. A majority of global cities, especially in Africa, Asia, and Latin America, contend with significant deficits in water and sanitation governance frameworks. Targets related to basic drinking water supply, sanitation, solid waste management, and climate adaptability remain elusive for many. These underline the gap between current practices and the ideals set by the SDGs.

Policy challenges

The policy landscape remains rife with challenges in establishing and maintaining sustainable water systems. Islam and Islam [55] succinctly captures this challenge by highlighting the pervasive issue of "coordination gaps" in water quality management. This encompasses a broad spectrum of concerns, from policymaking to technology deployment, financing, monitoring, data management, and capacity building. A critical gap has been recognized between technical advancements and academic discourse versus the practical applications by policymakers [56]. This disconnect means that despite growing scientific literature supporting SDG 6, emphasis is still on water governance for surface and ground waters and wastewater collection and treatment, and emerging concepts like water security, water-energy-food nexus and reused water for potable use [57] are still in nascent stages. This, inevitably, leads to a policy lag, which underscores the need to bridge the divide between science and policy for more effective water governance frameworks.

International cooperation

Given the global nature of water challenges, international cooperation remains the cornerstone in achieving SDG 6. Bibliometric analysis reveals a concerning trend [56]. While collaborations amongst authors from dominant countries like the USA and UK are frequent, ties amongst authors from the Global South are sparse. This underlines an uneven playing field in knowledge exchange and cooperation. Moreover, the significance of indigenous and local knowledge in achieving water sustainability has to be studied much further [58]. The rare partnerships between Global South nations highlight a systemic imbalance where solutions are often driven by wealthier countries, neglecting culturally specific insights. With the UN SDGs emphasizing the integration of indigenous knowledge systems, international cooperation becomes critical to assimilating knowledge and information into mainstream water governance across countries.

The path towards achieving SDG 6 remains convoluted, marked by weak governance, policy challenges, and less-than-optimal international cooperation. Yet, it is crucial to remember that SDG 6 is not just about water. It is also about establishing sustainable ecosystems, ensuring public health, and building resilient urban infrastructures. Historically, policies, legal and regulatory frameworks and collaboration among institutions at different administrative levels have addressed water crises globally if effectively applied [59]. To do so will require a reinvigorated commitment to strengthening governance structures, bridging the policy gap, and fostering meaningful international collaborations.

Outlook

Achieving SDG 6 in view of the challenges that we outlined here demands global, coordinated innovation and action. Proper tariffs promote conservation, fund infrastructure improvements, and ensure system resilience. Capacity constraints in low- and middle-income countries need greater attention [60, 61]. Investing more in both fundamental and applied research will promote water management innovations [62, 63]. The notable funding shortfall, intensified by disparities in resource allocation and high non-revenue water losses, emphasizes the need for diversified financial strategies. Embracing innovative financial tools, including impact investments, green bonds, blue bonds, and other sustainable finance instruments [64] is essential. However, these tools must not exacerbate existing socio-ecological inequalities. International aid, while crucial, should be tailored to recipient nations' specific needs [65], emphasizing transparency, accountability, and capacity-building without increasing financial strain or social injustice.

Recognizing water as a fundamental right is imperative. The true potential of sustainable finance will be realized by aligning it with economic policies that account for externalities [37]. Moreover, comprehensive investment in infrastructure and technological innovation are paramount to achieving financial sustainability. The collective aim to overcome these barriers and realize universal access to water and better sanitation by 2030 hinges on this multifaceted, collaborative approach. This approach needs to combine robust governance (including sustained attention to corrupt practices), innovative financing and appropriate technology.

In the face of climate change's growing impact on water scarcity and quality, there are practical and positive steps we can take. Firstly, we need to focus on sustainable water management in water stressed regions, promoting water conservation and appropriate distribution. This includes harnessing traditional water harvesting methods and adopting innovative storage solutions. Secondly, addressing water contamination is crucial. We should invest in resilient wastewater treatment facilities and improve early warning systems to safeguard populations against extreme weather events. Recognizing the interconnected nature of these challenges, we must address their root causes. This involves combatting deforestation and pollution, which harm water quality and availability. Collaboration on a global scale, with particular attention to vulnerable low-income countries, is essential. This can be achieved through technology sharing, capacity-building, and financial support. Lastly, educating and empowering communities is vital. However, we must remember that while education can be a catalyst for change, many individuals with education might misuse their knowledge to manipulate the system. Hence, while building knowledge and tools at the local level is essential, addressing the unequal power dynamics is equally crucial to truly promote and support resilience.

Addressing the complex challenges of water governance is imperative as we look towards an increasingly non-stationary future [66]. Adopting context-aware governance models, tailored to regional nuances, is paramount. Bridging the academic-research and policy-implementation divide, utilizing concepts like the water-energy-food nexus, will address current shortcomings. Inclusive international cooperation, promoting knowledge exchange while respecting local intricacies, is fundamental for collaborative and transformative water governance.

Abbreviations

UN	United Nations
SDG	Sustainable Development Goals
NRW	Non-revenue water
WaSH	Water, Sanitation, and Hygiene
O&M	Operations and Maintenance
Capex	Capital Expenditure
Opex	Operational Expenditure
MDBs	Multilateral Development Banks
ODA	Official Development Assistance
PES	Payment for Ecosystem Services
IWRM	Integrated Water Resources Management
CEO	Chief Executive Officer

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Author details
[1]Copernicus Institute of Sustainable Development, Utrecht University, Utrecht, Netherlands. [2]Project Drawdown, San Francisco, CA 94118, USA. [3]School of Social and Environmental Sustainability, University of Glasgow, Glasgow, Scotland, UK. [4]Center for Social Sciences, Southern University of Science and Technology, Shenzhen, Guangdong, China. [5]James Horne and Associates, Sydney, Australia. [6]The Water Center, University of Pennsylvania, Philadelphia 19104, PA, USA. [7]National Institute of Geological Sciences, University of the Philippines, Diliman, Philippines. [8]The Andlinger Center for the Energy and the Environment, Princeton University, Princeton 08544, NJ, USA. [9]Faculty of Fisheries Technology and Aquatic Resources, Mae Jo University, Nong Han, San Sai District, Chiang Mai 50290, Thailand. [10]Water Resources Research Center, University of Hawaii, Honolulu 96822, HI, USA. [11]University of Glasgow, Glasgow, Scotland, UK. [12]Water Management International Pvt. Ltd, Tanjong, Singapore. [13]Third World Centre for Water Management, Atizapan Estado de México, Mexico.

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