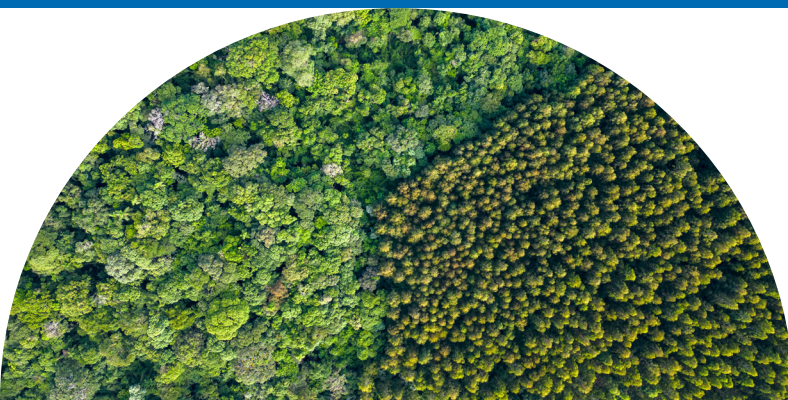


From Rain to Rivers

A SYSTEMS APPROACH TO THE GLOBAL
HYDROLOGICAL CYCLE IN GEF PROGRAMMING
A STAP INFORMATION NOTE
MAY 2026



STAP

SCIENTIFIC AND TECHNICAL
ADVISORY PANEL

*An independent group of scientists that advises
the Global Environment Facility*



From Rain to Rivers: A systems approach to the global hydrological cycle in GEF programming

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Executive summary

The profound changes to the environment at local, regional, and global levels continue to destabilize the global hydrological cycle and its numerous interconnected flows of water and moisture. Climate change, deforestation, and land degradation are simultaneously intensifying floods and droughts, eroding soil fertility, rendering hydrological flows ever more unpredictable, and undermining the freshwater systems that economies, food production systems, people, and ecosystems depend on. The hydrological cycle, as defined by the National Oceanic and Atmospheric Administration, refers to the continuous solar-driven movement and recycling of water in all three stages – liquid, solid, and gas – within the Earth’s atmospheric system. It involves the constant exchange of water between the ocean, freshwater bodies, atmosphere, and land, primarily through evaporation, transpiration, condensation, precipitation, and run-off.¹ The changes to the environment reported by flagship reports from the United Nations and non-United Nations scientific agencies (e.g. United Nations Environment Programme, Global Commission on the Economics of Water) continue to showcase the unpredictability that climate change is creating in the water cycle and the consequent need for a strategic mainstreaming approach to water management.

Water management has traditionally been organized around blue water: rivers, lakes, and aquifers. However, this approach is structurally incomplete and does not address the full extent of the hydrological challenge. The most consequential governance gap concerns green water, the rainfall stored in soils and returned to the atmosphere through vegetation, and atmospheric moisture flows, which carry water vapour across countries, regions, and continents. Green water connects communities and countries that share no physical water basin. However, these flows remain almost entirely absent from formal legal, policy, and institutional frameworks and have not received sufficient attention in projects and investments either.

The hydrological cycle needs to be governed as a global common: managing blue and green water together, across nested scales, from local watersheds to transboundary basins to the global atmosphere; attaining coherence from the source to the sea and across sectors such as the environment, agriculture, energy, climate, and finance; and meaningfully including Indigenous Peoples and local communities through whole-of-society approaches across governance levels.

The Global Environment Facility (GEF) is in a unique position to achieve these objectives and can lead in addressing the hydrological cycle in all its complexity, ensuring that the many benefits it provides are maintained and strengthened. As outlined in this paper, the GEF can:

- Expand the International Waters portfolio to blue–green water, embedding green water dynamics and atmospheric moisture flows into project design and monitoring frameworks from the outset. This can be done by in the GEF’s integrative program on drought and including green water dynamics in the GEF’s Biodiversity and Climate Change focal areas.

¹ NOAA (2023).

- Embed considerations of hydrological connections across all focal areas in the GEF, using the Integrated Programs as natural cross-focal vehicles.
- Support coherence among partners, such as multilateral environmental agreements, regional bodies, basin organizations, national governments and stakeholders, and the development of shared frameworks and structures to advance understanding of the importance of water governance in enhancing transboundary cooperation and improving the delivery of global environmental benefits and socioeconomic and peace co-benefits.
- Close evidence and knowledge gaps by supporting research on undermonitored water flows, advancing data sharing and capacity building, and systematically capturing and disseminating lessons crucial to water governance within and beyond the water sector.

1. Introduction

The hydrological cycle is the connective tissue of the Earth system (Box 1). Through the recycling of water in the atmosphere, it regulates precipitation patterns, shapes soil moisture and land productivity, sustains terrestrial and aquatic biodiversity, and underpins the freshwater flows that societies and economies depend on. Climate change is destabilizing the hydrological cycle: higher temperatures increase evaporation and atmospheric moisture, making the system more volatile, bringing heavier rainfall and flooding in some areas, and bringing greater soil drying and water scarcity in others. These conditions drive longer, more severe droughts while accelerating soil erosion, land degradation, and declines in soil fertility, undermining vulnerable livelihoods. Yet the pressures on the hydrological cycle extend beyond climate. Upwind land-use change, governance failures, and environmental degradation progressively alter moisture supply to downwind basins, often in a transboundary manner, in ways that no single country can address alone.²

These dynamics make the hydrological cycle best understood as a shared system that crosses national boundaries; connects not only people, societies, and countries but also the climate and biodiversity crises; and underpins nearly all the United Nations Sustainable Development Goals. The Global Commission on the Economics of Water (GCEW) – a platform of policymakers, international organizations, and experts that aims to address new dimensions of integrated water management in the Anthropocene – highlighted, in 2024, the global commons nature of the hydrological cycle.³ Like other global commons, the hydrological cycle requires collective stewardship, through governance arrangements that span sectoral, institutional, and national divides, to prevent its resources from being depleted and its benefits from being lost. This Scientific and Technical Advisory Panel (STAP) Information Note brings these elements together and calls for water to be addressed in an integrated manner that considers all the related interdependencies and that generates global environmental benefits (GEBs) and socioeconomic co-benefits, including contributions to peace and stability.

² GCEW (2024).

³ GCEW (2024).

Box 1: The global hydrological cycle: Viewing blue and green water in an integrated manner

The **global hydrological cycle** is the movement of water on, above, and below the Earth's surface. The cycle includes not only **blue water** in the form of rivers, lakes, and aquifers – the bloodstream of the biosphere, which have so far been the primary focus of water management – but also **green water**, the portion of water that infiltrates the soil, is stored by plants, and moves between land, water bodies, and the atmosphere through evapotranspiration. Green water, despite its often limited visibility, is as essential as blue. Together, blue water and green water, and the watersheds, precipitation sheds, and evaporation sheds they create, form the hydrological cycle, which is essential for all life on Earth.

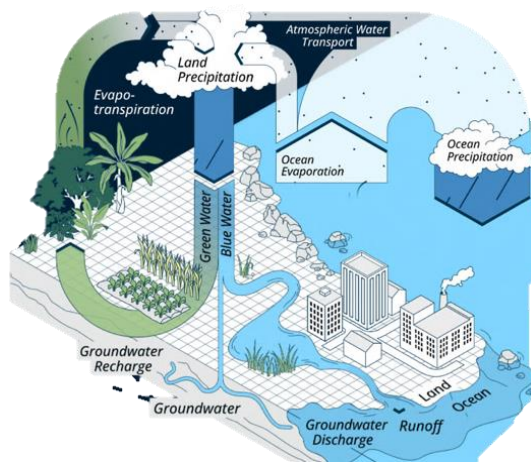


Figure 1: A conceptual illustration of the hydrological cycle

Atmospheric moisture transport refers to the transport of water vapour by wind and atmospheric circulation patterns, including large-scale phenomena such as atmospheric rivers, the arteries of the global hydrological cycle, which play a significant role in transporting water, contributing to the long-term atmospheric moisture network.⁴ These bands of concentrated water vapour link hydrological processes across regions, replenishing both blue and green water sources.⁵ Atmospheric moisture flows are a key mechanism in making the global hydrological system a global commons system, transcending national and regional boundaries. As such, disruptions of these rivers in one locale can shape hydrological patterns for both blue and green water across distant regions. The 2024 Global Commission on the Economics of Water report, *The United Nations World Water Development Report 2025*, and numerous others have highlighted the importance of these interconnected systems through examples and principles, especially in the context of their contribution to achieving the Sustainable Development Goals, their impacts across diverse ecosystems, and their role in influencing human well-being.⁶



Figure 2: Global terrestrial atmospheric moisture connection between countries⁷

⁴ De Petrillo et al. (2025).

⁵ De Petrillo et al. (2025).

⁶ GCEW (2024); UNESCO World Water Assessment Programme (2025).

⁷ GCEW (2024).

2. The global hydrological cycle: A foundation for climate, nature, and resilience

The global hydrological cycle underpins environmental health, human well-being, and economic activity at every scale, including food production, industrial processes, energy production, sanitation systems, and data infrastructure, all of which depend on a stable and predictable supply of freshwater. However, the increasing demands of modern economies, coupled with consumption patterns, are exceeding planetary boundaries (with seven of the nine boundaries already crossed), driving physical changes in the water cycle.⁸ These changes are further intensifying the unpredictability of rainfall patterns and accelerating the depletion of freshwater resources through multiple interconnected pathways.⁹ As a result, a growing number of economic sectors are contending with the effects of diminishing freshwater availability.

Understanding how climate change and human activity jointly shape hydrological processes offers critical insight into how ecosystems must be maintained to secure water resilience in an increasingly unstable climate and thus maintain and enhance GEBs in the future. Climate change is actively destabilizing the hydrological cycle. As global temperatures rise, the atmosphere's capacity to hold water vapour increases by approximately 6–7% per degree Celsius of warming, intensifying the hydrological cycle and increasing the frequency and severity of both droughts and floods.¹⁰ Driven primarily by human-induced climate change and nutrient pollution, oceans are becoming increasingly oxygen deprived: rising water temperatures reduce oxygen solubility and weaken the deep water mixing that replenishes the ocean interior, while agriculture and industrial run-off fuel oxygen-consuming algal blooms that create widespread “dead zones”.¹¹ The slowing of ocean ventilation continues to have significant consequences for marine ecosystems, global biogeochemical cycles, and human societies, mainly by forcing marine organisms upwards into warmer shallower waters, increasing competition for resources, and increasing exposure to surface pressures.¹² Simultaneously, deforestation and land degradation are depleting green water stocks, weakening the land–atmosphere feedback that generates nearly half of all rainfall.¹³ The ongoing loss of wetlands, peatlands, and soil moisture further reduces the planet's capacity for carbon sequestration, contributing to a reinforcing loop between water loss and climate deterioration.¹⁴

⁸ Planetary Boundaries Science (2025); Richardson et al. (2023).

⁹ Douville et al. (2021).

¹⁰ Stojanovic et al. (2026); Koutsoyiannis (2020).

¹¹ IUCN (2019); Limburg et al. (2020); UC San Diego (2026).

¹² Hogikyan et al. (2024).

¹³ Deforestation and land degradation deplete green water stocks by destroying the vegetative cover and soil structure that retain moisture, causing rainfall to run off rather than infiltrate and leaving soils compacted and unable to hold water. This also weakens the land–atmosphere feedback: healthy forests recycle moisture back into the atmosphere through transpiration, sustaining a continental “biotic pump” that generates nearly half of all inland rainfall. As forests are cleared, transpiration declines, atmospheric moisture drops, and rainfall weakens, a self-reinforcing cycle that progressively erodes the green water stocks that ecosystems and agricultural systems significantly depend on. Te Wierik et al. (2021); Damania et al. (2025).

¹⁴ GCEW (2024).

Crucially, these atmospheric moisture flows connect regions in ways that have nothing to do with how rivers flow, creating transboundary interdependencies between countries in addition to those already existing in the form of shared rivers, lakes, and aquifers; a country can therefore affect another's rainfall without sharing a river basin at all.¹⁵ Depending on their net position as importers or exporters of atmospheric moisture, some countries may be acutely dependent on land-use decisions made in countries with which they share no river basin whatsoever. Inland and landlocked countries, for instance, frequently rely on moisture that evaporates in neighbouring states, making their water security contingent on governance and land management choices entirely beyond their jurisdiction.¹⁶ This creates governance relationships and potential areas of conflict that existing international water law, built around basins, was never designed to address. Multi-level governance – across sectors and across spatial scales – is therefore needed. Boxes 2 and 3 illustrate how disruptions to the hydrological cycle play out across different contexts, drawing on the Amazon and Congo basins as regional examples of the same global challenges.

¹⁵ Te Wierik et al. (2021).

¹⁶ Posada-Marin et al. (2024).

Box 2: The Amazon and the global hydrological cycle

The Amazon rainforest, spanning 7.8 million km² across eight countries and home to 47 million people and nearly 13% of all known species on Earth, is far more than a regional ecological treasure; it is a critical engine of the global hydrological cycle. At the heart of this function are not only the Amazon's blue water rivers but also its aerial rivers (green water) – vast atmospheric streams of water vapour generated by the transpiration of its forests, connecting the Amazon to the Andes and the Atlantic¹⁷. As the *Amazon Assessment Report 2025* notes, these moisture flows are critical to water security, agriculture, energy, and livelihoods across much of South America. The Amazon's accelerating degradation represents one of the most consequential threats to planetary water security in human history.

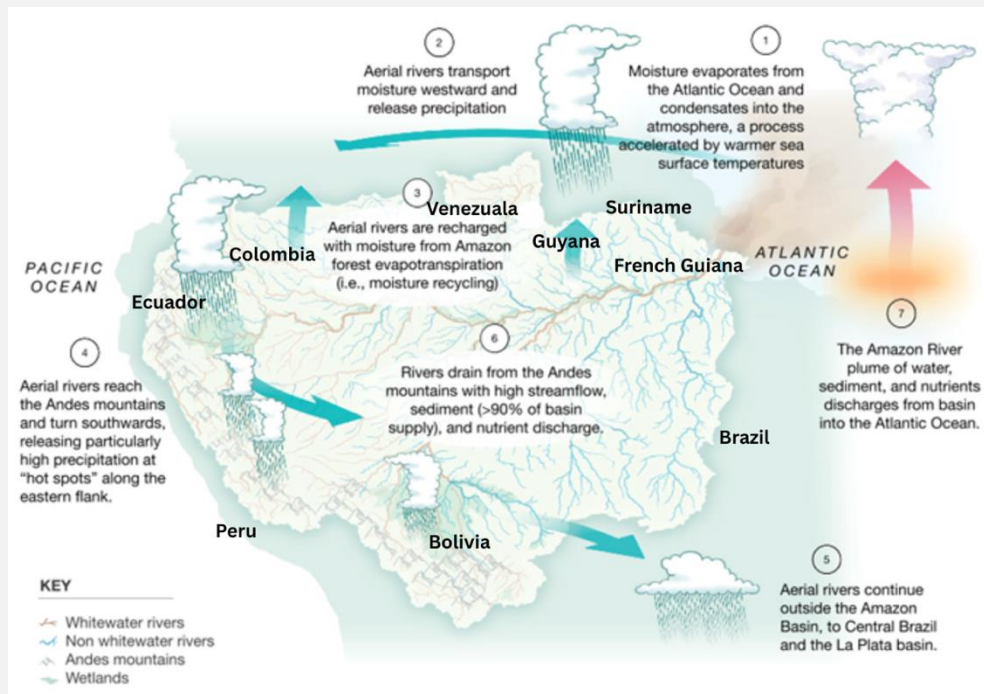


Figure 3: Processes along the Andes–Amazon–Atlantic hydroclimate pathway.¹⁸

But they are also highly vulnerable. The *Amazon Assessment Report 2025*¹⁹ noted that the extreme droughts of 2024 in the Amazon, driven by the synergistic effects of deforestation and climate change, triggered large-scale wildfires whose smoke spread across the South American continent to densely populated urban centres, increasing respiratory and cardiovascular disease, while simultaneously reducing moisture flows that sustain rainfall in Brazil's agricultural heartland. The report indicated that roughly 100 million hectares (about 18%) of the Amazon have already been deforested, with an additional 193 million hectares considered fragmented. This loss and fragmentation disrupt the ecological continuity that sustains the evapotranspiration rates necessary to maintain these atmospheric flows. The expansion of illegal mining, illegal logging, and industrial monocultures continues to fragment forests, displace Indigenous communities, and poison river systems with mercury. The report warns that the synergistic effects of land-use change and climate stress may be pushing the Amazon towards a tipping point, beyond which it could shift irreversibly to a degraded, savanna-like ecosystem, permanently losing its capacity to regulate climate, store the equivalent of 15 to 20 years of global carbon emissions, and sustain the aerial rivers that feed rainfall – a collapse that would not remain contained within South America but would propagate through global circulation patterns²⁰.

¹⁷ Meineke (2024).

¹⁸ Beveridge et al. (2024).

¹⁹ Science Panel for the Amazon (2025).

²⁰ Weng et al. (2024).

Box 3: The Congo River Basin

The hydrological cycle of the Congo River Basin, one of the world's largest and most complex river systems, is strongly shaped by dense tropical forests that regulate the exchange of water between land and air, with consequences well beyond the basin. Moisture evaporating from the Atlantic Ocean is transported inland, condenses over the basin, and falls as rain. This sustains the mighty Congo River and its tributaries in the form of green water but also replenishes soil moisture and thus green water in the basin, supporting dense tropical forests and other forms of land use, covering an area of close to 3.5 million km² that represents the world's second-largest tropical rainforest ecosystem.²¹

The Congo River Basin includes approximately 70% of the Congo River catchment and all the Ogooué and the Sanaga watersheds. The northern section of the Congo River watershed flows through extensive Miombo woodlands, spanning Angola, the Democratic Republic of the Congo, the United Republic of Tanzania, and Zambia, one of the most ecologically significant corridors on the continent. These forests function as a vital genetic reservoir, sustaining exceptional biodiversity and supporting Indigenous communities whose deep knowledge of the landscape underpins generations of sustainable land management. This biodiversity is not merely an ecological asset; it is the foundation of regional economic life for an estimated 120 million people. National economies across the basin depend heavily on the goods and services ecosystems provides, including timber, ecotourism, hydroelectric power, fisheries, agriculture, and river transportation



Beyond biodiversity, the Congo River Basin performs critical hydrological functions. Its forests and wetlands absorb and gradually release water, buffering against floods and maintaining water quality through the natural filtration of sediments and pollutants. At a broader scale, the basin also drives cross-continent atmospheric moisture transfer, recycling vast quantities of water vapour that sustain rainfall patterns far beyond its own borders.²² Deforestation, land degradation, and climate change increasingly disrupt the balance provided by the Congo River Basin. Deforestation in the Democratic Republic of the Congo, for instance, has risen to over 1 million hectares per year in the last 25 years, resulting in about 500 million tonnes of carbon dioxide emissions annually. This could potentially alter or disrupt atmospheric river pathways and the distribution of rainfall originating from the basin, leading to reduced rainfall, lower river flows, and droughts within and beyond the basin.

Figure 4: The geographic limits and major rivers of the Congo River Basin²³

²¹ Sori et al. (2017) ; Munday et al. (2023).

²² Libalah et al. (2026).

²³ Science Panel for the Congo Basin (2025).

3. Governance of the global hydrological cycle: Fragmented, incomplete, and incoherent

While the hydrological cycle is global in nature, it also comprises numerous subsystems, each with its own watersheds, evaporation/precipitation sheds, and sub-sheds. Managing water resources is, therefore, a complex multilevel endeavour, further complicated by the fact that both blue and green water transcend national boundaries.

Traditionally, water resources have often been managed along political boundaries. Recent decades have seen a growing, yet still insufficient, move towards integrated water resources management and transboundary water cooperation to manage the world's more than 300 shared surface water resources and more than 400 transboundary aquifers.²⁴ Green water flows, however, have largely been absent from formal governance structures, including legal, policy, and institutional mechanisms.²⁵ While recognition of the vital importance of green water flows and explicit consideration of the hydrological cycle in policy and action remain far from universal, some countries recognize blue and green water principles meaningfully. Rijkswaterstaat of the Kingdom of the Netherlands, the government department responsible for water management and infrastructure, has embedded climate adaptation into its national planning frameworks, including in the National Delta Programme 2026. This programme includes ongoing efforts to monitor salinity, manage freshwater availability, and advance nature-based solutions through multilevel governance and intergovernmental cooperation. Critically, water challenges in the Kingdom of the Netherlands are not addressed in isolation; they are approached as a whole-of-society concern, resulting in a wide range of initiatives aimed at strengthening climate resilience across the country and internationally. Examples of such projects are the Boosting Flood Resilience in Estuarine Systems (BONSAI) project,²⁶ the EM Flood Resilience initiative,²⁷ and Polder2C's (a cross-border climate adaptation strategy),²⁸ among others, including research that tracks blue and green water conditions.²⁹

Beyond the water sector, among the various multilateral environmental agreements, including the ones the Global Environment Facility (GEF) serves, only a few address hydrological flows and their complex links to other environmental aspects. The United Nations Convention to Combat Desertification, for instance, explicitly highlighted the role of green water and the hydrological cycle in its first *Global Land Outlook*, and subsequent work has emphasized how land degradation and water scarcity are closely linked, but this has so far resulted in little specific action under the convention.³⁰

²⁴ McCracken & Wolf (2019); IGRAC and UNESCO-IHP (2025).

²⁵ Borgomeo et al. (2026).

²⁶ Rijkswaterstaat (2026a).

²⁷ Rijkswaterstaat (2026b).

²⁸ Rijkswaterstaat (2023).

²⁹ Rijkswaterstaat (2026c).

³⁰ UNCCD (2017); UNCCD and FAO (2020).

Overall, the necessary parts of a comprehensive multilevel governance system for water resources – taking an integrated perspective across blue and green water and a multilevel approach from local to global hydrological flows – are lacking.

This lack of effective governance of the global hydrological cycle and its various dimensions, in particular green water and atmospheric moisture flows, is due to a combination of factors: insufficient data, knowledge, and technical capacity to address these challenges; sectoral approaches and incoherent policies that limit integrated governance; and lack of financial resources and investments for much needed action.

Some of these challenges are increasingly acknowledged and addressed. The World Meteorological Organization, for instance, has been advocating for hydrological data to be treated as a public good, developing guidelines for better data exchange, and exploring the use of innovative technologies, especially relating to remote sensing. The United Nations Environment Programme has called for better integration of water across other policies and the mobilization of investments and finance accordingly.³¹ The GCEW called for a fundamental shift in management, acknowledging that the global hydrological cycle is a global commons.³² The GCEW also suggested specific measures to support better management of the global hydrological cycle and called for transforming water governance, addressing economic tools, managing externalities, and spurring innovation.³³

Other actors have followed suit. The African Union, for example, has released its Africa Water Vision 2063 and Policy,³⁴ which aims to achieve universal access to water and sanitation, sustainable water availability, a thriving blue economy, good governance and leadership, and transboundary cooperation.³⁵ The European Union is addressing green water and the global hydrological cycle through various studies and opinions, such as the European Economic and Social Committee’s opinion “Water diplomacy in action: Restoring the global hydrological cycle”, which explores how water diplomacy can help achieve a paradigm shift in land use and water management.³⁶

Integrating global hydrological cycle considerations into water management (i.e. irrigation management for agriculture, groundwater extraction, river basin commissions, shared dam and reservoir operation agreements), however, should not come at the expense of attention to other scales of governance, whether local watersheds, large transboundary basins, or broader regional and interregional evaporation–precipitation sheds. Management will be required at all these levels, guided by the subsidiarity principle³⁷ and based on the many existing water management

³¹ Andersen (2025).

³² GCEW (2024); Andersen (2025).

³³ GCEW (2024).

³⁴ African Union (2026).

³⁵ African Ministers’ Council on Water (2026); African Union (2026).

³⁶ See: <https://www.eesc.europa.eu/en/our-work/opinions-information-reports/opinions/water-diplomacy-action-restoring-global-hydrological-cycle>.

³⁷ The principle of subsidiarity dictates that matters should be handled by the smallest, lowest, or least centralized competent authority, with higher-level bodies (like federal governments or regional bodies) intervening only when local levels cannot effectively resolve an issue. It protects against centralization and promotes local autonomy, human dignity, and efficient

mechanisms, from the 1997 UN Convention on the Non-Navigational Uses of Transboundary Watercourses (UN Watercourses Convention) and the 1992 Convention on the Protection and Use of Transboundary Watercourses and International Lakes (UN Water Convention) to the numerous basin treaties, to the array of national and subnational water laws, policies, and institutions.

Given the number of mechanisms, it is important to ensure policy coherence between them. Such coherence requires bridging existing governance gaps, the most prominent one at the global level being representation from Indigenous Peoples and local communities. Moreover, policy coherence needs to be ensured across the various sectors that are shaping and being shaped by the movement of blue and green water: environment, water, agriculture, infrastructure, urban planning, energy, health, education, finance, trade, tourism, foreign affairs, and disaster risk reduction. It also requires engagement among the various actors, from local entities (including Indigenous Peoples and local communities) to regional bodies, that play a pivotal role in shaping global water governance.

International instruments beyond the water sector that directly or indirectly address water or the factors and processes that shape the hydrological cycle and its various elements have a key role to play. Several international instruments already support this multilevel, cross-sectoral governance agenda. IW:LEARN advances learning and collaboration on international waters;³⁸ the UNESCO Intergovernmental Hydrological Programme provides the intergovernmental scientific cooperation needed to underpin sound water policy; the CGIAR Research Programme on Water, Land and Ecosystems drives research on water and agriculture for development; and the recently launched World Bank Group Water Forward program³⁹ works to deliver results at scale by combining government ownership, multi-partner financing, institutional strengthening, and coordinated global platforms. Together with numerous other initiatives, these instruments form an increasingly interconnected architecture for global water governance.

However, it is important to recognize that advancing more integrated approaches at broader, particularly global, scales introduce significant challenges, coordination complexities, and trade-offs. In recent decades, the basin level has been acknowledged as the most appropriate unit for analysis, planning, management, and legal and institutional arrangements for governing water resources.⁴⁰ The water-energy-food-ecosystem nexus has received increasing attention, but the focus has remained on blue water only.⁴¹

governance by keeping decision-making close to citizens. See <https://eur-lex.europa.eu/EN/legal-content/glossary/principle-of-subsidiarity.html>.

³⁸ IW:LEARN (the GEF International Waters Learning Exchange and Resource Network) is the knowledge management and learning platform for the GEF International Waters portfolio. It supports experience-sharing, replication of successful approaches, and capacity-building across projects through its online knowledge platform, portfolio results archive, visualization tools, targeted training workshops, regional dialogues, project twinning, webinars, and the biennial GEF International Waters Conference.

³⁹ World Bank Group (2026).

⁴⁰ Hoekstra (2011).

⁴¹ Mooren et al. (2025).

The increasing acknowledgement of the importance of green water and water flows that transcend even the boundaries of basins – so far, the largest hydrological management unit – reveals the need for an additional level of governance, expanding multilevel water governance to the hydrosched and precipitation shed level. This would make for a complex multilevel system that would need to operate in a coherent manner but for which instruments, mechanisms, and processes are still insufficiently developed. The GEF, with its unique experience in supporting the development and implementation of transformative arrangements for complex environmental challenges, can play a major role in strengthening and facilitating such effective multilevel governance.

4. GEF engagement across the global hydrological cycle

Across its programming, the GEF engages with the global hydrological cycle both directly in the International Waters focal area and in combination with other focal areas, yet often in a rather indirect manner. The Okavango River Basin project (GEF ID 12081), for instance, addresses water resources management in the basin in an integrated manner, from unsustainable land use and deforestation to climate change and from water resources infrastructure development to basin management. Given the Okavango River Basin's importance in green water storage and release, but also the threats it faces due to climate change and water resource developments, integrated approaches are of particular importance for ensuring GEBs but also for protecting socioeconomic co-benefits for the communities that depend on the river. In addition, the Okavango River Basin itself is affected by changing atmospheric rivers, especially from Central Africa,⁴² highlighting again the interconnectedness the hydrological cycle creates and the importance of managing water resources beyond individual basins.

Overall, GEF engagement still largely focuses on blue water, often in relation to climate change (e.g. the Okavango River Basin project; GEF ID 12081) and biodiversity (e.g. the transboundary basin of the Ubangi River project; GEF ID 11906). GEF engagement thus covers important elements of an integrated approach, but not to the extent possible.

GEF International Waters projects have thus far given limited attention to green water and atmospheric rivers, or the hydrological cycle more broadly, beyond the management of blue water and the links to climate change, biodiversity, or other matters. Projects addressing problems and barriers that affect the hydrological cycle – such as deforestation or land degradation – still insufficiently relate to the International Waters focal area or highlight the hydrological co-benefits the projects generate. Projects addressing challenges emerging – at least partly – from changes in the hydrological cycle, such as biodiversity loss or climate threats, often insufficiently address root causes located in hydrological patterns. The recently launched World Bank-implemented Medium-Sized Project (MSP) is the first MSP to explicitly address the global hydrological cycle and to focus on advancing investments that can improve the governance of water and moisture flows in an integrated and transformative manner.

⁴² Moses et al. (2023).

Projects from other focal areas increasingly acknowledge the importance of water – often still limited to blue water for the GEBs they work towards but often do not integrate water considerations with sufficient clarity (e.g. by explicitly incorporating measures that support water and moisture flows and the monitoring of related benefits or by effectively addressing hydrological causes of environmental degradation and designing programs to address them as root causes instead of only treating their symptoms). This is interesting, given that many GEF projects in other focal areas already undertake important work supporting the hydrological cycle. Forest and land management, specifically, are essential for the sustainability of green water stocks and flows, with the GEF’s work on these issues playing an important, yet often unintended and underreported, role in supporting the global hydrological cycle and all its benefits for people, ecosystems, and countries. The GEF’s work in the Amazon is one important example, with Amazon forest management under the Amazon Sustainable Landscapes Program also being a de facto engagement for the global hydrological cycle. An increasing focus on drought as a nexus topic between land, water, climate, and biodiversity also presents a promising approach to overcome silos, a core focus of the 2026 Scientific and Technical Advisory Panel (STAP) paper on drought.⁴³

The Integrated Programs (IPs), however, have so far paid limited attention not only to water in general but also to hydrological flows specifically, in spite of the importance of water for blue and green islands (Blue and Green Islands IP), sustainable cities (Sustainable Cities IP), and food security and food systems (Food Systems IP), as well as the critical importance of critical forest biomes (Amazon, Congo, and Critical Forest Biomes IP) and ecosystems (Ecosystem Restoration IP) in maintaining hydrological flows. Acknowledging the importance of conserving primary forests, including the Amazon and Congo, as highlighted earlier in this paper, presents an opportunity for the GEF to strengthen its contribution to protecting water and moisture flows.

5. Advancing the global hydrological cycle agenda in GEF-9: From fragmentation to integration

The global hydrological cycle, and with it all life on Earth, is undergoing rapid and complex transformations that can only be addressed through a more integrated approach to governing blue and green waters and the streams that connect them in a more integrated way. This paper has highlighted the importance of an integrated perspective on the entire hydrological cycle to maximize GEBs, as well as related co-benefits. The paper also points towards important opportunities for the GEF to move towards better integration and more ambitious transformation to address environmental challenges.

This paper has also acknowledged the challenges in addressing the complexity that originates from the highly multifaceted and interdependent nature of water in its various forms and its connections across ecosystems, sectors, countries, and continents. This complexity can make effective responses challenging as sectoral silos have to be bridged, multiple actors have to be

⁴³ STAP (2026).

coordinated, and persistent knowledge gaps have to be filled. However, over the course of GEF-9, there is opportunity to pursue these goals in four broad areas:

1. Integrating blue and green water across the GEF International Waters portfolio

- Expand GEF work beyond blue water as the primary unit of water management and incorporate green water dynamics into programming and into project planning, design, implementation, and monitoring. This could include incorporating green water elements in project design but also prioritizing initiatives that put blue–green water connections at the centre of the GEF’s work. The recommendations of the GCEW and the emerging activities of other actors – from academia to multilateral development banks (especially the World Bank) – can provide important guidance and opportunities for collaboration.
- Consider integrating green water and/or atmospheric river indicators into relevant International Waters projects and their monitoring systems, and into the broader GEF results framework, to better account for the entire hydrological cycle, strengthening the protection, management, and restoration of water and related ecosystems for a broad range of GEBs and co-benefits.
- Capture and share lessons on addressing blue and green water in an integrated manner across the International Waters portfolio –including project design, implementation, and monitoring – and across the entire GEF partnership and related actors, including partner countries and stakeholders. Leverage IW:LEARN’s network and related events, especially the biennial International Waters Conference, for knowledge dissemination.

2. Integrating hydrological links across GEF programming

- Better account for hydrological connections at the portfolio level to ensure that water’s function as a cross-cutting connector is fully leveraged across projects and within IPs, especially by strengthening the recognition of both blue and green water’s critical role in ecosystem health, biodiversity, climate adaptation, and multiple other GEBs. The development of a more elaborate taxonomy of such connections could be an important first step.
- Make hydrological connections explicit in the design of relevant projects in all focal areas, accounting for blue and green water connections as key elements of the planetary system. This could include addressing destabilizing precipitation patterns and their respective consequences in climate adaptation projects; addressing hydrological patterns as a source of biodiversity decline, both for individual species and for entire ecosystems; or addressing reduced blue water flows and green water elements in land degradation. Integrating water considerations in individual project or program theories of change and in future narratives or incorporating water metrics in the GEF results measurement framework or individual projects’ or programs’ monitoring frameworks, could help demonstrate and account for the GEBs and co-benefits a more integrated perspective on hydrological flows could produce. Incorporate an integrated hydrological perspective that captures the effects other sectors have on the hydrological cycle, and vice versa, into relevant GEF IPs and acknowledge water’s cross-cutting nature in the IPs. This perspective is particularly

important in the Blue and Green Islands IP, as well as the newly established Drylands and Drought Management IP, in which the GEBs and co-benefits attained through better managing hydrological flows can be strengthened and better demonstrated.

3. *Building capacity and political coherence among partners*

- Draw on relevant international scientific and policy frameworks to position the hydrological cycle as a connector that spans sectoral and institutional divides, and position the GEF as a key driver of progress, fostering cooperation and policy coherence across intra-basin and cross-basin actors, with a particular focus on relevant actors from the conservation, biodiversity, land, drought, and climate communities.
- Leverage the GEF's position serving multiple multilateral environmental agreements of relevance to the water cycle, and engaging with even more international and regional legal, policy, and institutional frameworks, to strengthen an integrated approach for water across these instruments. For instance, hosting regional workshops and dialogues, and providing global and regional platforms for high-level engagement, with examples from IW:LEARN, could offer opportunities to expand partnerships and develop actionable insights to effectively address multilateral environmental agreements.
- Support projects and programs to partner with relevant regional and basin organizations and relevant actors at all levels of water governance – encouraging a whole-of-government and whole-of-society approach, with a strong focus on Indigenous Peoples and local communities – to strengthen their existing and/or newly emerging work with an integrated perspective on blue and green water across ecosystems, countries, and regions. This work may include strengthening the required technical, human, and financial capacity for monitoring and observing the global hydrological cycle and its various flows as well as implementing adequate action to sustainably manage the cycle.

4. *Strengthening the evidence base of integrated management and financing*

- To ensure that the persistent data, information, and knowledge gaps on water flows – both blue and green water and their flows across ecosystems, countries, and regions – do not hamper progress, facilitate research and scientific endeavours to better understand water flows at all levels and the various impacts they are faced with in a rapidly changing Anthropocene world.
- Support the dissemination of knowledge and the capacity to engage on the basis of such knowledge among GEF partners. This could include supporting relevant research through appropriate projects (including MSPs) on particularly under-researched water flows or links to other sectors or connecting different knowledge actors to enhance synergies in knowledge generation and sharing. Leverage IW:LEARN's network as it has created spaces for cooperation, exchange, and capacity development (e.g. through regional MSP training in Latin America and the Caribbean), hosted work on global platforms (including the Pan-African Transboundary Dialogue), and made other significant achievements in this area.⁴⁴

⁴⁴ Leveraging IW: LEARN could help disseminate emerging knowledge on blue and green water flows, strengthen partner capacity, and facilitate cross-project learning on integrated hydrological management and financing approaches.

- Incentivize investments that support sustainable blue and green water management, including by better recognizing and valuing the multiple, often underappreciated benefits such approaches generate across sectors. This requires moving beyond siloed interventions and bringing together different focal areas in a coordinated way, particularly through the GEF IPs. From drought prevention and management to ecosystem restoration, and from biodiversity protection to climate adaptation, there is a compelling case for bringing together different focal areas in a coordinated way, particularly in work with the GEFs IPs. Addressing land degradation, biodiversity loss, and drought through a unified lens, rather than in isolation, unlocks compounding benefits, for example restored landscapes that simultaneously support wildlife corridors, replenish water catchments, and build community resilience, or drought-response measures that are designed from the outset to avoid soil degradation and habitat fragmentation. These coherent, integrative approaches generate shared wins across multiple ecosystems and sectors, while preventing the unintended harms that arise when interventions are planned and implemented without regard for one another.

Conclusion

The global hydrological cycle and its multiple water and moisture flows are facing challenges and undergoing transformations that no single sector, institution, or country can address alone. Meeting this challenge requires the GEF to move decisively from a focus on blue water flows and the governance of water through the water sector to an approach that embraces the full hydrological cycle. Such an approach would integrate green water dynamics, atmospheric moisture flows, and the blue–green connections linking ecosystems, sectors, and continents, and would harness the transformative potential of integrated solutions. Doing so would orient the GEF towards understanding and programming water-related concepts across the entire GEF portfolio in an integrative manner.

The GEF is well placed to position itself as a central driver of the integrated, cross-sectoral stewardship that water, as a global common, requires. Following this approach in GEF-9 would mark a substantive step towards governing water not simply as a separate focal area that addresses blue water challenges but as the connective tissue across all of Earth's systems.

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