EXECUTIVE SUMMARY

THE ESSENTIAL DROP TO REACH NET-ZERO: Unpacking Freshwater's Role in Climate Change Mitigation

Freshwater can make or break our ability to successfully implement many climate change solutions. This report presents why, where, and how freshwater should be integrated into climate change mitigation plans and activities.

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Contents

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Executive Summary

In the Sixth Assessment Report on Mitigation of Climate Change, the International Panel on Climate Change (IPCC) makes it clear that we need to act now: the findings show that greenhouse gas (GHG) emissions continue to rise, and current plans to address climate change are not ambitious enough to limit global warming to 1.5°C above pre-industrial levels – a limit necessary to avoid even more catastrophic impacts on people and ecosystems (IPCC 2022). With every fraction of a degree of global warming, climate change impacts will intensify. The IPCC therefore calls for an immediate and complete transformation of every sector of society. Emissions must peak by 2025 to achieve the 1.5° target as agreed in the Paris Agreement, and to reach the goal to halve greenhouse gas emissions by 2030 (UNFCCC 2015). Consequently, countries and companies are pledging to reach 'climate emissions neutrality' or 'net-zero greenhouse gas emissions', to try and achieve a balance between the carbon emitted into the atmosphere, and the carbon removed from it, which is in line with the 1.5° target. To that end, the IPCC has identified numerous climate mitigation measures that can provide a pathway to achieve rapid transition to net-zero emissions. Many of these measures have a direct link to freshwater.

Water is the foundation of successful mitigation action, as Earth's climate system and water cycle are deeply intertwined. Many of the transformations needed to reach climate emissions neutrality:

1. Depend upon a reliable access to freshwater.
2. Will have a significant impact on freshwater resources and/or ecosystems.

Functioning freshwater systems are essential for climate mitigation through measures such as reforestation, restoration of degraded ecosystems, and bioenergy with carbon capture and storage (BECCS). Some potential climate solutions even risk reducing mitigation effects if plans fail to assess and minimize water risks. Hydropower facilities with poor siting, design, and management, for example, can result in less power generation and greater emissions from impacted reservoirs. This is particularly important as most mitigation measures worldwide have an impact on freshwater resources and ecosystems. Therefore, the transformations of, for example, our food and energy systems must be accompanied by comprehensive analyses of water availability and impacts at local, regional, and global levels. At the same time, the water sector itself offers untapped mitigation potential: climate-smart water management, for instance, can significantly avoid and reduce emissions of carbon, methane, and nitrous oxide, emanating from urban water and wastewater management, and mismanaged or drained wetlands.

Nevertheless, the critical role of freshwater in climate mitigation is often overlooked for a number of reasons:

1. **Knowledge gaps** of the complex direct and indirect interrelations between freshwater and climate mitigation at global, national, and local levels.
2. **Data gaps** are leading to challenges for quantifying the climate mitigation potential.
3. **Lack of consideration of water-related risks and impacts.**
4. **Silo approaches** to governance, planning, and financing of climate change and water.
5. **Fragmented nature of global water governance** creates challenges when aligning water action with climate mitigation actions in ways that create synergies and avoid negative trade-offs.

Prevailing siloed approaches, i.e., a setup where interlinked issues such as climate, water, land, and sustainable development are conceptualized, governed, and financed separately, lead to missed opportunities for climate mitigation and pose risks to the successful implementation of measures taken, as well as fail to prevent and consider possible trade-offs.

By extension, the siloed approaches create barriers to climate mitigation. Integrated approaches are needed to overcome these barriers by identifying opportunities to reduce emissions and water stress, as well as to ensure that actions taken are resilient to water risks. Big investments in the many win-win solutions for climate and water security are necessary, while proceeding carefully where the potential for steep trade-offs is high.

Freshwater is essential to reach net-zero greenhouse gas emissions. In this report, we explain how the journey towards climate security requires massive, cross-sectoral efforts in improved management of water. It focuses on:

1. Climate mitigation measures that require or modify freshwater sources or freshwater-dependent social-ecological systems.
2. Climate mitigation options within the water and sanitation sector with upscaling potential.

The report also addresses the multiple freshwater-related synergies and trade-offs that exist between climate mitigation and adaptation measures, as well as other benefits of water-wise mitigation actions that work with nature and contribute to sustainable development, such as enhanced system resilience, functioning ecosystems, and enhanced biodiversity.

The findings attest to the urgent need to improve the understanding of the links between the many different climate mitigation measures, freshwater availability, and water management. While reviewing mitigation measures across sectors and biomes, for instance, in natural ecosystems, food production systems, and energy systems, the report provides guidance on how to move forward. It identifies high-potential water-related mitigation opportunities across the sectors and biomes where water management and Nature-based Solutions (NbS) can contribute to reduce GHG emissions and thus global warming. It further points out water-related risks to be avoided in mitigation planning, to prevent uninformed and therefore unsustainable GHG mitigation planning from negatively impacting water resources.

To that end, the report is structured as follows:

Part I: Setting the Scene on Freshwater's Role in Mitigation: A Physical Science and Governance Background

Part I of the report provides a background and context by introducing the biophysical interdependencies of freshwater's role for climate mitigation, and the governance context of climate mitigation measures.

Chapter 2

Chapter 2 focuses on the intricate relationship between climate and water in the larger context of the Earth system. It explains how **climate mitigation measures fundamentally depend on, and impact, freshwater resources and the water cycle**, and why a functioning freshwater cycle is crucial for climate mitigation measures to reach their full potential. For example, water stress can hamper energy production from hydropower, trigger carbon release from degrading forests, and hamper climate mitigation effects expected from measures such as protecting or sustainably managing these systems.

Climate mitigation measures can also modify land, climate, and water quality and quantity. For instance, irrigation-dependent plantations with measures such as BECCS, could unintentionally deplete local water resources, with detriments to the original ecological and carbon sequestering functioning of the impacted ecosystems. These changes happen on top of already shifting freshwater dynamics, such as droughts and floods caused by ongoing climate change. Combined, they could potentially trigger abrupt and irreversible ecohydrologic regime shifts that may not only affect the implementation and success of mitigation measures, but also threaten water security as a foundation of life for humans and ecosystems.

In the dynamic and hyperconnected Anthropocene, the relationships between water and climate mitigation can be remote, complex, and nonlinear. **Holistic system thinking approaches** are thus needed to account for freshwater's role, both in and for climate mitigation, to be able to take decisive and sustainable action.

Chapter 3

Chapter 3 illustrates that **strengthening governance is at the core of achieving water-wise climate mitigation**. The chapter provides an overview of the global governance frameworks and national instruments relating to climate change, biodiversity, land, water, and sustainable development including the United Nations Framework Convention on Climate Change (UNFCCC), the 2015 Paris Agreement, the Convention on Biological Diversity (CBD), the Convention to Combat Desertification (UNCCD), the Ramsar Convention, the UN Watercourses Convention, and the 2030 Agenda for Sustainable Development. The chapter also covers various financing mechanisms and instruments available to realise the goals outlined in these frameworks. The review illustrates that as interlinked issues such as climate, water, biodiversity, land, and sustainable development generally tend to be conceptualised, governed, and financed separately, siloed approaches become the norm. By extension, it creates barriers to achieve climate mitigation as leverage points are not capitalised on, and risks are not accounted for. It also highlights that integrated approaches are needed to overcome these barriers. **To better leverage connections, it is necessary to more clearly understand and articulate synergies between issues, and create links between different governance structures to facilitate integrated approaches that can capitalise on these synergies.** Failing to do so is a missed opportunity for climate change mitigation we cannot afford.

Part II: Water-related mitigation opportunities across biomes and sectors

Part II of the report provides an analysis of climate mitigation measures, keying in on their use of, and impacts on, freshwater and freshwater-dependent systems. This is done by mapping the climate mitigation potential, and associated opportunities and risks, in different biomes and sectors, including drinking water and sanitation services (Chapter 4), freshwater ecosystems, and freshwater-dependent coastal and marine systems (Chapter 5), terrestrial ecosystems (Chapter 6), and energy systems (Chapter 7). These chapters examine the effects of water-related feedbacks on mitigation outcomes, as well as trade-offs and synergies between water-related mitigation and adaptation measures. Each chapter identifies knowledge gaps for characterization and quantification of water's role for climate mitigation, and offers recommendations to either reduce potential water risks in mitigation measures or enable actions that provide multiple benefits to freshwater sustainability and climate mitigation.

Chapter 4

Chapter 4 illustrates how **reducing the release of GHGs in drinking water and wastewater management presents major opportunities for climate change mitigation**. The chapter examines the mitigation potential and risks in these measures, including abstraction, treatment, distribution and discharge, and accounting for both direct and indirect GHG emissions including the electricity consumption associated with indirect carbon emissions. For instance, significant amounts of GHGs from wastewater and faecal sludge can be reduced through the improved design, management, and adjustment of operating conditions of wastewater treatment plants. Energy efficiency measures, along the water and wastewater management cycle, can be implemented to decrease energy consumption and related CO2 emissions. Experience from water utilities, which have started to measure, reduce, and report their GHG emissions, needs to be scaled up to decarbonize water and wastewater management. Yet, a significant proportion of the wastewater generated in cities and rural areas remains untreated or only partially treated, with the emissions from untreated wastewater being an estimated three times higher than emissions from conventional wastewater treatment plants. The extension of wastewater collection and treatment systems, including decentralized solutions, emerges as a win-win for development and climate mitigation. **The actual mitigation potential of this sector is largely unknown because data on GHG emissions is limited and has high levels of uncertainty**, resulting in hampered efficiency in the integration of drinking water and wastewater management in climate policies and mitigation strategies. Thus, strengthening the assessment, monitoring, and reporting of GHG emissions from water and wastewater handling, including on-site sanitation, must be a priority for better GHG estimates and access to climate finance.

Chapter 5

Chapter 5 examines mitigation potential and risks in freshwater ecosystems. **Aquatic environments, such as freshwater peatlands, marshes, swamps, lakes, streams, rivers, and tidal wetlands, can function as either GHG sources or sinks**, depending on, for example, land use, pollution, human activities, hydrologic regime, and climate change. Wetlands, for instance, have one of the highest stores of soil carbon in the biosphere, storing more than 30% of the estimated global carbon emissions, making conservation and restoration measures crucial for the protection of these carbon stocks. To account for the emission reduction services from freshwater systems, it is necessary to include them as part of a portfolio of measures to reduce GHG emissions alongside sectors outside of land use. In addition, catchment and coastal zone scale policies, programmes, and investments should be adopted to support effective and sustainable emission reduction strategies. GHG emissions in aquatic systems are fuelled by inputs from watersheds. Therefore, **effective emission reduction strategies may entail integrated approaches for land management, restricting nutrient loading (including improved water treatment capacities), maintaining, and improving ecohydrologic connections**. It is important to note that aquatic systems provide many other valuable services in addition to carbon sequestration, such as water quality control and flood risk reduction. Natural climate solution schemes should be designed with holistic system thinking, including the full range of ecosystem services alongside carbon sequestration. For efficient climate mitigation, emission reduction goals need to be given greater emphasis: in broad water resources management strategies; financing mechanisms; and tools need to be in place to monitor and reduce emissions at the local, regional, and national level; while capacity building and other forms of support, including better data of aquatic environments, is needed to materialise implementation.

Chapter 6

Chapter 6 examines mitigation potential and risks in land systems. Climate mitigation in land systems is primarily achieved through the binding of carbon to soil and below- and above-ground biomass in for example forests, grasslands, and croplands. Thus, land systems hold high carbon emission reduction potential, including restoration, afforestation/reforestation, prevention of land degradation or deforestation, as well as various land management approaches. However, **the success of mitigation measures in land systems relies substantially on the water cycle and freshwater availability**. For example, unsustainable management of carbon-rich soils such as excessive grazing, unsustainable logging, or fluctuating surface-groundwater can cause a shift from a GHG sink to a source of emissions. In addition, land systems are already now subject to hardly predictable and unfavourable environmental changes under rising global temperatures. Mitigation in land systems must adapt to the local hydrological, climatic, and social-ecological contexts, including the political economy, in order to generate co-benefits and minimize trade-offs between sustainability goals. This includes accounting for local warming (e.g., boreal forests absorb more radiation than boreal shrubs) and soil carbon emissions from agriculture and afforested peatland areas. This also includes accounting for land management effects on water cycle dynamics, both directly (e.g., irrigation, drainage) and indirectly (e.g., harvest rate, choice of tree or crop species, degree of collaboration with local communities). **Climate change has already substantially altered land systems' water cycles**. For instance, the carbon sink strength in tropical forests has recently peaked while the growth in the mid-latitude forest carbon sink strength appears to be slowing in recent decades. Continued deterioration of the regulating effect of forests on the water cycle risks lowering agricultural productivity regionally and globally, causing irreversible damage to biodiversity, and turning the forest carbon sinks into carbon sources. **Mitigation measures in land systems can have notable synergies but also trade-offs with local-to-regional water sustainability goals**. Land system mitigation measures have the potential to decrease flood risks, increase groundwater recharge, and increase water vapour exchange with the atmosphere, thereby enhancing local cooling and regional rainfall. Misguided implementation of land system mitigation measures can, on the other hand, cause local water shortage, biodiversity loss, and harm to local communities.

Chapter 7

Chapter 7 examines the water-related climate mitigation potential and risks of low-emission energy transition plans, highlighting the need to include an analysis of projected demands, availability, and impacts on freshwater, including the potential risks to water availability caused by climate change. **The transition toward low-emission energy can reduce pressure on water, however, this will depend on the future mix and management of energy sources.** Water is a significant consideration for all energy production except possibly wind power and solar photovoltaics (PV). Excluding hydropower, 70% of water used by the energy sector goes to fossil fuels and thermal power generation plants. The transition to renewable energies can provide opportunities to reduce pressure and impacts on water resources from the energy sector, primarily due to the low water demands from solar PV and wind versus fossil sources. On the contrary, low-emission scenarios with high demand for 'negative emissions', i.e., activities that remove carbon dioxide from the atmosphere, imply an increase in water consumption particularly for bioenergy, with large ranges in potential water requirements (for irrigation). Sustainable water management in bioenergy with carbon capture can, in certain contexts and well-managed systems, provide both energy and climate mitigation benefits, but it is critical to consider factors such as extent, type and location of the bioenergy production for the impact on the global water cycle. Besides bioenergy, hydropower and thermal energy generation – from solar, geothermal, and nuclear power – are low-emission energy sources that have substantial water requirements. To ensure sustainability, the benefits provided by these options must be weighed against potential water risks and impacts on freshwater ecosystems. Impacts of climate change on the availability of water for cooling thermal power plants and hydropower generation are key concerns for resilient energy planning and operations. To enable the transition to renewable energies, strategies are also needed to mitigate potential water risks for energy storage solutions, including pumped hydropower, as well as mining for minerals such as copper, cobalt, lithium, and rare earth materials. **Low emission energy scenarios often lack quantification of impacts on water quality and ecosystems, which must be incorporated into national and regional planning.**

Part III: Integrating freshwater into climate change mitigation planning and action

Part III of this report draws cross-sectoral conclusions building on the findings in Part II, identifying priority risks and opportunities for water-wise climate planning, including 'win-wins', i.e., significant co-benefits to reduce the use and pollution of water bodies. Further, it explains how integrated approaches are required to account for freshwater-climate mitigation interconnections to achieve water-wise climate mitigation and presents leverage points to move forward with water-wise mitigation action.

Chapter 8

Chapter 8 presents priority water risks that need to be evaluated in climate mitigation plans. Building on Part II of the report, this chapter outlines opportunities to effectively mitigate emissions through measures taken in water and sanitation services (Chapter 4), and the protection, restoration, and management of ecosystems (Chapters 5 and 6). This also includes risks in the development of different renewable energy options, as well as potential implications of land and water degradation to reduce the sequestration potential of ecosystem-based mitigation measures, or that lead to increased emissions of GHGs (Chapter 7). **Essential areas for investment and action are identified that will enable benefits for both water and climate mitigation, critical for sustainable development in the coming decades.** Four leverage points are highlighted to ensure climate mitigation is resilient, robust, and water-wise – including the:

1. **promotion of sustainable low-emission water management**
2. **investment in nature**
3. **navigating water-wise energy pathways**
4. **accelerating circular solutions and sustainable lifestyles.**

The chapter also touches upon key issues for climate mitigation that are beyond the scope of this report, including industrial processes and design, transport, solid waste management, as well as issues related to diet, sustainable consumption, and behavioural change.

Chapter 9

Chapter 9 demonstrates that **integrated approaches, accounting for the interconnections between freshwater and climate mitigation, are necessary to achieve water-wise climate mitigation.** Integrated approaches draw on systems thinking, and unlike siloed approaches, recognize the systemic and connected nature of climate and water. As such, they can assess and address trade-offs, and identify synergies. This chapter provides an overview of some of these approaches, including Integrated Water Resources Management (IWRM), the Water-Energy-Food Nexus approach, Source-to-Sea (S2S), the Landscape approach, and Integrated Urban Management, each exemplified through case studies. The chapter notes that successfully delivering integrated approaches require the acknowledgement of complexities across different geographical and management levels, temporal scales, and contexts. Specifically, the chapter argues that governance systems need to be strengthened and enabling conditions created, to deliver water-wise climate mitigation through integrated approaches. Enabling conditions include building transparency and data-based decision-making, strengthening capacity through inclusive knowledge systems, innovating finance, and linking governance structures across sectors and scales to create more polycentric and inclusive governance arrangements.

Looking at Part I, II and III holistically, the chapter attests to the pivotal importance of building strong, polycentric, and inclusive governance systems, which have the capacity to deliver the integrated solutions required for water-wise climate mitigation. Building on that, it is clear that working in silos will fail to deliver the change needed. For our governance systems and national implementation plans to succeed **we need to place water in its rightful place: at the heart of all efforts to adapt to, as well as to mitigate climate change**.

Wetland at Thalaynoi, Thailand. Image by Mongkolchon Akesin.

Key Messages – Unpacking Freshwater's Role in Climate Change Mitigation

Water must be mainstreamed into climate mitigation planning. Sustainable water management across key sectors is essential to achieve the Paris Agreement mitigation targets. This report identifies high-potential opportunities for water-related mitigation action, and further examines water-related risks which need to be assessed to ensure that mitigation actions can be sustainable and account for water. Climate mitigation cannot be achieved at the pace and scale required unless it is water-wise. Such water-wise climate mitigation planning integrates the understanding of the following five report key messages.

1. Climate mitigation measures depend on freshwater resources. Present and future freshwater availability needs to be accounted for in climate mitigation planning and action.

2. Climate mitigation measures impact freshwater. Freshwater impacts – both positive and negative – need to be evaluated and included in climate mitigation planning and action.

3. Water and sanitation management can reduce GHG emissions. Climate mitigation planning and action should include the substantial emission reduction potential in drinking water and sanitation services, and through the management and protection of freshwater resources.

4. Nature-based solutions to mitigate climate change can deliver multiple benefits for people and the environment. Priority should be given to measures that can safeguard freshwater resources, protect biodiversity, and ensure sustainable and resilient livelihoods.

5. Joint water and climate governance need to be coordinated and strengthened. Mainstreaming freshwater in all climate mitigation planning and action requires polycentric and inclusive governance arrangements that can facilitate integrated approaches.

Improvements in sanitation services can greatly reduce emissions. Image from Shutterstock.

Key benefits of taking action on these key messages are provided below:

1. Climate mitigation measures depend on freshwater resources

Present and future freshwater availability needs to be accounted for in climate mitigation planning and action in order to:

Assess and coordinate sustainable freshwater demands across climate mitigation measures

The success of most mitigation measures relies substantially on freshwater availability and quality, as well as sustainable water management. Freshwater, however, is a finite resource already over-exploited in many places, and climate change is increasing the pressure on water resources even further. Mitigation planning and action must therefore urgently, and increasingly, understand and consider both freshwater availability and constraints for climate mitigation. Considerations for water cannot only be integrated in individual measures or sectors, but sustainable demands need to be coordinated and determined across measures and sectors.

Navigate water-wise energy transitions

The energy sector, in particular, needs to account for freshwater availability while planning transitions to low-emission sources. Most energy production requires substantial amounts of water, and this includes significant water use in renewable energy: hydropower, bioenergy, and thermal energy generation from solar, geothermal, and nuclear power. Comprehensive analysis of actual water availability, projected water demands and savings, as well as technologies and impacts to assess options at local, national, regional, and global level is needed when assessing current and future energy alternatives. These assessments must consider competing water demands, including those for ecosystem needs, as well as potential changes to water availability caused by ongoing climate change.

Protect water for nature

The success of nature-based solutions, including the mitigation potential of aquatic and terrestrial ecosystems, are intrinsically interlinked with freshwater availability and the water cycle. These natural processes are subjected to strong changes under current and future environmental changes. For instance, improved protection and management of wetland or forest water cycles can avoid the risk of turning ecosystems from carbon sinks into carbon sources. Similarly, sustainable water management plays a key role in safeguarding already sequestered carbon in croplands and managed grasslands, such as by maintaining existing soil carbon stocks through sustainable management of these multifunctional landscapes.

2. Climate mitigation measures impact freshwater

Freshwater impacts – both positive and negative – need to be evaluated and included in climate mitigation planning and action in order to:

Consider water risks and environmental impacts of climate action

Climate change mitigation efforts can have negative impacts on freshwater balances and the water cycle, leading to reduced or polluted water resources, as well as degraded ecosystems – whose services we oftentimes rely on to generate the water resources. These negative impacts are therefore critical to consider when determining the specific type of mitigation measure, for example when selecting a suitable renewable energy source or determining the viability of plant growth for carbon storage. The production of bioenergy is of particular importance as questions around quantity, location, crop species, and production technique all have potential large impacts on water cycling and availability, and land use overall.

Manage and minimise trade-offs between mitigation potential and water risks

Analysis of trade-offs between mitigation potential, and impacts on freshwater resources and implications for future water security is critical. Climate mitigation potential needs to be weighed against the risks of degrading water cycles and polluting or over-abstracting freshwater resources. For instance, reservoirs created by hydropower dams may emit significant amounts of GHG, depending on factors such as organic content and nutrient loading, reservoir sediments, primary productivity, and water temperature, but also the characteristics of the reservoirs themselves (local temperature, depth, etc.) and their catchments (land use, human activities, etc.). Plantations of fast-growing, water-demanding tree or crop species, for carbon storage or energy production, is another example of a mitigation trade-off that requires risk assessment, as well as know-how on sustainable water management that may mitigate those risks. Poorly planned implementation of mitigation measures can cause local water shortage, biodiversity loss, and harm to local communities and livelihoods.

Maximise synergies and co-benefits across sectors

Climate mitigation efforts that have positive impacts on freshwater balances often also benefit other values, such as climate adaptation, livelihoods, and biodiversity.

For instance, protecting and restoring aquatic ecosystems, such as wetlands, can mitigate climate change, while also supporting the water cycle, improving the health of nearby ecosystems, and reducing impacts of droughts and floods. Similarly, mitigation measures in land systems – such as agroforestry, ecosystem restoration, and improved soil carbon management – have the potential to increase groundwater recharge and increase water vapour exchange with the atmosphere, thereby enhancing local cooling and regional rainfall, while also boosting crop production and resilience to a changing environment. A water-wise perspective in climate mitigation can therefore present an opportunity to improve climate mitigation potential, while also enhancing other benefits such as water security and both human and ecosystem health.

3. Water and sanitation management can reduce GHG emissions

Climate mitigation planning and action should include the substantial emission reduction potential in drinking water and sanitation services, and through the management and protection of freshwater resources. This requires actions to:

Measure, report and reduce emissions, and recover energy in water and sanitation services

Drinking water and sanitation services account for a significant share of GHG emissions, and implementations of targeted GHG mitigation actions exist. Direct GHG emissions from wastewater and faecal sludge can be reduced through the improved design, management, and adjustment of operating conditions of WWTPs, while energy efficiency measures in water supply and sanitation can greatly reduce indirect emissions. For instance, technology-based solutions and new treatment configurations and processes, low-carbon energy created from wastewater management, and extension of wastewater collection and treatment systems, including decentralised solutions, can serve to meet mitigation targets. There is also mitigation potential in the transition to low emission energy sources, resource recovery and energy generation from wastewater, circular systems of reusing and recycling water and wastewater, and improved efficiency and management of water supply and distribution. In addition, significant techniques and tools already exist to strengthen assessment, monitoring, and reporting of GHG emissions from water and wastewater. Available tools, guidance and technologies for enhanced climate mitigation potential should be scaled up via investment and training.

Accurately account for and reduce GHG emissions from polluted freshwater systems

Critical gaps in data and reporting lead to the likely underestimation and under-prioritisation of GHG emissions from water supply and sanitation. It is crucial to ensure that these emissions are accounted for by supporting data-gathering and inventory of CO_2, CH_4, and N_2O emissions, from water and wastewater utilities, and untreated wastewater in aquatic environments. It is also needed to strengthen emissions reporting and integration into national GHG inventories. The process of untreated wastewater degradation can entail the release of GHGs into the atmosphere. Therefore, wastewater treatment and discharge for domestic and industrial sectors should be reported, as should emissions from untreated wastewater. Underestimation of the emissions released from water bodies polluted by untreated wastewater, and data and reporting gaps on wastewater treatment globally, may result in these emissions not being included in national GHG accounting. By extension, it does not properly incentivise actions to reduce emissions through, for instance, dry sanitation solutions. Wastewater treatment can cause these same emissions plus additional emissions from fossil energy consumption (e.g., anaerobic lagoons or basic on site sanitation solutions). There is high potential to reduce these emissions by climate friendly approaches of wastewater treatment (e.g., biogas production and flaring, or even utilisation).

4. Nature-based solutions to mitigate climate change can deliver multiple benefits for people and the environment

Priority should be given to measures that can safeguard freshwater resources, protect biodiversity, and ensure sustainable and resilient livelihoods by working to:

Support nature's ability to sequester and store carbon

Nature-based solutions (NbS) have a critical role to play in meeting climate mitigation targets. They involve measures of protecting, restoring, and better managing ecosystems, including ecosystems' natural capacity to absorb and store atmospheric carbon, while maintaining or enhancing biodiversity and ecosystem services. The availability of rainwater and soil moisture is critical for the ability of land ecosystems (e.g., forests, grasslands, croplands, shrublands, and savannas) to maintain carbon uptake. Similarly, 'blue carbon' ecosystems (saltmarshes, seagrass meadows and mangrove swamps) are highly productive with the potential to capture 0.5%-2% of global carbon emissions in the biomass of living organisms, soil, and sediments. Also noteworthy, nutrient pollution causes lakes, rivers, and reservoirs to emit GHG, while clean water bodies can act as GHG sinks. Reservoirs created by dams, with fluctuating water tables and a high occurrence of organic material, produce considerably more methane than natural lakes or other surface waters. Good water management is also critical to ensure the productivity and carbon storage potential in land systems, such as forests, croplands, and grazing lands.

Protect the water cycle to sustain critical carbon sinks

Changes in freshwater dynamics risk compromising the effectiveness of nature-based mitigation. An intact water cycle is required to achieve full mitigation potential and to ensure long-term carbon storage. Climate change-induced decreases in soil moisture can limit the capability of plants to store carbon, both below- and above-ground. Examples include conserving and restoring wetlands, forests including coastal mangroves, and natural floodplains in water courses to protect these net sources of GHGs. For example, peatlands only cover about 3% of the world's land surface but store at least twice as much carbon as all of Earth's forests, while mangrove soils can sequester up to 3-4 times more carbon than their terrestrial counterparts. Policies need to facilitate immediate water-wise actions and management that restrict the drivers of ecosystem degradation and loss, such as conversion for agriculture, urbanisation, aquaculture, or coastal development.

Value benefits from NbS beyond carbon sequestration

NbS are often low-cost, and dependent on sustainable and water-wise management of ecosystems and their services. Ecosystems' carbon sequestration is a key NbS that with the right planning and management can have multiple synergistic benefits for people, the economy, and the environment. In order to optimise the impact of an NbS, it is necessary to consider and manage the trade-offs from expected benefits. For instance, the strategy for restoring a forest or a wetland will be different depending on the goal of the restoration effort; restoration to enhance mitigation potential requires one set of species, while restoration to enhance biodiversity may require a different set of species. Effectively and equitably conserving Earth's land and freshwater habitats, and restoring degraded ecosystems, leverages nature's capacity to absorb and store carbon and mitigate climate change. It can further accelerate progress towards sustainable development. Adequate finance and political support are essential to direct and prioritise action to protect natural systems to provide these benefits.

5. Joint water and climate governance needs to be coordinated and strengthened

Mainstreaming freshwater in all climate mitigation planning and action requires polycentric and inclusive governance arrangements that can facilitate integrated approaches. This requires policymakers to:

Embrace integrated approaches to climate mitigation

Efforts are needed to establish water coordination mechanisms with other governance processes, particularly when setting Nationally Determined Contributions (NDC). This is to facilitate participation of all relevant ministries and other actors to design more polycentric and inclusive governance frameworks, which enable and support integrated approaches that move away from siloed problem-solving. Effective emission reduction strategies will entail coordinated approaches for land and water management, whilst also considering factors such as disaster risk reduction, biodiversity recovery, and sustainable community livelihoods. Better aligning the planning and goal setting would leverage synergies across sectors where relevant.

Enhance governance across levels and sectors by ensuring polycentricity and inclusivity

There is a strong need to adapt water and climate governance frameworks and instruments to different contexts. Some situations, like the provision of drinking water and sanitation services, require decentralised solutions resting on local governance. Other contexts, like management of aquatic environments and forests, require watershed-level governance. This clearly demonstrates that no one approach fits all cases, but rather that governance frameworks and instruments need to be adapted to fit local circumstances. There is also a strong need for better coordination and collaboration between stakeholders, sectors, and transboundary watersheds to help address trade-offs.

Enable knowledge-based decision-making through data generation, harmonisation, and transparency

There is a critical need to improve the quality and coverage of scientific data to enable mainstreaming of water into climate mitigation, and improve the capacity of managers and policymakers to make informed, evidence-based decisions. For example, information and reporting gaps currently lead to a likely underestimation and under-prioritisation of GHG emissions from water supply and sanitation, despite available measurement and reporting tools. Similarly, improvements in biophysical data collection and coverage at different scales, are key to ensure that inland water bodies, wetlands, and coastal systems are more commonly included within the GHG inventories, in terms of emissions or storage. Harmonisation across accounting methodologies to ensure consistency is also needed. Even when data is available, transparency and data-sharing need to be improved, requiring efforts to strengthen disclosure and enhance the scientific knowledge underpinning the generation of robust data. Collaboration should be fostered to drive disclosure, as well as cost-efficient data collection. There is a need to build institutional and citizen capacity to strengthen data collection, management, and sharing capacities. This includes improving frameworks and knowledge to better utilise digital solutions, data management systems, and build capacity to develop integrated and cross-sectoral data collection and monitoring systems.

Build capacity through inclusive knowledge systems

Building capacity to better understand the increasingly complex interdependencies across scales and actors is fundamental. A great majority of mitigation measures worldwide – including in ecosystems, food systems, and energy systems – influence, or are influenced by, water management and water availability in ways that must be understood and planned for. Building capacity to strengthen and integrate knowledge is therefore critical. Capacity can be strengthened by learning across governance systems and leverage existing governance regimes. For instance, by building upon the strong global frameworks that exist for climate action and the robust national plans that often exist for water management. Overall, it is fundamental that measures to build capacity are inclusive, paying special attention to youth, women, and vulnerable groups.

Strengthen water-wise climate governance to tap into existing climate funds

There is an untapped potential to access international climate finance for water-related mitigation measures. Currently, large sums are being committed at the international level to mitigate and adapt to climate change, but only a small fraction of these funds are being directed to water-related mitigation measures. There is an opportunity to tap into these funding sources and redirect funds for investments in water-related projects, if such mitigation measures are integrated into the NDCs and other national and sectoral instruments. Most financing committed today, however, is mobilised at the national level; there is still a substantial need to mobilise additional financing for local projects, particularly in low-income countries. Additional investments are needed in all sectors: for wastewater treatment, improved energy efficiency and use of renewable energy in water utilities, sanitation services, for restoring degraded aquatic environments, forests, and agricultural lands. To meet these funding demands, new pathways need to be explored that can facilitate investments and direct funding into areas that can support water-related mitigation measures. This will require action to foster innovative financing models that can incentivise commercial, as well as non-commercial, sources of funding that can make targeted investments to benefit those most vulnerable. It is critical that the water sector alone does not carry the sole fiscal responsibility for delivering projects upstream with substantial climate mitigation potential.

Wild bird wetland park along the Gimpo Han River at Gimpo-si, South Korea. Image from Shutterstock.

Concluding statement: We need to act now

The earlier we act on water and climate jointly, the more synergies can be reaped and trade-offs avoided. Limiting global warming to 1.5 degrees is still narrowly within reach, and water across terrestrial, aquatic, and technological systems, plays a critical role for the necessary transformation towards net-zero.

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