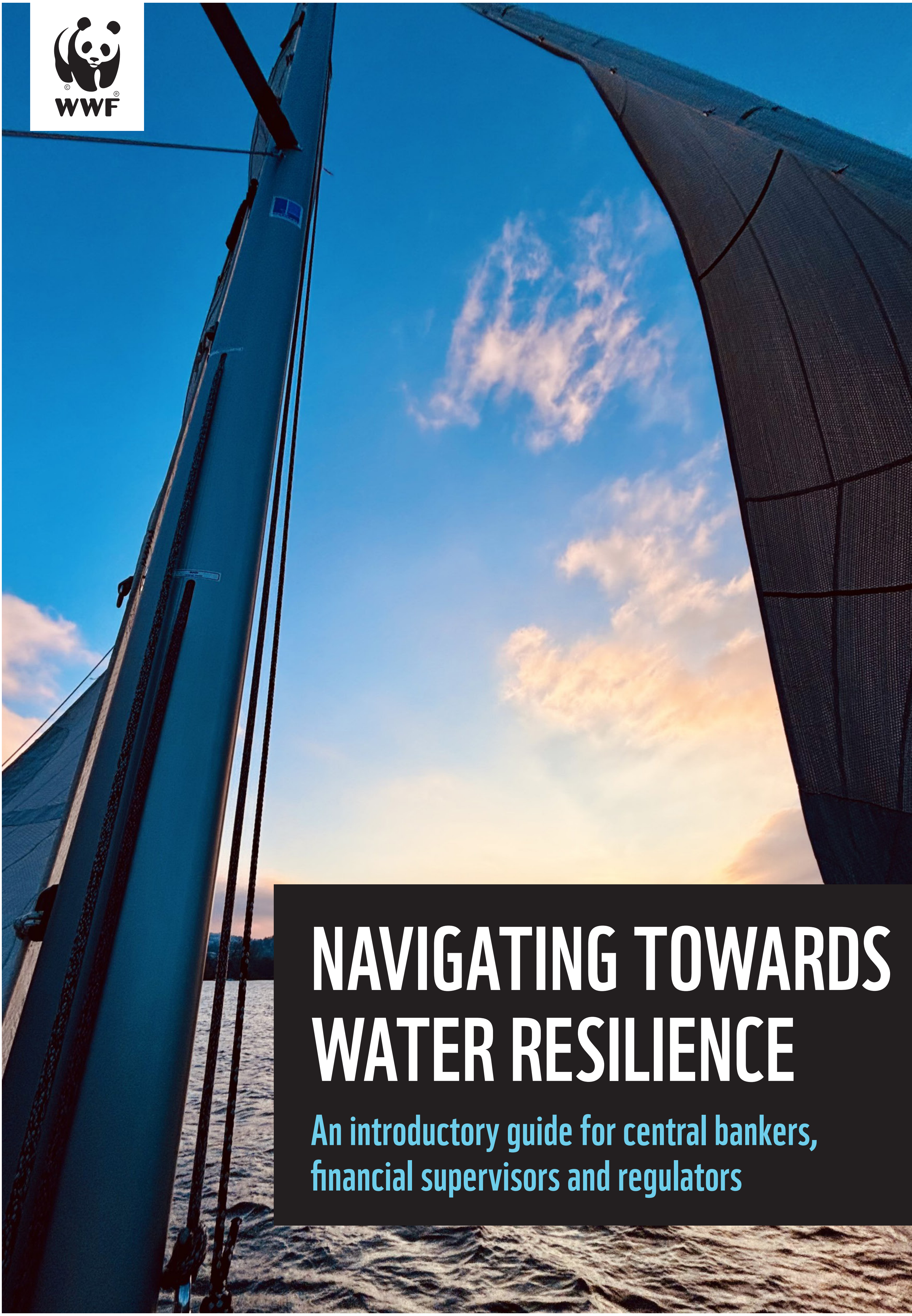

NAVIGATING TOWARDS WATER RESILIENCE

An introductory guide for central bankers, financial supervisors and regulators

ACKNOWLEDGEMENTS

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About WWF's Greening Financial Regulation Initiative (GFRi)

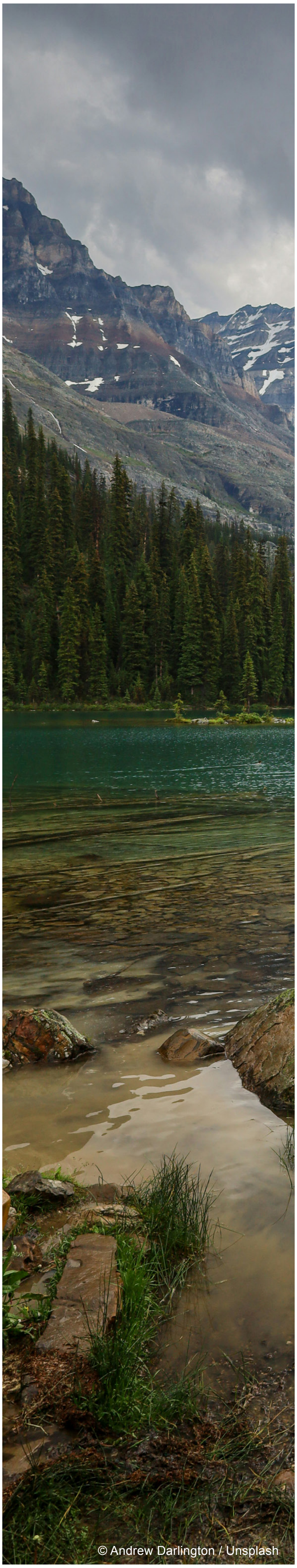
WWF's Greening Financial Regulation Initiative (GFRi) seeks to place climate and environmental risk at the heart of the financial system. Through this initiative, WWF aims to demonstrate the interconnections between financial risks and environmental risks like climate change, water scarcity and biodiversity decline and engage policy makers, central banks and financial supervisors on the need to integrate those risks into their mandates and operations. In this way, WWF provides the necessary tools, scientific research, assessments, and assistance to elevate ambitions in the global sustainable finance policy agenda.

For more information, visit panda.org/gfr or contact us at gfr@wwf.ch

About the GFRI Thematic Guides

WWF is publishing a series of thematic guides that deconstruct the complex topic of nature-related risks into practical, accessible units for financial authorities. This freshwater guide represents the third in the series, following those on deforestation and conversion (Contreras et al., 2024) and oceans (de Vos et al., 2025). Together, these will be part of a broader online handbook for central banks, financial supervisors and regulators developed by WWF's GFRi.

This guide aims to bridge the gap between the central banking, financial regulatory community and water experts. It explains why water security and resilience are vital to financial stability and long-term prosperity- and thus directly relevant to their mandates. We encourage readers, especially those in these institutions, to approach the guide with an open mind so as to recognise the complex, yet essential role that water plays in sustaining global prosperity for current and future generations.



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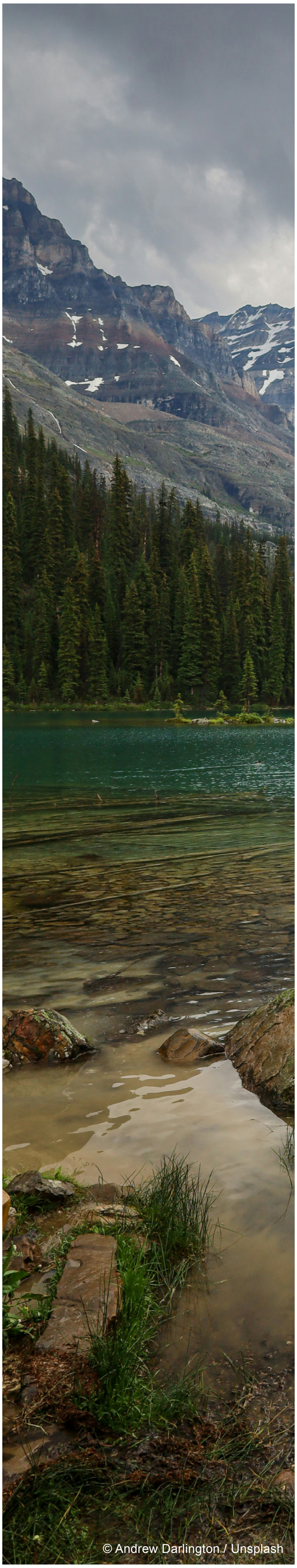

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EXECUTIVE SUMMARY

THE GLOBAL WATER CRISIS

The global water crisis threatens price and financial stability – the core mandates of central banks, financial regulators and supervisors. Economic foundations – from food and energy security to public health, industrial activity and trade – rely on a stable hydrological cycle, reliable supplies of clean water and resilient freshwater ecosystems.

However, the world is facing a growing water crisis on multiple fronts: too much water, too little water, too dirty water, exacerbated by failing green and grey infrastructure and weak governance. Already, this is slowing economic growth, fuelling inflation, straining public budgets, disrupting import-export dynamics, and undermining business revenues, asset values and credit quality.

By 2050, nearly half of global Gross Domestic Product (GDP) may be generated in areas facing high water risk, expected to cause significant economic losses in some regions (WWF, 2020).

MACRO-FINANCIAL TRANSMISSION CHANNELS

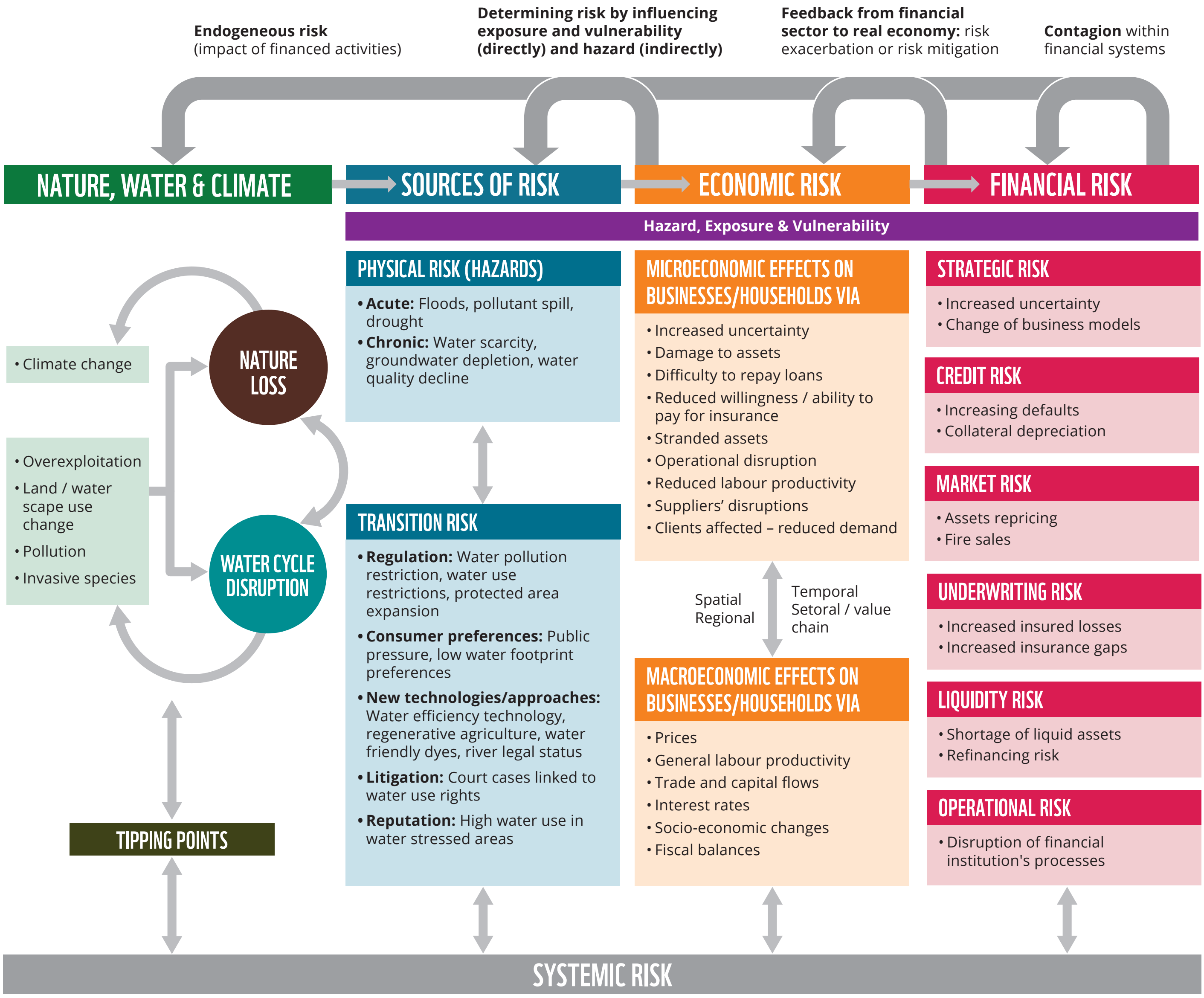
Water scarcity may materialise across multiple macro-financial transmission channels, including credit exposure, insurance losses, market repricing, sovereign risk and declining collateral values, as illustrated below.

DIMENSIONS	EFFECT
ECONOMIC OUTPUT AND GROWTH	**Water insecurity reduces GDP growth:** Since a large share of corporates and loans are critically dependent on freshwater ecosystem services, extreme water risks such as droughts could jeopardize up to 15% of Eurozone output, disrupting agriculture, manufacturing, hydropower and shipping (Ceglar, Danieli, et al., 2025).
MARKETS, PRICES AND INFLATION	**Water insecurity triggers inflationary pressures:** Hydrological shocks like droughts reduce crop yields and disrupt trade routes, increasing commodity price volatility and inflation. For instance, Italy's 50% rice yield drop in 2022 due to the Po River drought (Spaggiari, 2024), or droughts induced reductions in water traffic in the Panama Canal traffic (Associated Press, 2024; IMF, 2022).
FISCAL BALANCES	**Water insecurity elevates sovereign credit risk, placing additional burdens on already strained public budgets:** In economies reliant on water-intensive sectors or experiencing floods and water stress, states face reduced revenues and higher spending. Moody's have found one-third of assessed states are already facing material water-related credit risks (Reuters, 2024).
EMPLOYMENT AND LABOUR MARKETS	**Water insecurity undermines workforce health and resilience:** Droughts and heatwaves lower productivity in sectors like agriculture and construction, as documented in Spain (see AMCESFI, 2023). Rising antibiotic use, projected to increase by over 30% by 2030 for human consumption, will likely worsen public health challenges, potentially causing up to 10 million deaths per year by 2050 and significant productivity losses. Antimicrobial resistance, for which water is a major vector, may cost the world between US$300 billion and US$1 trillion annually by 2050 (CDC, 2013; Ranger et al., 2024).

TYPES OF WATER-RELATED RISKS

Water-related risks impacting economies and financial systems stem primarily from two sources: physical risks and transition risks, often intensified by the complex and unpredictable nature of water systems. Physical risks arise from acute events like floods and droughts, or chronic shifts such as declining water quality and altered rainfall patterns. Transition risks arise as governments, markets and industries respond to water stress via new policies, regulations, technologies and evolving consumer behaviour.

Moreover, water-related shocks – from scarcity to pollution – transcend national borders; rapidly propagating through global supply chains, commodity markets and capital flows. Critically, water systems risk crossing tipping points, where cumulative pressure leads to sudden and potentially irreversible ecological changes. These non-linear, unpredictable dynamics can amplify losses and increase the risk of extreme weather events, especially in concentrated regional or sectoral exposures.



Water-related financial risk framework. Source: Authors adapted from NGFS (2024b)

ENDOGENOUS RISKS FROM FINANCE

Freshwater ecosystems provide vital natural defences against extreme weather and long-term environmental changes, however prevailing business-as-usual economic activities are progressively eroding this function. Financial flows supporting environmentally harmful activities substantially exceed those directed toward nature-based solutions, with recent estimates suggesting an imbalance of approximately 30 to 1 (UNEP, 2026).

Today's water insecurity is a direct consequence of economic activity. Economic activities across key sectors – including food and beverage production, textiles, chemicals manufacturing, metals and mining – are pushing freshwater ecosystems beyond their regenerative capacity heightening prospects for systemic, widespread disruption (see table below). Overextraction, land-use change, freshwater ecosystem conversion, pollution and inadequate governance steadily diminish water availability and the resilience of water systems. Meanwhile, financial flows – via lending, investment and insurance – often fund the very practices that drive the degradation of water systems. This not only fuels systemic vulnerabilities but also increases the risk of reaching irreversible tipping points.

Sectors and industries with the most severe impacts on freshwater ecosystems. Source: adapted from Famiglietti et al. (2022)

GICS SECTOR	INDUSTRY	IMPACT PATHWAYS					
		Supply chain		**Direct operations**		**Product use/end of life**	
		Water quantity	Water quality	Water quantity	Water quality	Water quantity	Water quality
CONSUMER STAPLES	**Food products**	very high impact	very high impact	high impact	high impact	not enough available information	not enough available information
	Beverages	very high impact	very high impact	high impact	high impact	not enough available information	very high impact
CONSUMER DISCRETIONARY	**Textiles, apparel and luxury goods**	high impact	high impact	medium impact	very high impact	not enough available information	high impact
ENERGY	**Oil and gas**	high impact	very high impact	high impact	very high impact	not enough available information	medium impact
HEALTH CARE	**Pharmaceuticals**	not enough available information	not enough available information	not enough available information	very high impact	not enough available information	very high impact
MATERIALS	**Chemicals**	high impact	high impact	medium impact	very high impact	not enough available information	not enough available information
	Metals and mining	high impact	high impact	high impact	very high impact	not enough available information	not enough available information
	Paper and forest products	high impact	high impact	high impact	very high impact	not enough available information	not enough available information
IT	**High-tech and electronics**	high impact	high impact	high impact	high impact	not enough available information	not enough available information
	Semiconductors and circuit boards	not enough available information	not enough available information	medium impact	high impact	not enough available information	not enough available information
	Battery manufacturing	high impact	high impact	not enough available information	high impact	not enough available information	high impact
UTILITIES	**Renewable electricity (hydropower)**	not enough available information	not enough available information	very high impact	medium impact	not enough available information	not enough available information

● (red) = very high impact ● (orange) = high impact ● (yellow) = medium impact ○ = not enough available information

No single actor can solve the water crisis alone. It requires coordinated action across governments, businesses and the financial system. Although governments and policymakers play a central role, their efforts will fall short if the financial flows continue to undermine resilience. As guardians of financial stability, central banks, financial supervisors and regulators (CBFRs) are uniquely positioned to drive change. They can:

- Assist the financial sector understand and manage the economic risks linked to water stress.
- Enable capital reallocation from water-degrading activities to more sustainable, resilient solutions.
- Incorporate water security into financial stability, supervisory frameworks and monetary policy.

CURRENT GAPS AND THE PATH FORWARD TO WATER SECURITY

Despite growing awareness of the water crisis and its financial implications, current responses from companies and financial institutions remain inadequate in addressing systemic risks. Key gaps include:

- **Fragmented corporate action:** Although some companies are improving water management practices, these efforts typically focus on their direct operations rather than basin-level collective action, where risks are shared.
- **Limited integration in risk management and disclosure:** Water-related risks are less consistently assessed and disclosed than climate-related risks, and financial institutions seldom evaluate their portfolio-wide exposure holistically.
- **Overlooked impacts:** Few financial institutions systematically evaluate how their activities contribute to long-term water system degradation, or its implications for future financial resilience.

CBFRs increasingly acknowledge that water is macro-critical, yet its integration into financial stability and supervisory frameworks remains at an early stage:

- Water is typically addressed as part of broader environmental or climate risk categories, with little dedicated water-specific guidance.
- Although evidence of financial impact is growing, water risks are not yet fully integrated into financial models. While early disclosure frameworks and exploratory macroprudential pilot studies demonstrate project feasibility, the complexity of hydrological water systems – including pollution and tipping-point risk – remains largely absent from mainstream financial stability analysis.

TOOLS FOR ASSESSMENT

An expanding array of tools, metrics and scenario analyses enables authorities to identify the most exposed sectors and economically vulnerable regions. The primary challenge lies in translating complex hydrological dynamics into clear financial risks, and embedding them within standard risk management frameworks. This includes capturing unpredictable tipping points and non-linear impacts. Enhanced data quality, interoperability, more robust scenario design and result interpretation capability will prove crucial in progressing from early-stage analysis to comprehensive frameworks that support long-term financial resilience. Even where tools, datasets and methods remain under development, CBFRs possess sufficient capabilities to strategically deploy existing resources towards enabling a water-resilient economy and financial system.

KEY MEASURES FOR CENTRAL BANKS, FINANCIAL REGULATORS AND SUPERVISORS

CBFRs possess a toolkit within their existing mandates to bolster financial resilience against water-related risks. A first essential step is to recognise the urgency of the water crisis, and its deep links with climate change, biodiversity loss, environmental degradation and economic stability. Concurrently, CBFRs should enhance their analytical capacity to progressively incorporate water risks into financial supervision and monetary policy, fostering greater alignment across policy areas.

IMMEDIATE PRIORITIES

Urgently, authorities should formally acknowledge water-related risks as material to financial stability. Given their potential systemic impact, uncertainty and risk of irreversible tipping points, a precautionary approach is justified, whilst analytical capacity is being developed.

This could include:

- Evaluating system-wide exposure to water stress, holistically addressing the full spectrum of water crises challenges beyond mere water quantity.
- Examining how risks spread through the financial system, particularly how finance itself generates water-related risks (endogenous risk).
- Conducting exploratory stress tests or reverse stress-tests in data-scarce contexts.

Critically, the absence of immediate, visible disruption must not be misconstrued as low risk or lack of materiality, since natural buffers, insurance mechanisms and policy responses may themselves be weakening over time. Bolstering internal expertise, resources and partnerships with scientific and statistical institutions will prove essential for ensuring a resilient financial system.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SHORT-TERM INTEGRATION INTO SUPERVISORY FRAMEWORKS AND MONETARY POLICY

In the short term, water-related risks can be embedded within supervisory expectations, financial stability monitoring, and monetary policy.

- Financial institutions should be required to identify and manage material water-related risks through stronger risk management, scenario analysis, and transition planning—especially in water-stressed regions and water-dependent sectors and activities exacerbating water ecosystem degradation.
- Upon identifying concentrated or correlated exposures, policymakers can consider measures such as capital requirements, concentration limits, or alternative supervisory tools – all within existing regulatory frameworks.
- System-wide, macroprudential authorities should incorporate water scenarios into monitoring frameworks, addressing cumulative environmental degradation and potential tipping-point risks.
- Central banks should set an example by integrating water-related risks into their own monetary policy frameworks.

MEDIUM-TERM ALIGNMENT AND SYSTEM-WIDE RESILIENCE

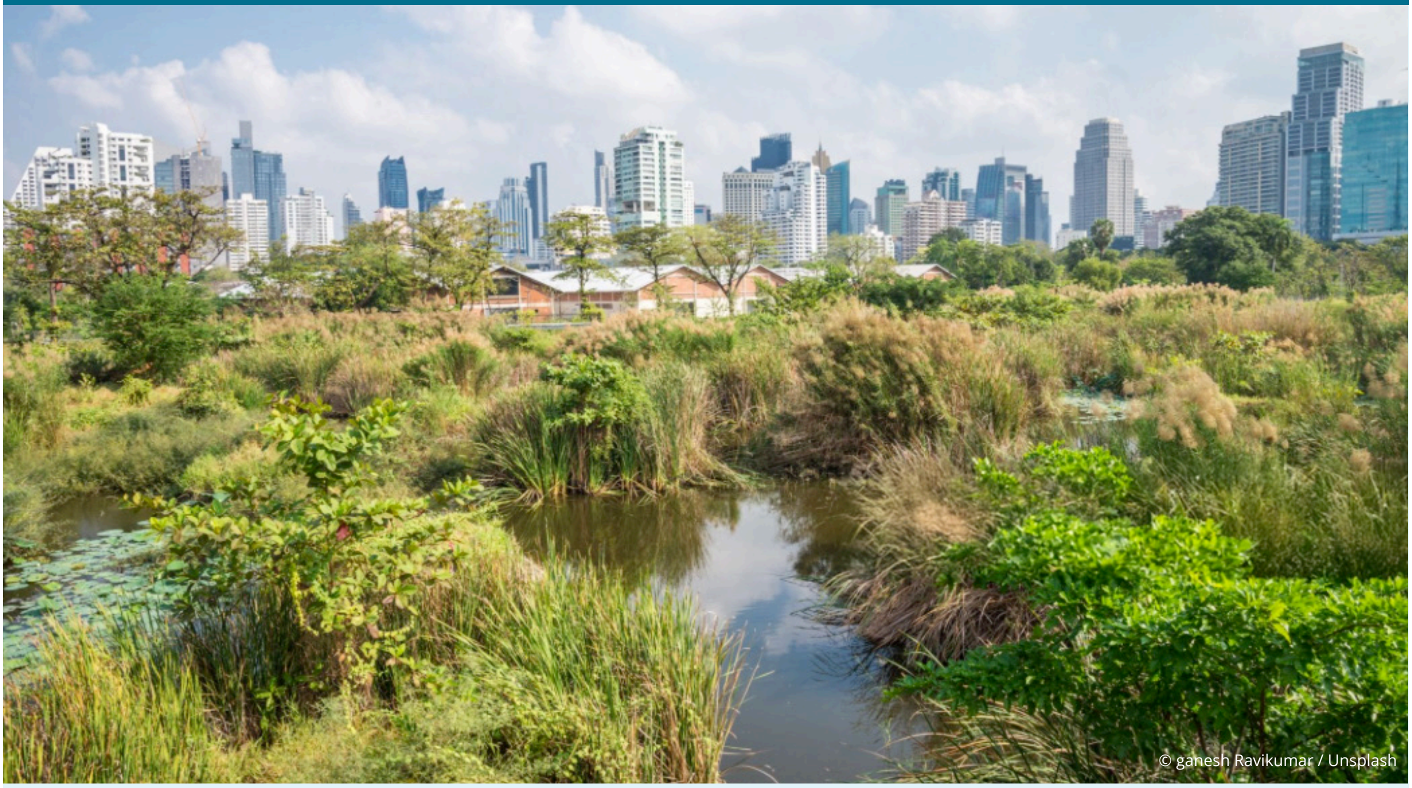
Over the medium term, greater alignment across microprudential, macroprudential, monetary policy and fiscal policies will be essential to managing both gradual degradation and abrupt systemic shocks.

CBFRs can leverage their policy instruments by:

- Establishing clearer supervisory expectations for financial institutions on water-related risks.
- Strengthening disclosure and risk assessment standards.
- Incorporating water risks in financial stability dashboards and monitoring frameworks.
- Reviewing collateral frameworks and reserve management practices as appropriate.

Finally, international coordination will be essential to manage cross-border spillovers and promote consistent supervisory approaches.

NAVIGATING TOWARDS WATER RESILIENCE



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Navigating towards Water Resilience: An Introductory Guide for Central Bankers, Financial Regulators and Supervisors assist CBFRs in navigating the water crisis and their role in mitigating associated systemic risks.

Chapter 1 outlines the fundamentals of the hydrological cycle and freshwater ecosystems and elucidates economic dependencies upon them.

Chapter 2 applies the Network for Greening the Financial System (NGFS) conceptual framework on nature-related risks to demonstrate how water-related risks transmit to economic, financial and systemic dimensions. It also addresses endogenous water risks borne by the financial system, alongside opportunities for proactive sectoral action.

Chapter 3 examines current responses – and persistent gaps – across the real economy, financial sector and financial regulatory landscape.

Chapter 4 surveys tools, data sources and key metrics to facilitate identification, assessment and monitoring of water-related exposures, while reviewing emerging regulatory practices.

Chapter 5 offers policy options for CBFRs to reinforce risk management regimes and foster a just transition to a water-secure resilient economy.

ABOUT THIS GUIDE

While governments hold critical levers when it comes to the water[1] crisis, it is essential that the financial sector also supports the necessary transition. To that end, decisions by central banks, financial supervisors and regulators (CBFRs) are crucial. This is not however to say that CBFRs alone possess the silver-bullet solution, since comprehensive action from all relevant actors is absolutely required to address challenges effectively.[2]

The focus of this entry-level guide is on freshwater systems and their interactions with the financial system. These freshwater systems include surface and groundwater ecosystems, soil moisture, transitional ecosystems (between freshwater and marine), snow and ice ecosystems, and atmospheric water. The other nature realms are covered by other WWF Greening Financial Regulation Initiative (GFRi) guides.

The guide consolidates evidence demonstrating why water matters to the mandates of CBFRs, and provides high-level guidance on navigating the challenges this entails. To that end, it also outlines key frameworks, tools and methodologies that CBFRs can use to integrate water-related risks and impacts into their everyday work, with the ultimate aim of supporting the financial system in accelerating the transition to a sustainable, resilient economy. It is important to note that this guide seeks to ensure comprehensive geographical representation within its case studies and data, while recognizing an inherent bias toward regions with more readily available research.

The intention is not to prescribe specific solutions, but rather to serve as a starting point for further initiatives and in-depth explorations tailored to each jurisdiction's exposure to the water crisis, associated financial sector dynamics and policy maturity level. Readers are encouraged to draw insights from the evidence presented, and consider their application within the context of their own jurisdictions. This publication only marks the beginning of WWF's GFRi collaboration with the CBFRs community: WWF's GFRi will continue advancing this work through tailored workshops, training and capacity-building initiatives with a range of partners.

The guide comprises sections designed to guide CBFRs and other stakeholders (such as banks, insurers and other financial institutions) through essential concepts, and includes case studies that underscore the importance of water in maintaining price stability, financial stability, and the effective operation of the financial system.

Section 1 provides an overview of freshwater systems, core terminology, the hydrological cycle and the foundational role of freshwater in supporting earth system stability. The chapter also introduces the main drivers and consequences of the current water crisis. This chapter includes a case study on the East Kalimantan economy's impact and dependency on the Mahakam River Basin (Indonesia).

Section 2 contextualizes water within the nature-related risks conceptual framework from the Network for Greening the Financial System (NGFS) (2024b) illustrating how water-related issues translate into economic, financial and systemic risks. It also explores the significant financial opportunities that emerge from addressing the water crisis.

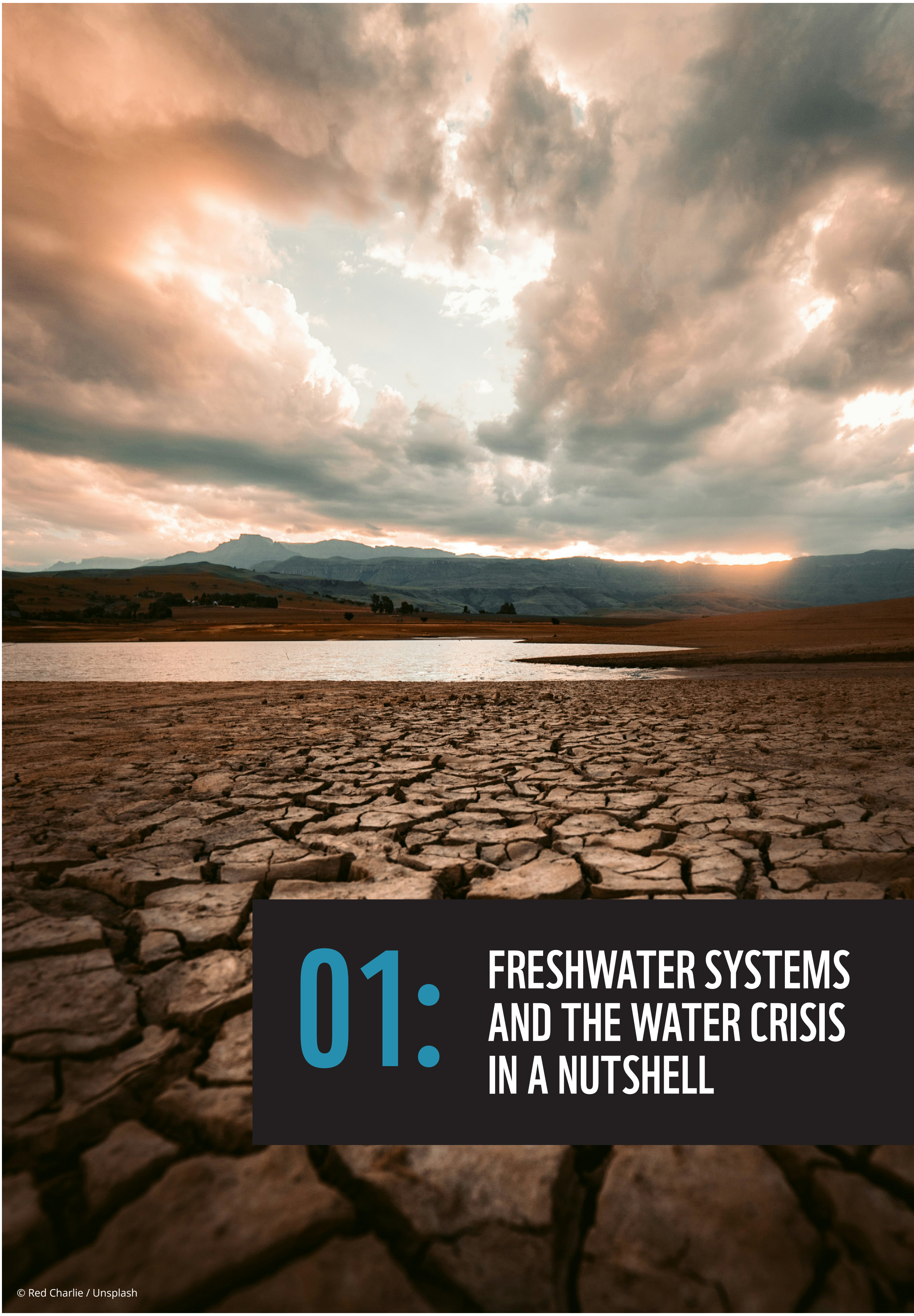
Section 3 examines the spectrum of actions emerging internationally, across the real economy, the financial sector, and particularly the CBFR community. This chapter includes a case study on assessing the progress and challenges in integrating water-related financial risk into the banking system in Spain. Further, it presents results from the 2025 WWF SUSREG assessment of how CBFRs are addressing water-related risks through regulation, supervision and monetary policy.

Section 4 provides an overview of the tools, methods and metrics available to support CBFRs in comprehensively considering water-related risks and impacts in their decision-making. Spotlights on various approaches offer inspiration for CBFRs seeking to deepen their understanding of water-related risks and opportunities.

Section 5, the concluding section, summarizes all key recommendations for CBFRs.

Finally, it's important to note that this guidance does not attempt to create a separate line of work for CBFRs to those already developed for climate change and, more recently, for nature loss. Instead, it advocates building on existing climate and nature frameworks: this is essential for addressing nature-related risk – which includes water-related risk – holistically.

1 The term "water" refers exclusively to freshwater unless otherwise specified.
2 Other WWF documents cover other key actors (see WWF, 2024).



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01: FRESHWATER SYSTEMS AND THE WATER CRISIS IN A NUTSHELL

SECTION 01:
FRESHWATER SYSTEMS AND THE WATER CRISIS IN A NUTSHELL

THE HYDROLOGICAL CYCLE AND ITS CONTRIBUTION TO PEOPLE AND NATURE

Before diving into the ways in which water is integral to the economy and financial system, we need to unpack what "water" is, where it is, how it flows and how it sustains all life on Earth. Importantly, too, we must understand what is threatening water systems as we know them.

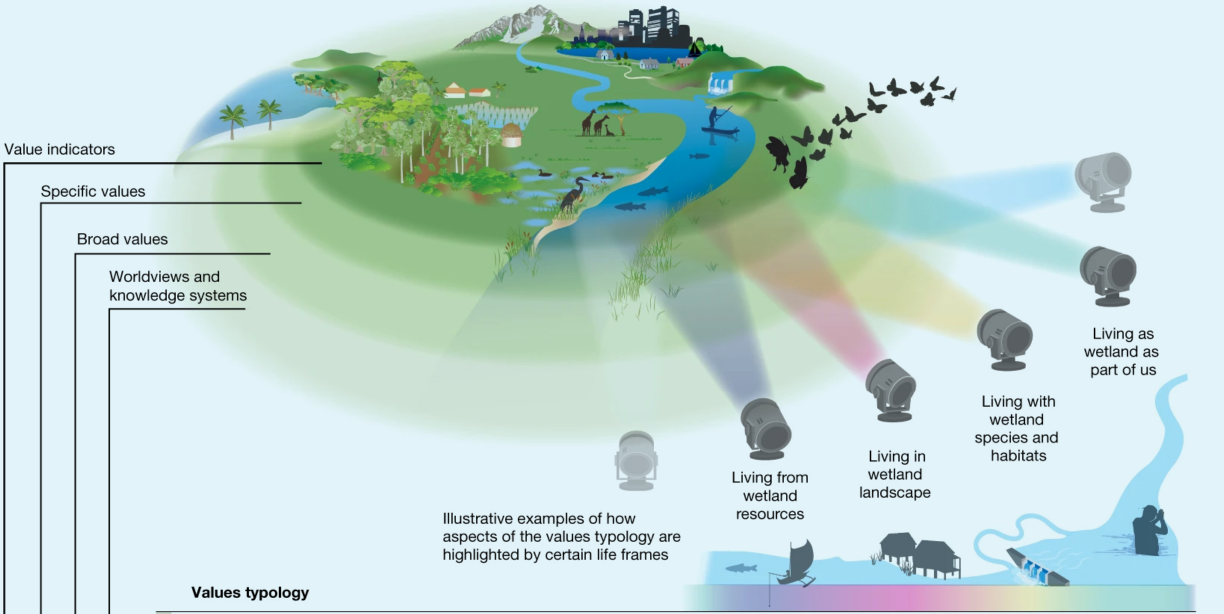
Freshwater is crucial for human survival, and provides multiple benefits to the environment, public health, society and the economy. For instance, freshwater ecosystems are key habitats for many species. Freshwater supports over 10% of all known species, including approximately one-third of all vertebrates and a half of all fishes (Sayer et al., 2025). Although only a tiny fraction of the world's aquatic habitat is freshwater, it hosts 51% of all fish species (Hughes, 2021).

The value of freshwater – as with nature more broadly – can be viewed in multiple ways beyond monetary terms (see Text box 1). Nonetheless, research that has sought to take a financial approach has estimated that freshwater, through it is direct value[3] and indirect use[4] annually is worth approximately US$ 58 trillion (equivalent to roughly 60% of global GDP). About 85% of that estimated value is indirect, coming from services that maintain biodiversity, reduce disaster risk and provide environmental regulation (WWF, 2023).

3 Direct use value in the assessment considered the "tangible benefits that humans derive from consuming or utilizing water that is stored and supplied by freshwater ecosystems for different purposes (e.g. water supply for household, industrial and agricultural purposes, recreation, freshwater, fishing, hydropower generation etc.)".
4 Indirect use value in the research is defined as "benefits that individuals and societies derive from using ecosystem services provided by rivers, lakes, wetlands and aquifers (e.g., water purification, flood regulation, carbon sequestration, biodiversity conservation, cultural and spiritual value etc)".

TEXT BOX 1: THE DIFFERENT VALUES OF WATER

Nature, including water, can be valued in different ways. Some see nature as a resource to exploit for human purposes. When they look at a river, they see a mode of transportation or fish for consumption. This is an anthropocentric view. On the other hand, one can value nature as a landscape we live in. It is important to acknowledge these different values. Neoclassical economics and capitalistic systems upon which global economies and financial systems are based, are largely rooted in an extractive view of nature, thus nature is valued for the "goods" it provides to the economy and people. This guide presents nature's contributions to people from a financial institution's perspective, that is by taking a "living from nature" approach – while encouraging readers to acknowledge there are other ways to value nature.



Values typology

		Living from wetland resources	Living in wetland landscape	Living with wetland species and habitats	Living as wetland as part of us
Worldviews	Ways through which people conceive and interact with the world	Anthropocentric	Anthropocentric	Bio/ecocentric	Pluricentric
Knowledge systems	Bodies of knowledge, practices and beliefs • Academic, indigenous, local				
Broad values	Guiding principles and life goals	Prosperity, livelihood	Belonging, health	Stewardship, responsibility	Oneness, harmony with nature
Specific values	Judgements regarding the importance of nature in particular situations				
	• Instrumental: means to an end, nature as a resource or asset, satisfaction of needs and preferences, usefulness for people	Fish to sell at market	Health benefits of recreation on the river	Fish as regulators of food web structure and function	Fish to eat
	• Intrinsic: agency of other-than-humans, inherent worth of biodiversity as ends in and of themselves			The right of fish to exist	Fish as co-inhabitants
	• Relational: importance of desirable, meaningful and often reciprocal human relationships	Cultural meanings of fishing	Sense of place of a fishing community	Awe inspired by spawning fish	Fish as part of kinship or clan relationships
Value indicators	Quantitative measures and qualitative descriptors				
	• Biophysical	Tonnes of fish	Physiological effects of being in nature	Number of fish species	Fish as nutrition
	• Monetary	Price premium of eco-certified fish	Willingness to pay (WTP) for recreational fishing	Non-use (that is, existence and bequest) WTP of a river feature	
	• Socio-cultural	Gender-specific participation in fishing	Ratings of special places	Legal standing of biodiversity	Narratives of sacred places

Source: Pascual et al. (2023)

Usable freshwater is scarce. Although 70% of the planet's surface is water, only about 2.5% of that is freshwater. Most of the freshwater is locked in glaciers and ice caps (68.7%), around a third is stored in groundwater, and only a small fraction is surface water (1.2%). With two-thirds of total surface water comprised of ground ice and permafrost and 20% being stored in lakes and as moisture in vegetation, the remaining usable share is limited (Water Science School, 2019).

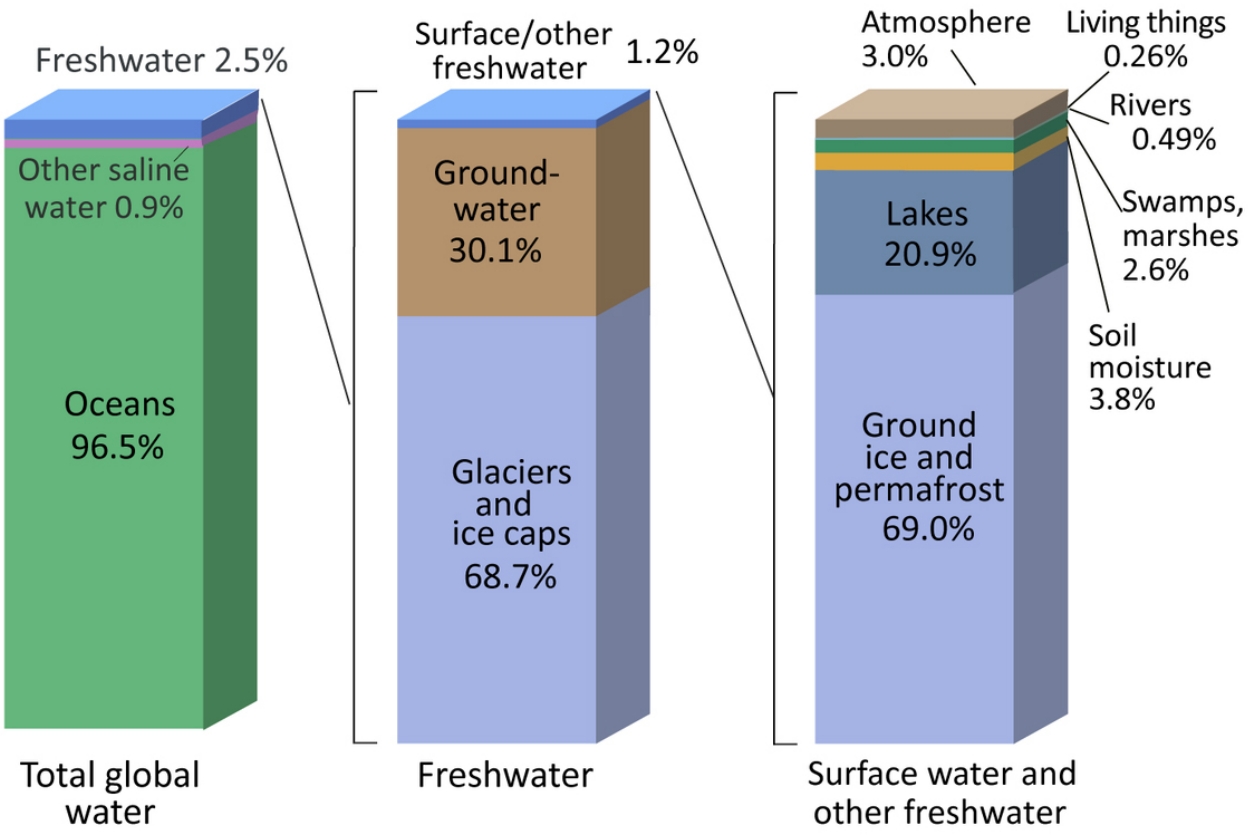


Figure 1: *Where is earth's water? (Source: Water Science School, 2019)*

Water availability is set by the hydrological cycle as it is stored in pools (stocks) and travels through paths (flows) (see Figure 2). Solar energy powers evaporation from the ocean and vegetation, causing moisture to rise and cool; concurrently, the transpiration process also releases water vapour to the atmosphere. When the water condenses and becomes heavy enough, it falls as precipitation, for example as rain or snow. This replenishes water in glaciers, rivers, lakes, soil and vegetation. Water that is not evaporated moves between freshwater sources, like snowmelt feeding streams, lakes, rivers and groundwater, which supports surface waters or returns to the ocean. The global hydrological cycle is a closed loop, meaning that total water remains constant, though local shortages can occur if extraction exceeds replenishment.

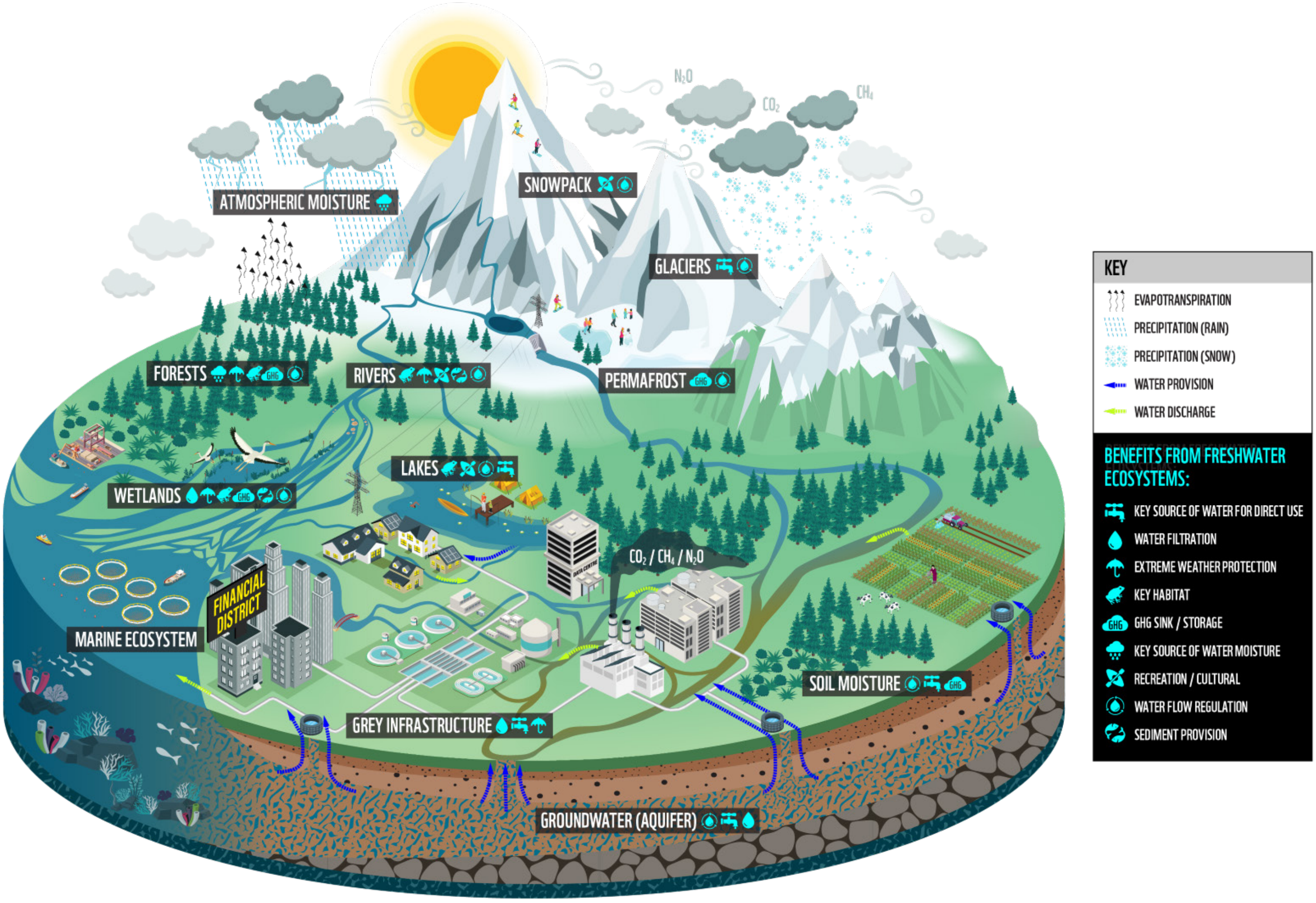


Figure 2: *Hydrological cycle and freshwater benefits within a water catchment. Source: authors inspired by Water Science School, 2022*

The stocks and flows of water provide a wide array of benefits to nature, the economy, society and public health. **Glaciers** act as regional water towers managing the paced flow of water downstream; **snowpack** provides seasonal tourism activities; **rivers** are sediment and nutrient suppliers making deltas highly productive environments and critical for aquaculture operations, which today supply around two-thirds of all fish consumed. Healthy rivers, through their meandering shape, reduce water flow speed, mitigating the intensity of possible floods. Both rivers and **lakes** provide areas for recreation as well as spiritual practice, and can attract tourism. **Wetlands** – terrestrial areas that are permanently or seasonally water-logged or flooded – are key CO2 absorbers (peatlands in particular), are key filterers of pollutants, and provide a critical habitat for a wide range of species, including migratory birds. It is estimated that wetlands contribute more than 20% of the total value of ecosystem services at a global level (Costanza et al., 2014; Speed et al., 2026).

Freshwater systems are not only kept afloat by abiotic processes but also through the actions of a range of species. For instance, **biodiversity** (at population, species and genes levels) is key for maintaining balance and resilience within freshwater ecosystems. There are ecosystem engineers that play important roles, for example when beavers construct small wood dams that create pockets of slow water, allowing for life to flourish. **Groundwater** is a key source of water for households, agriculture and industry; and an especially crucial reserve for buffering dry spells. **Forests** also contribute to the hydrological cycle as sources of water moisture that is transported across continents through wind patterns, providing rain to replenish the surface and groundwater on which agriculture, industry and households depend.

The many ecosystem services provided by freshwater are summarized in Figure 3.

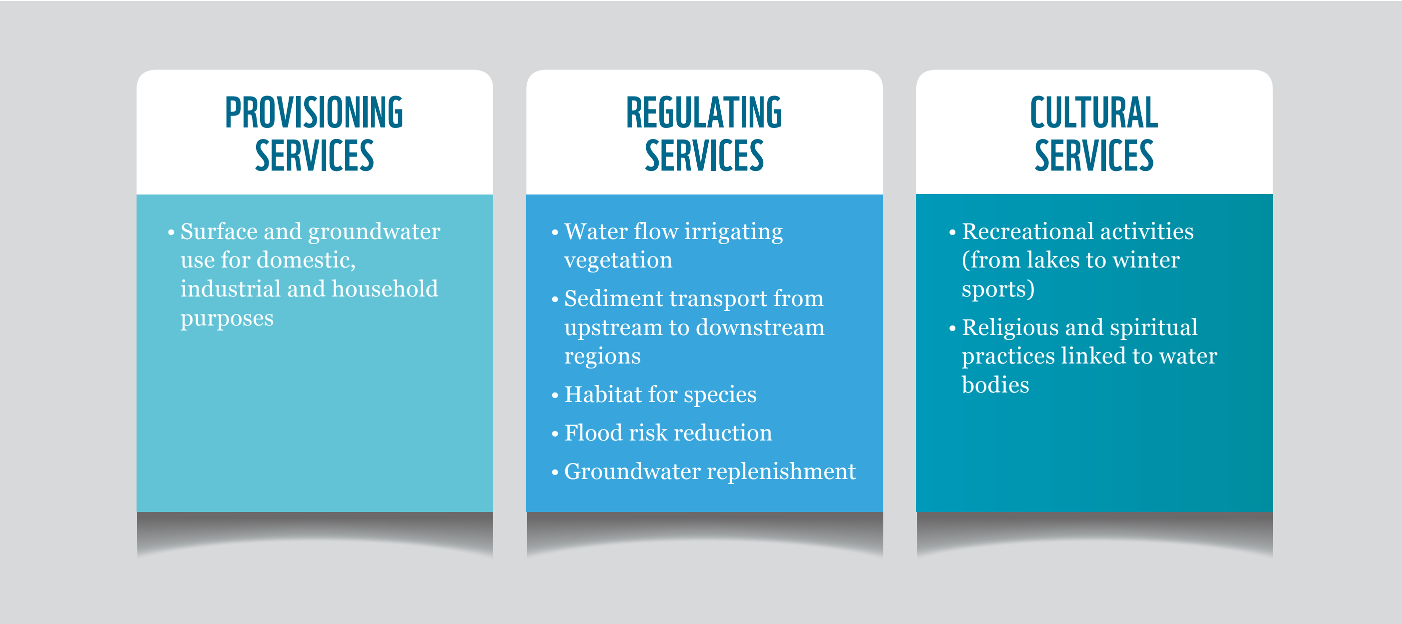


Figure 3: *Freshwater ecosystem services (non-exhaustive)*

Significantly, **grey water infrastructure** plays a crucial role in providing widespread access to safe drinking water and ensuring that clean water is returned to the environment. It is critical for achieving goals related to Water, Sanitation, and Hygiene (WASH). Grey water infrastructure includes wastewater treatment plants, wells, distribution piping, water towers, and all the associated plumbing. When this infrastructure is well designed and maintained it provides reliability and continuity even as extreme weather events are increasing.

Effective water governance mechanisms are a cross-cutting necessity. If water in a given basin or catchment relies on a common source while being used by different actors upstream, midstream and downstream, collaboration is needed to ensure that different users' water needs remain fulfilled.

TEXT BOX 2: NOTE ON WATER TERMINOLOGY

The terms **watershed, basin and catchment** are frequently used interchangeably to describe a land area where all water converges towards a common outlet, such as a river, lake or ocean. Although these terms are generally seen as synonymous, they do have slightly different connotations:

- **"Basin"** typically refers to a large geographical region.
- **"Catchment area"** may represent a more general, or occasionally smaller, delineated area.
- **"Watershed"** is often used as a substitute for catchment area; however, in certain countries, "watershed" specifically designates the boundary ridge (divide) rather than the entire drainage area.

In addition to the geographic scope (area) of analysis, *types* of freshwater are distinguished via different colours: blue, green and grey (Global Commission on the Economics of Water,2024; Hoekstra et al., 2011):

- **Blue water:** water in surface water and groundwater.
- **Green water:** water moisture stored in soil and vegetation – for the purpose of this report, also including freshwater biodiversity and ecosystems.
- **Grey water:** wastewater and related infrastructure.

Water-related interactions occur within and are shaped by different "spheres":

- **Biosphere:** the parts of Earth where life exists.
- **Atmosphere:** the layers of gases surrounding Earth.
- **Cryosphere:** frozen water, including snow cover, glaciers, ice sheets and permafrost.
- **Hydrosphere:** the total amount of water on the planet, from underground, on the surface and in the air.

THE WATER CRISIS, ITS DRIVERS AND TIPPING POINTS

Freshwater systems possess notable resilience. However, they are not indestructible.

Freshwater system functioning depends on a balance between living (biotic) and non-living (abiotic) ecological processes. When excessive pressures exceed the ability of freshwater ecosystems to regenerate, recover and replenish; hydrological systems begin to break down. This manifests in ways including extreme flooding, a lack of water availability, a deterioration in water quality, and collapsing ecosystems. It is estimated that about half of the countries in the world today have one or more types of freshwater ecosystems that are degraded (UNEP, 2024). Average size of freshwater populations has seen an 85% decline since 1970, reflecting a significant loss of ecosystem integrity that is contributing to hydrological breakdowns (WWF, 2024b).

The hydrological cycle has been mostly stable during the Holocene epoch, although in recent years increased human impacts – such as water overuse, climate change, land use change, pollution and invasive species – have disrupted the hydrological cycle and ecosystem health (Caretta et al., 2022) (see Figure 4). While average global shifts may seem minor, altered rainfall at the regional or catchment scale directly affects activities that are dependent on weather patterns, such as rainfed agriculture. These effects can cascade further, impacting migration, public health, livelihoods, and food and energy security, with consequences reaching beyond the initially affected area. This can have further economic ramifications; affecting business continuity, supply chains and asset values as well as broader macroeconomic indicators such as price levels and labour markets.

Clearly, the water crisis is more than a problem of quantity: unsustainable production and consumption patterns are also affecting water quality, freshwater ecosystem health and biodiversity. The crisis also manifests in issues of water governance and inadequate grey infrastructure (see Table 1). While the geographic, biophysical and socioeconomic context determines the specific challenges faced in a given catchment, country or region, these challenges are essentially universal in global terms. In response, various organizations have warned of a global water crisis (Global Commission on the Economics of Water, n.d.), and have highlighted the fact that the planet is facing "water bankruptcy", meaning we are passed the stage for crisis management and what is needed is urgent recovery (Madani, 2026).

For a detailed summary of the benefits offered by blue, green and grey water systems, as well as the pressures affecting their decline (shown in Figure 2 and Figure 4) see Table 12 in the Annex.

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5 Earth's geological time scale is divided into eons, eras, periods, epochs and ages, as determined by the stratification of rock layers. The current epoch, the Holocene, began approximately 11,700 years ago following the last major ice age. Nonetheless, there is ongoing debate regarding whether we have entered a new epoch – the Anthropocene – beginning around 1950 with the onset of the "Great Acceleration", characterized by significant human-induced alterations to the planet's climate and ecosystems (National Geographic Society, 2023) .

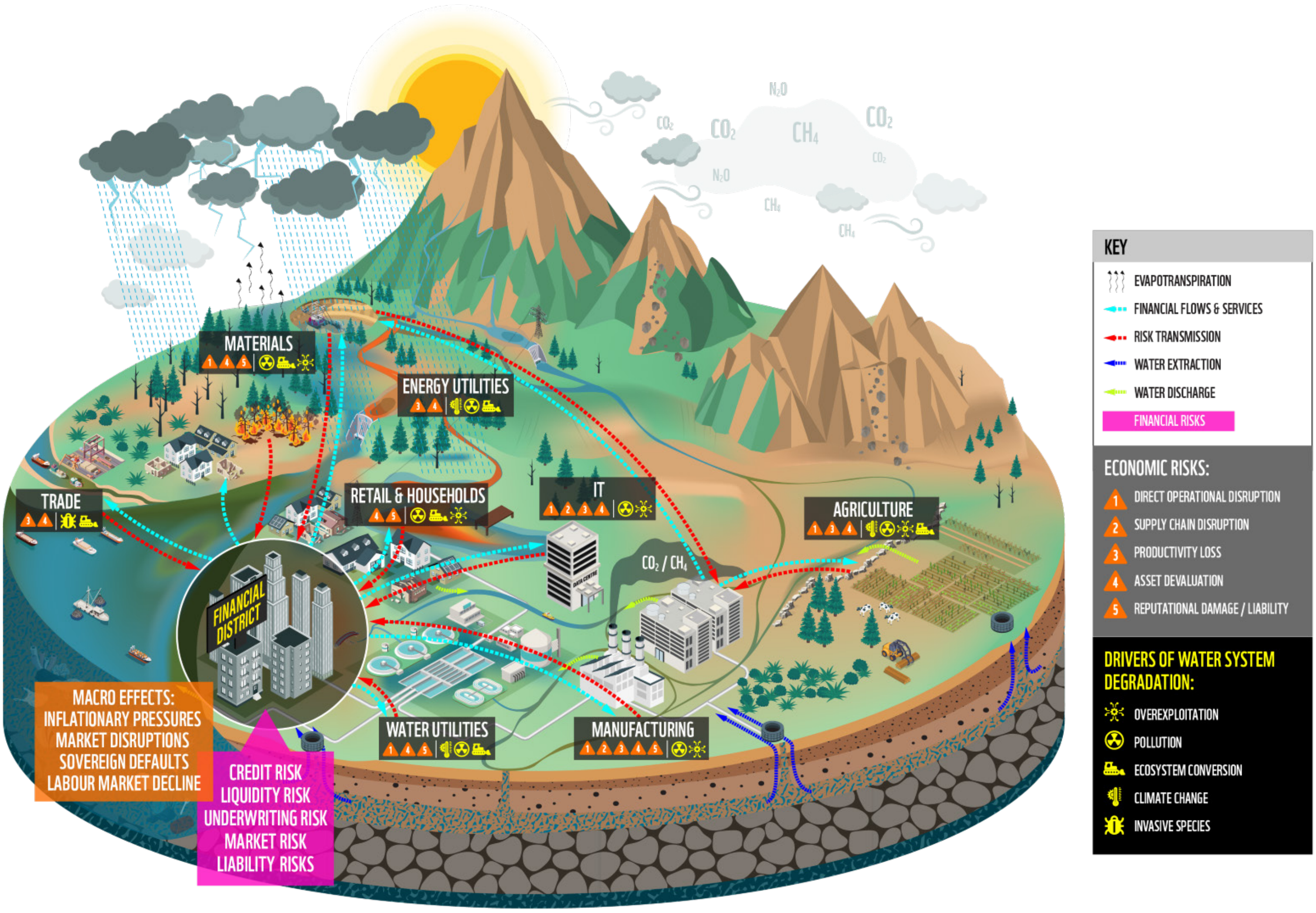

Figure 4: *The drivers disrupting the hydrological cycle and freshwater ecosystems and its consequences. Source: authors inspired by Water Science School (2022)*

Table 1: *The water crisis mosaic*

DRIVER	DIMENSION	CONSEQUENCE	DESCRIPTION
Overexploitation Climate change Water pollution Flow modification and fragmentation Destruction and degradation of habitats Invasive species Saltwater intrusion Infectious diseases	Water quantity	Too much	**Climate change, the deterioration of flood plains, and greater interactions between humans and natural systems are contributing to more frequent and severe pluvial and fluvial floods, as well as storm surges. These events result in economic losses, public health issues, and population displacement.** • 90% of natural disasters are weather-related, with hydro-related hazards such as floods causing the most economic damage (UNISDR, 2015). • Due to major insurance protection gaps, households and business are left to bear the brunt of the economic damage – between 2002 and 2021 floods caused losses equivalent to US$832 billion globally (UNESCO, 2024). In the past decade, only 17% of flood-related economic losses were insured (Bevere & Remondi, 2022).
		Too little	**Groundwater and surface water overexploitation, degradation of freshwater ecosystems and land conversion, climate change and unsustainable water management have led to chronic water stress and acute drought events, increasing in frequency and severity.** • The United Nations forecasts there will be a 40% shortfall in water supply by 2030 (Global Commission on the Economics of Water, 2023). • Twenty-five countries, which together represent one-quarter of the world's population, already experience "extremely high" water stress annually (UNESCO, 2025). • Droughts, whose intensity and frequency are increasingly exacerbated by climate change, are placing additional burdens on areas already facing water stress; this directly impacts food and energy security, both fundamental pillars of economic and societal stability.
	Water quality	Too dirty	**Excessive industrial and agricultural pollution is degrading water quality, especially with pollutants that are difficult to break down, increasing treatment costs. Increasing levels of polluted water also means there is less clean water available for critical purposes such as drinking water, thus posing a risk to public health.** • Eutrophication of surface waters is increasingly becoming the norm in areas with intensive industrialized agriculture, the result of excessive nutrient run-off. • Micropollutants – that even in low concentrations can have extremely disruptive effects on the environment – are increasingly polluting water systems. This stems from industrial chemicals, microplastics, pesticides, pharmaceuticals and consumer products. • Water treatment is becoming increasingly expensive, especially for treating micropollutants (e.g. PFAS) which require additional steps. This can place additional financial burdens on households and businesses relying on clean water directly or via their value chains (Price & Heberling, 2018).

DRIVER	DIMENSION	CONSEQUENCE	DESCRIPTION
	Freshwater biodiversity and ecosystems Grey water infrastructure	Broken green and grey infrastructure	**Outdated grey infrastructure, fragmentation and conversion of freshwater ecosystems, and overexploitation of freshwater resources all pose serious problems.** • Wetlands, rivers and lake ecosystems are crucial for buffering against droughts and floods. This green infrastructure is also fundamentally important for maintaining water quality and sequestering carbon (Ferreira et al., 2023). • Freshwater species diversity and abundance is key in ensuring the resilience of green infrastructure, yet freshwater species have seen the sharpest decline of all monitored species groups: around a quarter of freshwater animal species are at risk of extinction, and average population sizes are estimated to have dropped by 85% in the past 50 years (WWF, 2024b). • 2.2 billion people still lack access to safely managed drinking water (United Nations, n.d.). • Globally, much of the water-related infrastructure such as wastewater and sanitation facilities is becoming outdated, posing potential threats to surrounding environments and people's health.
	Water governance	Broken governance	**Power imbalances and short-sighted governance arrangements are widespread, and bilateral governance of shared water systems often breaks down.** • Competing interests and increasing demand for water from upstream, midstream and downstream users are straining catchment resources, often exacerbated by inadequate government mechanisms that lead to overexploitation. • Beyond the national level, transboundary waters make up 60% of the world's freshwater flows (UN-Water, 2021), yet only 43 out of the 153 countries with shared water resources have established operational arrangements covering 90% or more of the resources in question (UN-Water, 2024a). • Weak governance instruments risk making water access weaponizable for geopolitical purposes (UN-Water, n.d.).

TEXT BOX 3: NOTE ON WATER CRISIS TERMINOLOGY


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Terms such as water scarcity, water stress and drought often get used interchangeably when in fact they capture different, yet interrelated, dynamics.

Water shortage: This is a relative concept denoting a water deficit due to excessive demand or dwindling supplies. It usually refers to a short-term, acute event-driven deficit.

Water scarcity: This is also a relative concept relating to supply and demand dynamics. Water scarcity occurs when demand for water outstrips the available supply. Often water scarcity refers to a longer period of imbalance, and it tends to be chronic in nature.

Water stress: Water stress is a concept similar to water scarcity in that it compares water demand and supply in a certain region, but it also considers broader limitations to water availability such as quality and accessibility.

Drought: There are different types of droughts and related definitions, but in essence drought refers to a prolonged period of low or no rainfall resulting in a shortage of water.

(Lack of) water availability: Water availability refers to the physical abundance or lack of freshwater resources, and is generally calculated as a function of the volume of surface water and groundwater available in a given area.

Water insecurity: This term describes a lack of reliability or consistency in a water supply, which may result from demand surpassing available resources, contamination of water sources, or variability in water volumes due to events such as floods or droughts (UNGA, 2009).

TEXT BOX 4: DESALINATION – WE HAVE SO MUCH OCEAN WATER, WHY NOT SIMPLY TURN IT INTO CLEAN, USABLE FRESHWATER?

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Desalination is the process of removing salts and impurities from seawater or brackish water to produce freshwater for drinking, agriculture and industry. It offers a reliable water source, especially in arid regions or during droughts, reducing dependency on traditional supplies. However, desalination is i) **highly energy-intensive**, often relying on fossil fuels, ii) **produces brine waste** that can – and frequently does – harm marine ecosystems, and iii) **is only suitable for coastal areas**. Although new technologies such as solar-powered plants and mineral reuse are being explored, significant challenges remain due to high costs and environmental concerns. While desalination may increase water availability overall, it does not address the root causes of water-related challenges.

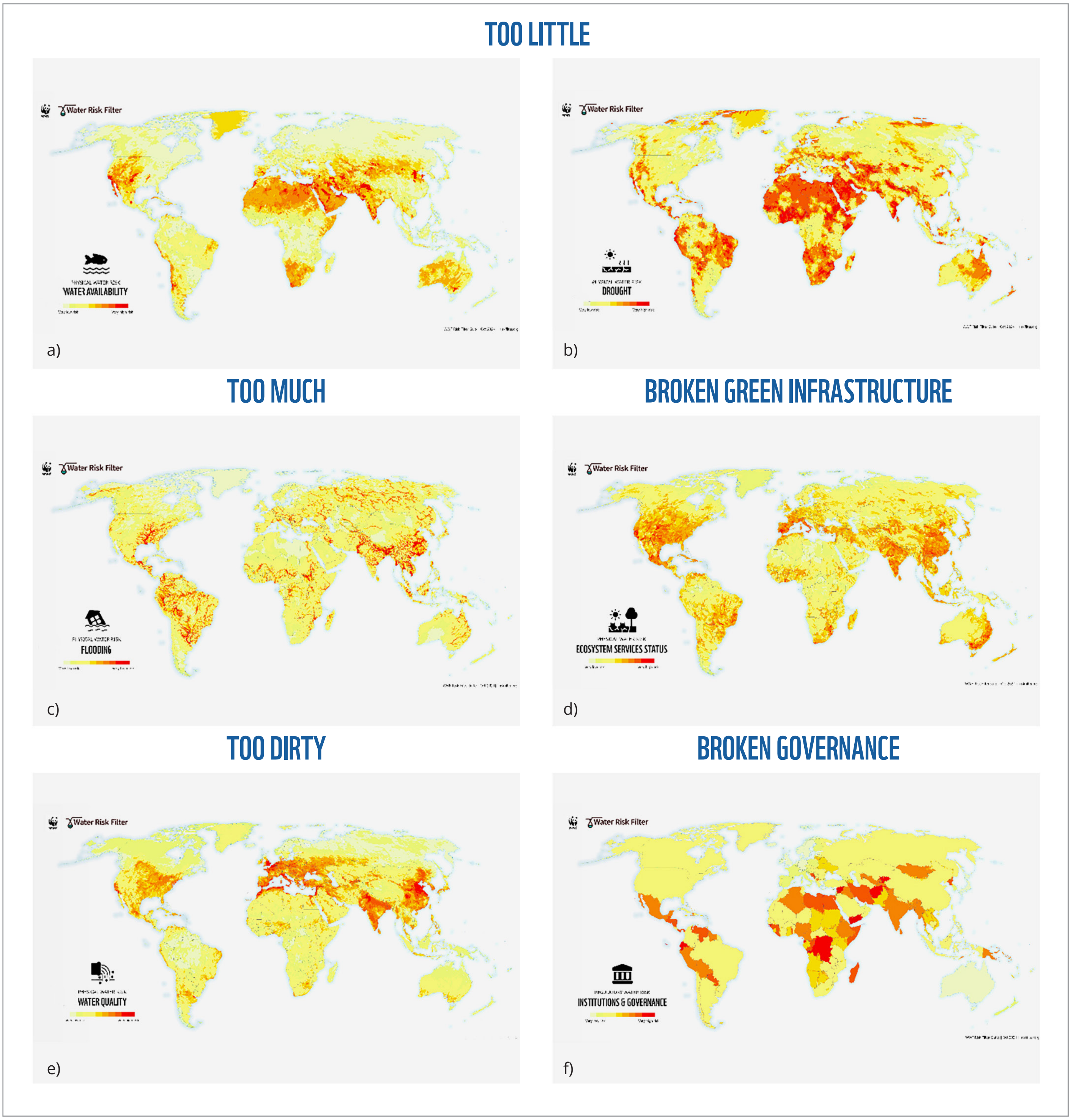

Figure 5: *Selected risk maps from Water Risk Filter. Source: WWF Risk Filter Suite (2024)*[6]

6 a) Water availability: This risk category integrates indicators for water depletion, baseline water stress, blue water scarcity and groundwater levels. b) Drought is measured with the Standardized Precipitation and Evaporation Index (SPEI) and the JRC World Atlas of Desertification where considered. c) Flooding takes into account historical patterns, drawing on empirical evidence from major flood events since 1985, within the context of a 100-year flood event. d) Ecosystem services status is determined by indicators including river fragmentation as measured by the Connectivity Status Index (CSI), catchment degradation such as forest loss, wetland degradation, the presence of invasive species, and changes in river extent. e) Water quality is assessed using nine leading peer-reviewed datasets that encompass various aspects and modelling approaches. These include biological oxygen demand (BOD), which serves as a general indicator of overall water quality; electrical conductivity (EC), representing salinity balance and pH changes; coastal eutrophication potential; nitrate-nitrite concentrations; periphyton growth potential; toxicity stress; mismanaged plastic waste; pesticide pollution; and total dissolved solids. f) Institutions & governance are measured by two indicators: control of corruption, and SDG 6.5.1 on private sector involvement in water management. See the full Risk Filter Suite documentation for more details (WWF Risk Filter Suite, 2025b).

In the context of global climate change, the imperative to significantly reduce anthropogenic greenhouse gas emissions has become central to ongoing discussions, obscuring interactions with the water system.

If climate change, water insecurity, and biodiversity loss are addressed independently, potential synergies between solutions may be overlooked and important trade-offs may remain unrecognized. The interconnections between these challenges are outlined in Table 2 below.

Table 2: *Interlinkages between water, climate and other nature realms*

PROCESS	IMPACTS
CLIMATE CHANGE IS ALTERING THE HYDROLOGICAL CYCLE **(physical processes)**	• **Evaporation and variability:** Warmer air holds ~7% more water vapour per 1°C, increasing precipitation intensity and variability (NASA, 2024). • **Rainfall shifts and "climate whiplash":** Shifting rain belts and rapid alternation between drought and heavy rainfall (Swain et al., 2025; WMO, 2026). • **Cryosphere loss:** Reduced snow and glacier storage leads to erratic river flows and long-term water scarcity (UNESCO, 2025).
CLIMATE CHANGE EXACERBATES FRESHWATER BIODIVERSITY LOSS AND POLLUTION **(chemical and biological processes)**	• **Pollutant run-off:** Heavy rainfall accelerates run-off of nutrients, sediments and pesticides (Skidmore et al., 2023). • **Eutrophication and salinization:** Warmer waters increase algal blooms, while sea-level rise and groundwater changes of replenishment drive saltwater intrusion (Adams et al., 2024; EU Commission DG for Environment, 2023). • **Pollutant concentration and ecosystem disruption:** Drought increases pollutant concentration and favours invasive species (Bonet et al., 2023).
FRESHWATER ECOSYSTEM DEGRADATION EXACERBATES CLIMATE-RELATED RISKS	• **Flood risk:** Wetland conversion and river (sand) dredging diminish wetland health and can heighten flood-related risks (Guo et al., 2026). • **Land subsidence:** Dams and groundwater depletion reduce sediment replenishment and cause subsidence, increasing coastal flood and salinity risks.
CLIMATE MITIGATION AND ADAPTATION MAY HARM FRESHWATER SECURITY	• **Climate change mitigation via electrification:** Th energy transition and digitalization are increasing water demand and pollution across supply chains (Cousins et al., 2024; UN-Water, 2024b). • **Low-carbon energy trade-offs:** Hydropower expansion disrupts river connectivity and ecosystem health (Zarfl et al., 2019).
FRESHWATER/NATURE-RELATED INTERVENTIONS CAN MITIGATE CLIMATE-RELATED RISKS	• **Ecosystem restoration:** River renaturalization, depaving and urban greening improve water retention and groundwater recharge, increasing resilience to floods and droughts.

Due to the complex, non-linear interdependence between climate, biodiversity and freshwater systems, excessive pressures can initiate shifts that cross critical thresholds, potentially resulting in cascading and often irreversible ecosystem collapses. Identifying these points of no return is a significant challenge, as there are currently no universally recognized global thresholds for freshwater. Despite significant research gaps on freshwater tipping points (de la Riva et al., 2023), numerous researchers have sought to evaluate our current proximity to such tipping points.

- **Blue and green water:** The latest planetary boundary assessment by the Stockholm Resilience Centre, in 2025, found that for seven out of nine boundaries we are outside the "safe operating space". The two most recent assessments both showed how we have exceeded safe operating boundaries for blue water (i.e. surface water such as lakes and rivers) and green water (i.e. water in vegetation and soils) (van Vuuren et al., 2025).


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- **Absolute soil moisture decline:** Increasing temperatures in the atmosphere and the ocean have altered precipitation and evapotranspiration patterns, with potentially irreversible consequences for soil water storage. A study found that between 2000 and 2002 global soils lost more water than Greenland's ice sheet did between 2002 and 2006, indicating permanent shifts in freshwater system regimes (Seo et al., 2025).

- **Permafrost:** Various researchers have identified tipping dynamics of permafrost (ground that that is frozen for at least two years), particularly for large areas located in Russia, Canada, the United States (Alaska) and China (Tibetan Plateau). It is estimated that the upper 3 metres of permafrost soils contain about 1'035 Giga tonnes of carbon (Hugelius et al., 2014), equivalent to 50% more than what is in today's atmosphere. With the Arctic is warming almost four times faster than the rest of the planet, permafrost soils continue to melt, releasing CO_2 and methane (CH_4) and further accelerating climate change (Lenton et al., 2023).


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- **Greenland ice sheet:** A study published in 2023 found that the Greenland icesheet is likely halfway through reaching its first tipping point, at which point further melting will be difficult to halt once the icesheet loses a critical mass and sea level has continued to rise (Höning et al., 2023).

- **Localized eutrophication:** Hypoxia – low oxygen levels in lakes and coastal areas – is an increasingly serious issue. This problem is mainly caused by eutrophication (nutrient over-enrichment), which results from nitrogen and phosphorus runoff from agricultural and industrial activities entering water bodies. Such runoff becomes worse with extreme rainfall events. Moreover, climate change is raising temperatures in bodies of water, which intensifies stratification and prevents excess nutrients from being diluted. Lakes depleted of oxygen absorb less CO_2 and can instead emit methane. Increased concentrations of dissolved organic matter in lakes and rivers, often driven from land-use changes, as notably is the case in boreal areas, promote greater stratification, exacerbate oxygen depletion, and contribute to elevated greenhouse gas emissions (Lenton et al., 2023).

- **Freshwater biodiversity:** Population sizes of freshwater species have dropped more than for any other species type since 1970, declining by an average of 85% (WWF, 2024b).


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THE WATER CRISIS, HUMAN RIGHTS AND SOCIOECONOMIC STABILITY


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Access to safely managed clean drinking water and sanitation infrastructure and services is still not universal. Despite significant improvements since 2015, about 2 billion people still do not have access to safely managed drinking water and 3.4 billion do not have access to safely managed sanitation services (WHO & UNICEF, 2025).

In 2010, the United Nations General Assembly recognized the human right to water and sanitation, emphasizing that clean drinking water and sanitation are essential to the realization of all human rights. When water resources are compromised the consequences can be severe, particularly for vulnerable communities in which health, the pursuit of livelihoods and the exercise of many other human rights are directly affected by environmental degradation (UNGA, 2010). The onset of the water crisis has been further amplifying disparities in access to clean water. Not addressing root causes threatens progress toward achieving SDG 6 (Water and Sanitation) within the next five years – a goal that already demands accelerated action.

Critical dimensions to address are outlined below:

- **Health risks to vulnerable communities:** Numerous instances worldwide demonstrate that the health of certain communities has been adversely affected by polluting activities such as metallurgical coal mining and petrochemical production plants, as well as by inadequate drinking water management. Communities experiencing prolonged exposure to contaminated water – either directly through drinking or indirectly via food – are at increased risk of developing diseases. Children, in particular, are highly susceptible to the negative effects of water contamination (CELCOR et al., 2024; Environmental Justice Atlas, 2021; Riley, 2024; Robinson et al., 2025). These water-borne issues risk exacerbating socio-economic inequalities.
- **Forced migration:** Water scarcity drives communities to relocate as they seek access to water, which can put pressure on resources in receiving areas, impact food security, and increase social tensions. Between 1970 and 2000, approximately 10% of global migration was connected to water shortages (Zaveri et al., 2021).
- **Conflict, instability and geopolitical tensions:** Water scarcity can be a catalyst for conflict, particularly in areas with transboundary water sources or competing interests (Michel, 2025). Such instability can emerge even in what is perceived to be a stable region: the European Environmental Agency has warned that under a 3°C average warming trajectory, cross-border disputes between EU Member States are likely to rise due to potential water scarcity (Hancock, 2024). Water insecurity has the potential to heighten geopolitical risks, especially when competing interests arise over freshwater usage and power imbalances are exacerbated by upstream control of water sources (Aguiar, 2025).
- **Global security implications:** The impact of water insecurity extends beyond local and regional conflicts. It poses a significant threat to global peace and security (UNESCO, 2024), placing economic, price and financial stability at risk.

CASE STUDY

THE EAST KALIMANTAN ECONOMY'S IMPACT AND DEPENDENCY ON THE MAHAKAM RIVER (INDONESIA)

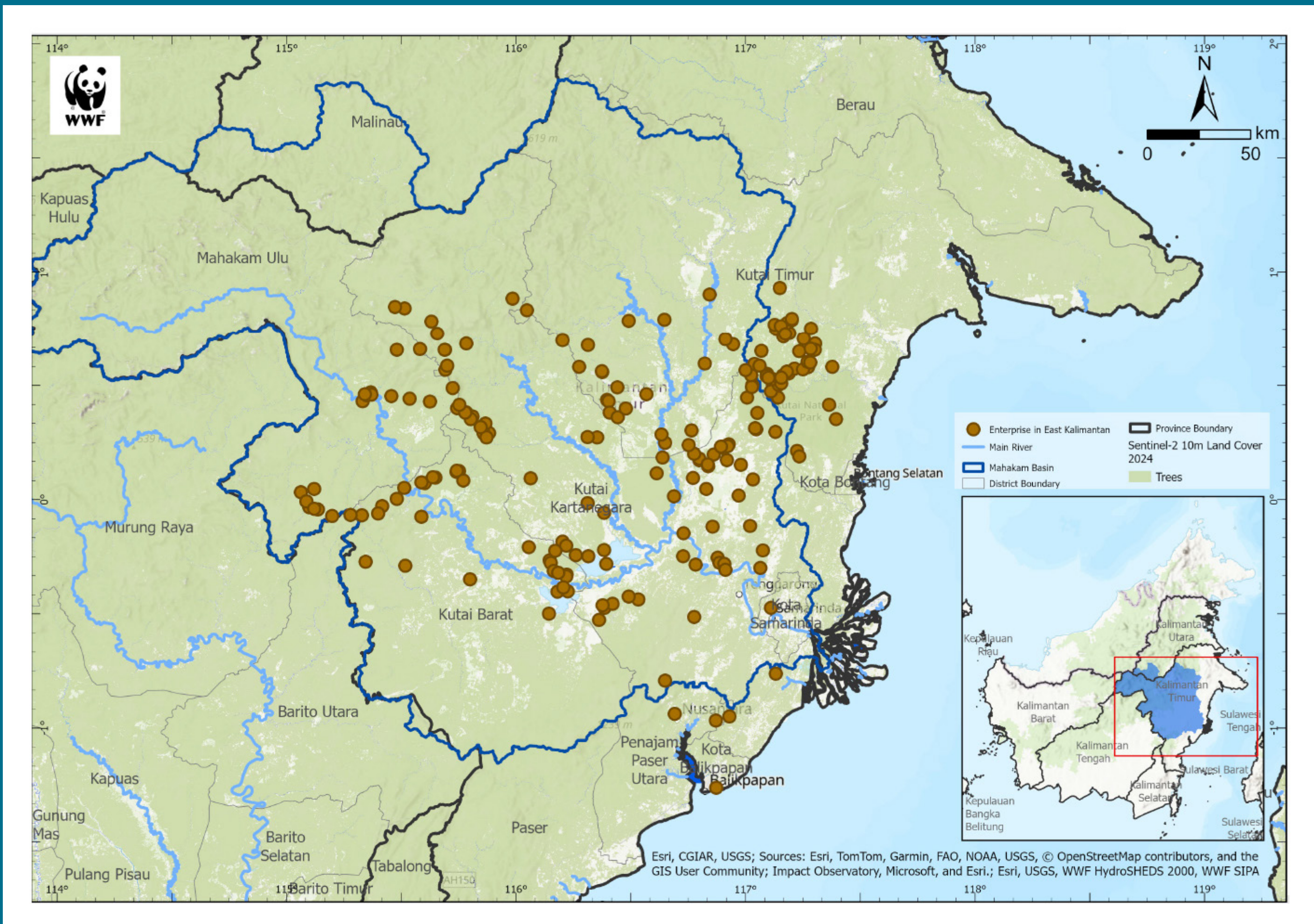


Figure 6: *Map of enterprises located in the Mahakam Basin*

This assessment combines local basin-level data on water quality, sedimentation, and economic dependencies with indicative spatial screening using the WWF Water Risk Filter. While the Water Risk Filter uses global datasets best suited for comparative screening across geographies, it provides a useful complementary perspective when combined with locally validated data for basin-level analysis.

BASIN CONTEXT AND ECONOMIC ROLE

The Mahakam Basin is Indonesia's third-largest watershed. It covers 77.432 km², and is designated as a National Strategic River Basin (Indonesian Ministry of Public Works, 2015). The Basin includes four regencies (Mahakam Ulu, Kutai Barat, Kutai Timur and Kutai Kartanegara) and a city (Samarinda) in East Kalimantan, as well as one district (Malinau) in North Kalimantan. It plays an important role in the regional economy, supporting transportation, agriculture, fisheries and industry.

KEY FRESHWATER PRESSURES

The Mahakam Basin/River faces severe and persistent freshwater pressures, particularly pollution and land-use change, which contribute to sedimentation and ecosystem degradation, among other impacts. Based on the national water quality parameters under Government Regulation No. 22/2021, the National Statistical Bureau of Indonesia classified the Mahakam Basin as "Moderately Polluted–Heavily Polluted" in 2016-2018 and "Heavily Polluted" in 2019-2020. One of the contributors to the river's deteriorating water quality is the extractive activities which surround the Mahakam Basin, especially coal mining operations. Acidic coal wash waste containing heavy metals is frequently discharged into the Basin (Forest Watch Indonesia, 2018).

In addition to extractive industries, plantation development also contributes to environmental pressures in the area.

Large-scale land conversion alters natural vegetation cover, reduces soil stability and increases surface runoff, accelerating erosion and sediment transport into river systems. Over time, these processes influence river morphology and water quality. Sedimentation has become a notable concern in the lower basin, particularly in the deltaic area, where geological assessments estimate accumulation rates of approximately 0.27–0.45cm per year (Darlan et al., 2008). Such changes may affect channel dynamics and aquatic habitat conditions.

Under increasing climate variability, pollution and sedimentation are likely to intensify. Extreme rainfall events can accelerate soil erosion and mobilize sediments and contaminants, particularly in areas affected by mining and land-use change. Meanwhile, prolonged drought conditions may reduce river discharge and dilution capacity, leading to higher pollutant concentrations and deteriorating water quality. These climate-related hydrological extremes may amplify existing anthropogenic pressures within the Mahakam Basin.

SECTORAL DEPENDENCE AND ECONOMIC EXPOSURE

East Kalimantan's economy is highly dependent on sectors that rely on or impact the Mahakam Basin. The extractive sector, particularly mining, contributed IDR 329.46 trillion (US$ 20.8 billion) to gross regional domestic product (GRDP) in 2024, making it the largest economic contributor in the province (38% of GDRP) (Central Bureau of Statistics of East Kalimantan Province, 2025).[7] Other river-dependent sectors include manufacturing (18%), construction (12%), agriculture (9%), and transportation and warehousing (5%).

These same six sectors collectively account for 71.54% of the province's total outstanding financing portfolio (based on ISIC classification), equivalent to approximately US$ 100.17 billion as of 2024.[9] This concentration of economic and financial activity within ecosystem service priority areas signals substantial ecosystem dependency and material exposure to freshwater-related risks. Integrating restoration priorities into corporate risk management frameworks is therefore critical to ensuring long-term resilience.

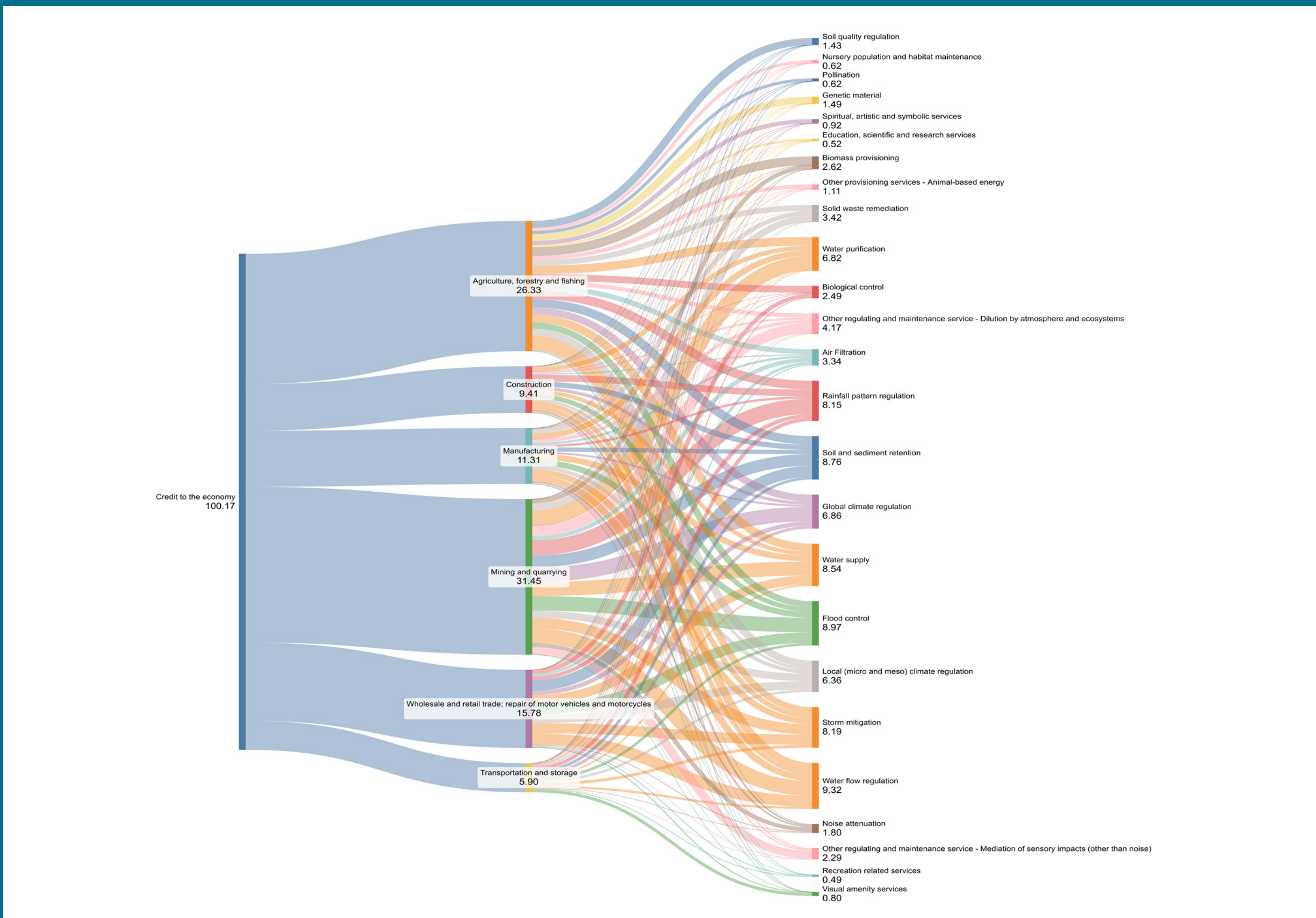


Figure 7: *Mapping of bank credit exposure across key economic sectors to ecosystem service dependencies in East Kalimantan. (Source: WWF-Indonesia analysis based on aggregated Indonesia financial services authority (OJK) bank credit portfolio data for top six sectors based on GRDP in East Kalimantan (December 2024), combined with ENCORE ecosystem service dependency classification)*

7 Converted using average 2024 exchange rate (IDR 15,860/US$).
8 Otoritas Jasa Keuangan, Kredit Subsektor Ekonomi Lokasi Penggunaan Kalimantan Timur 2022 s.d. 2025, 2025.

The six sectors shown in Figure 7 have a very high level of dependency on ecosystem services, with 25 out of 25 ecosystem services identified as relevant to operations. The distribution of dependency levels is dominated by the medium to very high categories, suggesting that operational continuity is strongly influenced by the condition and functioning of natural ecosystems. From the graph, the most significant dependency observed in water flow regulation refers to the ecosystem's capacity to absorb and store water. In addition, the analysed sectors were found to rely on ecosystem services provided by mangrove forests, coral reefs and other vegetation to mitigate the impacts of storms and flooding. Damage to the ecosystem can affect the productivity of these economic sectors and may impact the overall economy of East Kalimantan Province.

Additionally, indicative spatial screening using aggregated enterprise location data provided by the River Basin Authority (BWS), combined with WWF's Water Risk Filter (WRF), suggests that exposure is structurally concentrated in areas classified as high to very high risk for Catchment Ecosystem Degradation (see Figure 8). A substantial proportion of mapped enterprises in mining, agriculture and manufacturing intersect with these higher-risk zones. Elevated exposure patterns are also observed for flood hazard, wetland degradation, and river extent change indicators.

DRIVER	CATCHMENT ECOSYSTEM SERVICES DEGRADATION LEVEL									
	Agriculture		Construction		Manufacture		Mining		Transportation	
	No. of companies	%. of companies	No. of companies	%. of companies	No. of companies	%. of companies	No. of companies	%. of companies	No. of companies	%. of companies
Very low risk	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%
Low risk	1	1.11%	0	0.00%	0	0.00%	0	0.00%	0	0.00%
Medium risk	2	2.22%	0	0.00%	0	0.00%	11	13.25%	1	16.67%
High risk	5	5.56%	0	0.00%	0	0.00%	9	10.84%	0	0.00%
Very high risk	82	91.11%	4	100.00%	14	100.00%	63	75.90%	5	83.33%
	90	100%	4	100%	14	100%	83	100%	6	100%

Figure 8: *Sectoral exposure to catchment ecosystem degradation risk in the Mahakam Basin (WWF Water Risk Filter, BWS data)*

Restoration priority areas identified through the SIPA Nature-based Solutions (NbS) project (Bappenas–WWF) represent the top 10% of zones delivering critical hydrological services. According to Figure 6, spatial overlay analysis using company location data from the River Basin Authority (BWS) indicates that 34 out of more than 200 mapped enterprises (≈17%) across the six priority sectors operate within these restoration zones.

CONCLUSION

The Mahakam River Basin case study shows that degradation in freshwater quality and quantity coincides with high economic and financial exposure in specific regions and sectors, underscoring the relevance of freshwater-related risks for financial analysis and supervision. Aligning capital mobilization with basin-level restoration efforts is therefore essential. Protecting and restoring critical water-related ecosystem services will strengthen environmental resilience and support long-term economic stability amid increasing climate pressures.

KEY MESSAGES TO CENTRAL BANKS, FINANCIAL SUPERVISORS AND REGULATORS

01 FRESHWATER IS A LIMITED AND VALUABLE RESOURCE, WHOSE SIGNIFICANCE EXTENDS BEYOND MEASURABLE QUANTITY; IT PLAYS A FUNDAMENTAL ROLE IN NATURAL PROCESSES AS DESCRIBED BY THE HYDROLOGICAL CYCLE.

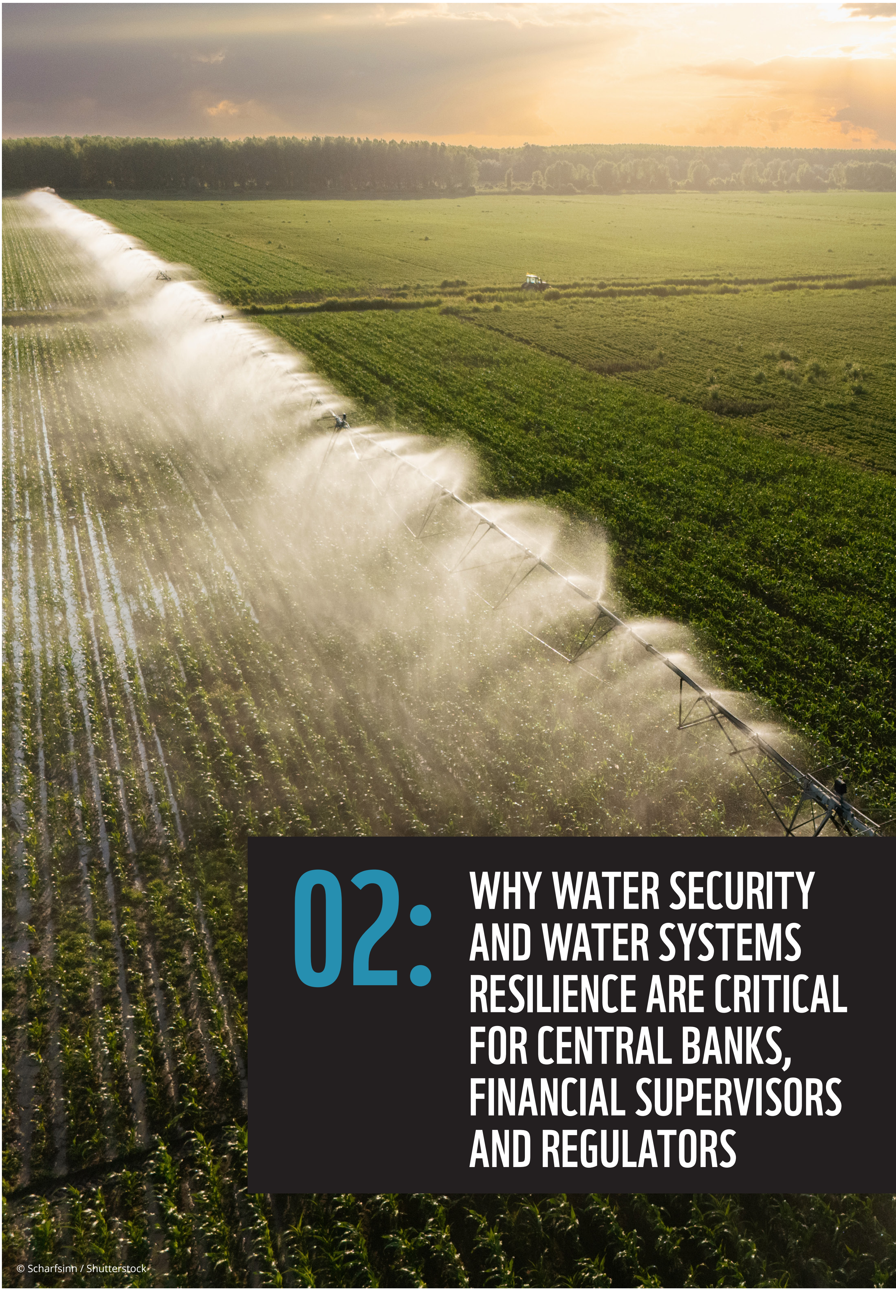
Freshwater ecosystems encompass the cryosphere (glaciers, ice sheet, snow cover), the atmosphere (atmospheric rivers), inland waters (surface water, including rivers, ponds and lakes as well as groundwater aquifers), freshwater biodiversity (species and ecosystems), and the human-made infrastructure needed to make water accessible for drinking and sanitation (WASH).

02 THE WATER CRISIS IS NOT A NATURAL PHENOMENON BUT RATHER THE RESULT OF UNSUSTAINABLE HUMAN ACTIVITIES.

Acute hydrological hazards and chronic shifts are mainly driven by climate change, excessive exploitation of water resources, conversion of freshwater ecosystems (including wetland drainage), land conversion, pollution, and saltwater intrusion. Human-induced pressures, compounded by climate impacts, have resulted in a global water crisis characterized by localized issues of too much water, too little water, too dirty water, broken green and grey water infrastructure, and broken water management governance.

03 RESOLVING THE WATER CRISIS IS IMPERATIVE NOT ONLY ON ITS OWN MERITS BUT ALSO AS A PREREQUISITE FOR THE GREEN ENERGY TRANSITION, THE ACHIEVEMENT OF BROADER CLIMATE OBJECTIVES, AND THE SAFEGUARDING OF BIODIVERSITY AND ECOSYSTEMS.

These challenges must be addressed through holistic approaches to optimize synergies among goals and mitigate potential trade-offs.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02: WHY WATER SECURITY AND WATER SYSTEMS RESILIENCE ARE CRITICAL FOR CENTRAL BANKS, FINANCIAL SUPERVISORS AND REGULATORS

SECTION 02:

WHY WATER SECURITY AND WATER SYSTEMS RESILIENCE ARE CRITICAL FOR CENTRAL BANKS, FINANCIAL SUPERVISORS AND REGULATORS

CONCEPTUALIZING THE INTERACTIONS BETWEEN WATER, ECONOMY AND FINANCE

The preceding chapter demonstrated that the economy and financial system are fundamentally reliant on water and, more generally, nature. Accordingly, they should be viewed as subsystems integrated within the broader natural environment rather than as independent entities. This perspective highlights how the continued degradation of nature can precipitate the collapse of socioeconomic structures (see Figure 9 below).

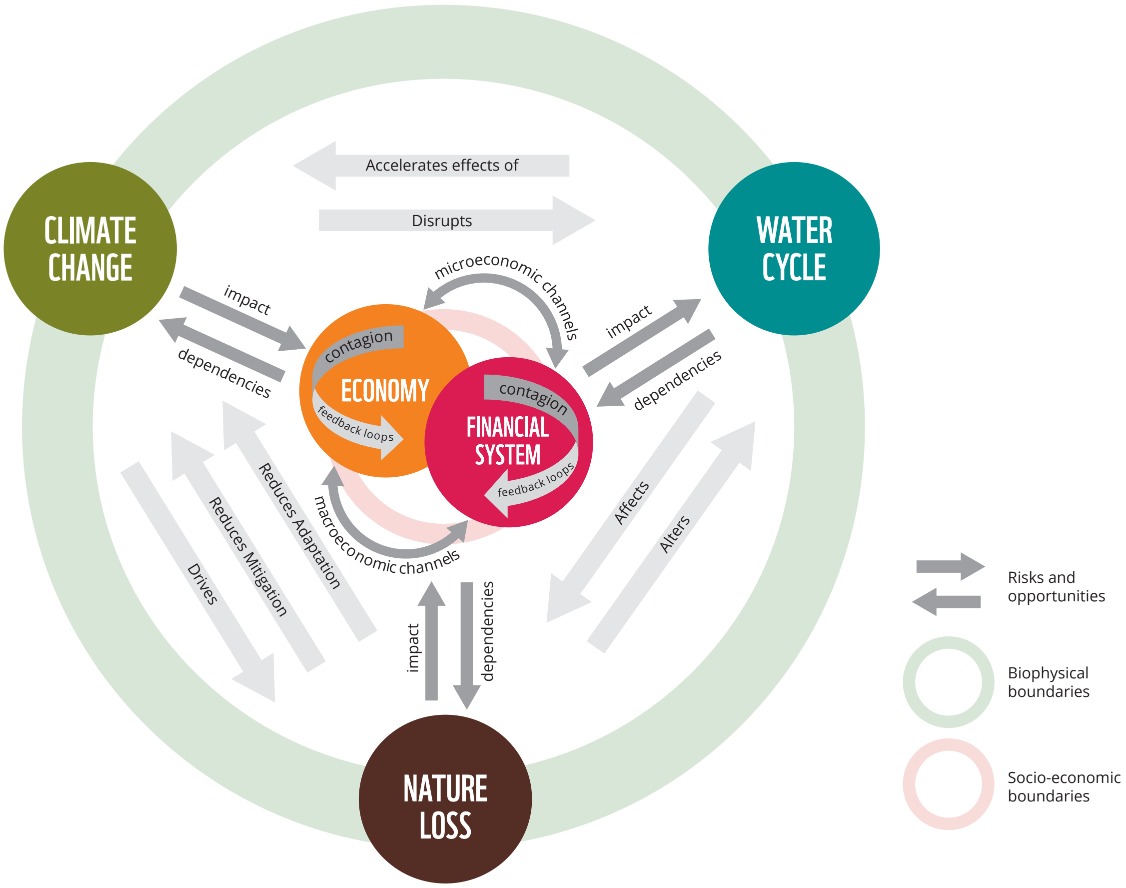

Figure 9: *Climate change, nature loss, water crisis and the economy and financial system. Source: authors, adapted from Pörtner et al. (2021)*

The outer circle of Figure 9 reflects the fact that climate change is one of the drivers of water systems disruption – that, for example manifests in the increased frequency, severity and recurrence of floods and droughts – but that the concurrent degradation of natural systems (e.g. of wetlands or river continuity) is exacerbating the risks it poses. Therefore, tackling water regimes purely from a climate change perspective can obscure the broader interconnections that are essential to factor into risk and opportunity identification and management.

The connection of the inner circle to the outer circle of Figure 9 illustrates how economic activities, facilitated by the financial sector, shape and are shaped by the interactions between the nature, the climate and the water cycle, including the biosphere, atmosphere, cryosphere and hydrosphere.[9] The socioeconomic system, under business as usual, is eroding the resilience of (freshwater) ecosystems and related functional services (e.g. flood and storm protection, groundwater and surface water provision), which in turn may destabilize the economy and the financial sector. This interconnected dynamic is often termed "double materiality", incorporating both the impact of the environment on the economy and financial sector (financial materiality), and the impact of the financial and economic system on the environment (environmental materiality), which in turn can again become financially material (endogenous risk).

FINANCIAL MATERIALITY: HOW WATER-RELATED RISKS TRANSMIT TO THE ECONOMY AND FINANCIAL SYSTEMS

Our economies depend on water systems, which means that their degradation poses risks to economic activity and stability. It is estimated that up to 46% of global GDP could come from areas facing high water risk by 2050 (WWF, 2020). A separate study indicated that certain regions might experience a decline in GDP growth rates by as much as 6% by 2050 due to water-related losses across various sectors, potentially contributing to sustained negative economic growth (World Bank Group, 2016). Furthermore, sudden policy efforts to tackle water-related issues can create risks for those who are not making such transitions themselves, or whose suppliers are not doing so. This may lead to significant drops in asset values or to stranded assets, resulting in financial losses, reputational damage and potential legal liabilities.


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9 For information on the terminology see Text box 2.

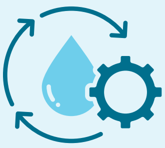
TEXT BOX 5: WHAT ARE WATER-RELATED FINANCIAL RISKS AND HOW DO THEY MATERIALIZE?

Water-related financial risks can be understood as a subset of broader nature-related risks. The NGFS defines nature-related financial risks as "the risks of negative effects on economies, individual financial institutions and financial system that result from: (i) the degradation of nature, including its biodiversity and the loss of ecosystem services that flow from it (i.e., physical risks); or (ii) the misalignment of economic actors with actions aimed at protecting, restoring, and/or reducing negative impacts on nature (i.e., transition risks)" (NGFS, 2024b). Likewise, water-related risks – such as droughts, floods, freshwater ecosystem degradation or water restrictions – can undermine asset values or operational continuity, driving financial impacts (Davies & Martini, 2023) that could eventually pose a risk to financial stability (OECD, 2025). Water-related risks may accumulate slowly and then trigger tipping points – sudden, disruptive shifts in systems previously perceived as stable (e.g. precipitation regimes, river ecosystems, glaciers). These non-linear dynamics challenge traditional risk assessment approaches that assume past patterns can predict future outcomes and that detailed quantifications of such risks will adequately predict risk manifestation. The NGFS conceptual framework on nature-related risks elevates risk elements rooted in the definition of risk from the Intergovernmental Panel on Climate Change (IPCC), and serves as a helpful guide in understanding sources of risk and their transmission.

IPCC FRAMEWORK: HAZARD, EXPOSURE, VULNERABILITY

- **Hazard:** Potential occurrence of a water-related event that could cause damage (e.g. drought, flood, contamination, new regulation).

- **Exposure:** The presence of people, assets or ecosystems in places that could be adversely affected by the hazard.



- **Vulnerability:** The degree to which these assets or systems can cope with, adapt to, or recover from the hazard.

Context is critical in understanding risk drivers and materialization. Water risks are local and context-specific, and can be obscured by the metrics chosen to measure them. For example, average indicators such as annual rainfall may appear stable, yet rainfall can fall in short, destructive bursts. In October 2024, Valencia recorded a year's worth of rain in eight hours, causing catastrophic floods (WMO, 2024). At the same time, such locations may also experience the effects of droughts: after droughts, the soils can compact (hydrophobic soils), which turns rainfall into runoff, worsening floods and exacerbating pollution risk rather than replenishing groundwater. These shifts create a mismatch between water supply and demand, requiring adaptive infrastructure and planning. Assets located in areas with infrastructure ill-equipped to manage erratic weather are particularly vulnerable; for example, the UK has faced drought risks despite record rainfall, as it does not have the infrastructure needed to retain and distribute such uneven flows (Horton, 2024).

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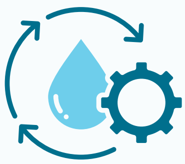
To assess water-related risks, CBFRs could consider the following non-exhaustive list in Table 3:

***Table 3:** Set of questions to unpack water-related risks*

PROCESS	BIOPHYSICAL	ECONOMY AND FINANCIAL SYSTEM
HAZARD 	What types of water-related hazards are projected? How severe or frequent might they become? Are ecosystems key to freshwater provision likely to cross tipping points?	What water-related hazards are present and/or on the rise that could affect multiple economic actors at once?
EXPOSURE 	What assets (real estate, equipment etc.) are located where the water-related hazards are projected to occur?	Which sectors, regions and institutions are most exposed to the hazards? What is the portfolio exposure of a financial institution to these industries? What supply chain bottle necks is the company or financial counterpart exposed to?
VULNERABILITY 	**Sensitivity:** How critically dependent is the asset on the potentially affected ecosystem service (e.g. clean water, water cooling)? Does it have substitution options? **Adaptive capacity:** How resilient is the ecosystem and the exposed assets? What adaptation measures are in place – and are they able to withstand shocks and chronic water-related hazards under future scenarios?	**Sensitivity:** How financially healthy are companies within the supply chain, and what adaptive capacity do they have? Are there trade route bottlenecks, and if so how they are affected? How static are the supply chains of a specific company/sector? Could spillovers affect peers or financial institutions? Is there high leverage in the system? Is there a tendency for asset mispricing? **Adaptive capacity:** Do companies have buffers in place (finance, insurance, diversified suppliers) to absorb damage to their operations? How will these buffers perform under future scenarios?

Note: While this framework is usually applied to physical risks, its reasoning can also be used for transition risks. Furthermore, the identification of hazards, exposure and vulnerability depends greatly on the specific context, and there is no single guideline; instead, categorization choices should always be made transparently (see, for example, the framework by the Financial Stability Board (2025) designed for the assessment of climate-related vulnerabilities).

Current frameworks that conceptualize climate-related and nature-related risks provide effective foundations for understanding water-related risks. While climate-related risk frameworks typically consider hazards such as floods and droughts, nature-based frameworks offer a more comprehensive perspective, including issues related to water quality and freshwater ecosystems. Leveraging these interoperable frameworks, which address broader concerns beyond just water, can help address climate change, nature degradation, biodiversity loss and water insecurity simultaneously, enhancing synergies and reducing trade-offs.

A framework widely used by the financial sector is the 2024 conceptual framework on nature-related financial risks created by the Network for Greening the Financial System (NGFS) (NGFS, 2024b). A few months later the International Monetary Fund (IMF) developed a more granular framework closely mapping the interlinkages between stocks and flows across different states of the world,[10] particularly emphasizing macroeconomic transmission channels and their impact on the economy through double materiality (Gardes-Landolfini, 2024). Other useful frameworks include the OECD's supervisory framework for assessing nature-related risks (OECD, 2023), with supporting information from recent water-specific publications (OECD, 2025), and frameworks developed in specific jurisdictions, such as in the EU (European Commission: Directorate-General for Financial Stability et al., 2024). Such frameworks can serve as a basis for understanding how water-related risks translate to financial risk to individual companies, financial counterparts and the broader financial system (see Figure 10). These elements are elaborated individually below.

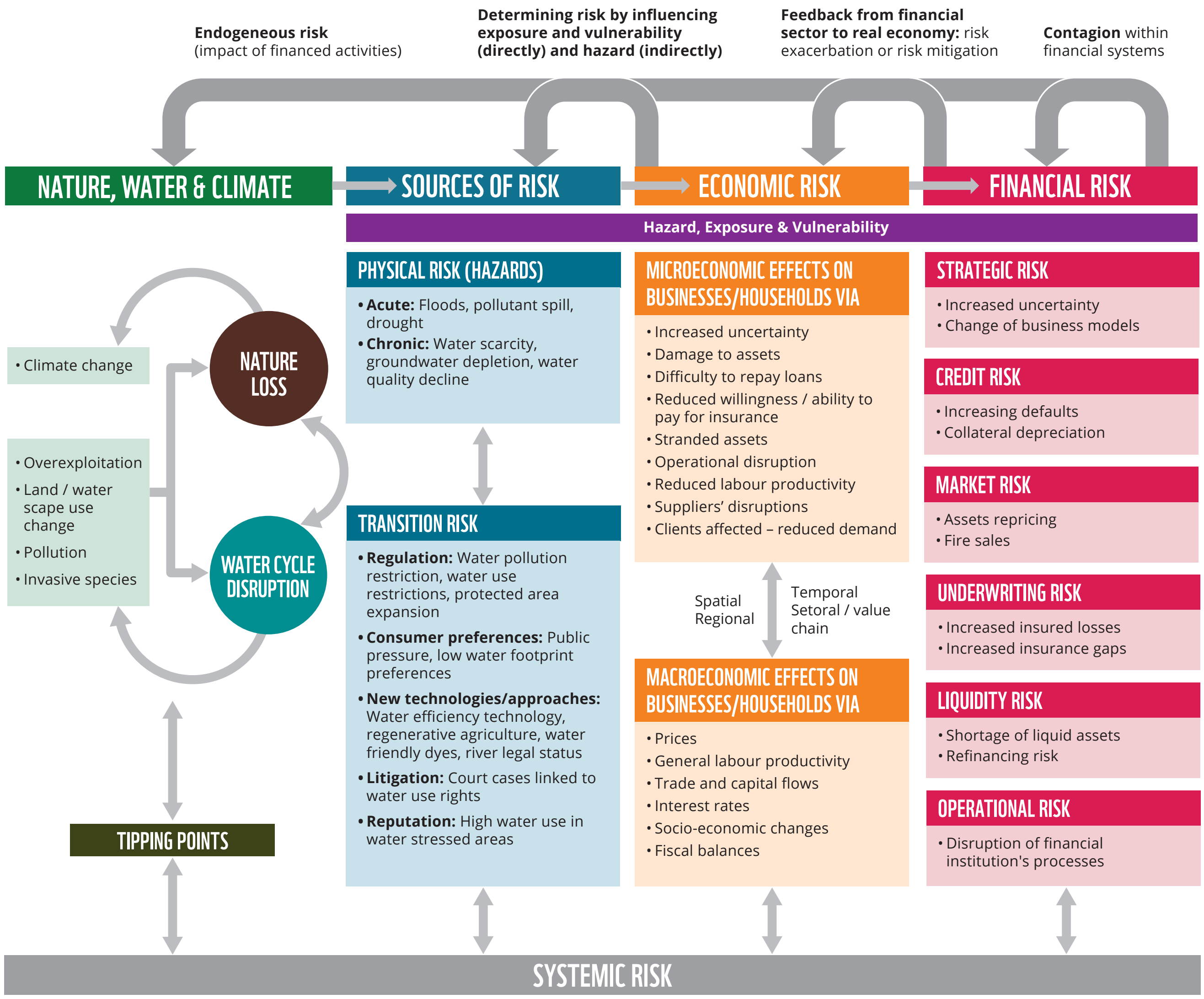


***Figure 10:** Conceptual water-related financial risk framework. Source: adapted from NGFS (2024b)*

10 The potential states of the world here refer to different scenarios according to production sustainability over time (sustainable, unsustainable, and irreversible collapse) (Gardes-Landolfini, 2024).

SOURCES OF RISK

Water-related physical risks can be chronic or acute. Both types can negatively impact business operations directly, or indirectly via supply chains or worker productivity, which in turn affects costs and revenue streams as well as assets and liabilities.

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ACUTE

Acute events include flash floods, large-scale pollutant spills, and droughts.

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CHRONIC

Chronic shifts include declining groundwater levels linked to excessive extractions.

Preliminary and exploratory nature-related physical risk assessments have found that the absence of water-related ecosystem services could have the most detrimental impact on the economy and financial institutions (Bank Negara Malaysia & World Bank, 2022; Ceglar et al., 2023; Deutsche Bundesbank, 2026; Ranger et al., 2024; Svartzman et al., 2021; UNDP, 2025; van Toor et al., 2020; Visentin, 2026). These studies explored the dependencies of financial institutions' portfolios on ecosystem services, collectively concluding that ground water and surface provision as well as flood and storm protection were among the most critical ecosystem services (for a summary of the findings see OECD (2025, p. 95)).

Water-related transition risks arise from societal, technological and regulatory shifts that make a company's water-damaging activities costly to continue. Regulatory efforts targeting pollution and water usage, technological advances that make water-efficient operations more cost-effective, and consumer preference for companies with lower water footprints can all significantly impact the bottom line of companies that are directly or indirectly water-intensive or polluting.

Regulation, policy and rulings: In recent years, there has been a marked increase in regulatory measures addressing critical water-related issues (see Figure 11).

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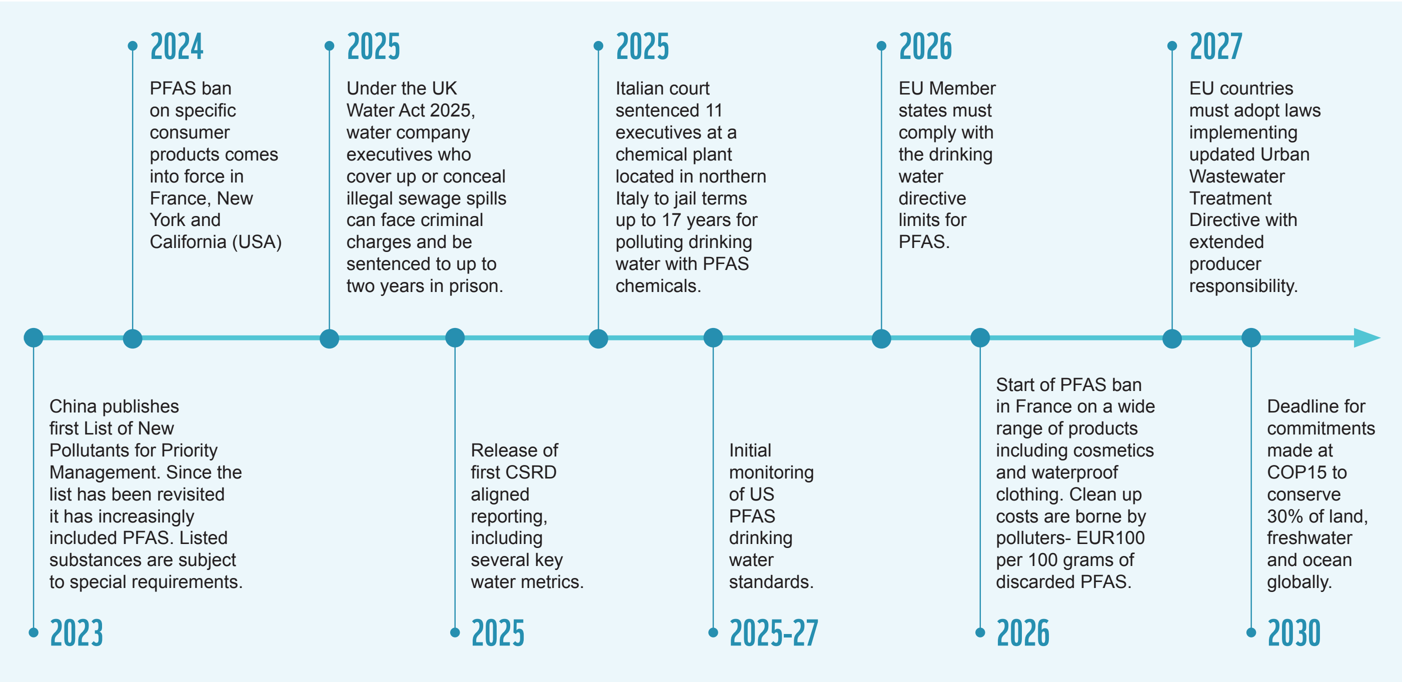

Figure 11: *Overview of key water-related regulatory developments. Source: adapted from E. Kane et al. (2025)*

Litigation: The 2024 NGFS report on nature-related litigation (NGFS, 2024a) was published to draw attention to the increasing risk in this area. Out of the almost 50 nature-related litigation cases described in the report, more than 10% involved water-related issues. In parallel, the media has been increasingly reporting about court cases pertaining to water quality, particularly involving per- and polyfluoroalkyl substances (PFAS), also known as "forever chemicals", or sewage spills. These cases are posing an imminent litigation and reputational risk to companies directly or indirectly involved with them. Some of these cases have resulted in criminal charges for top executives:

- **PFAS pollution in Italy:** A chemical plant located in northern Italy was found to have polluted 100km2 of drinking water with PFAS. Eleven executives were sentenced to cumulative jail time of 141 years (CHEMTrust, 2025).
- **Sewage spills in the UK:** After increasing scandals concerning untreated water being dumped in rivers, lakes and the sea, the government has recently issued powers to criminally charge top executives who may have been hiding sewage spills (Bloomberg, 2025).

Even where water-related regulations have not yet come into force, an increasing number of national-level water strategies are being developed, which will drive future regulatory developments. For example, water resilience is identified as a priority in the 2024-2029 EU Commission Political Guidelines, which underpin the EU's Water Resilience Strategy, signalling that managing the hydrological cycle, water quality, green and grey infrastructure will be of central importance in the coming years (European Commission, 2026).

TEXT BOX 6: WATER BODIES WITH LEGAL STANDING

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The 2024 report by the NGFS on nature-related litigation highlights the emerging "Rights of Nature" movement. This is concerned with granting natural assets – such as glaciers, lakes, rivers and forests – a form of legal personhood, which gives them rights and the power to sue rights violators in court (NGFS, 2024a). An increasing number of countries are either generally recognizing the rights of nature within their constitution (such as Ecuador) or recognizing individual bodies of water, particularly rivers, as legal persons. Colombia, for example, gave legal personhood status to the Atrato River, following a High Court decision. The High Court also established a commission of 14 guardians of the river, representing seven organizations affected along the length of the river. Rights of Nature movements have resulted in court cases supporting the protection of nature's rights. Even though these rights are rarely enforced, granting legal status to nature has elevated the importance of resources like rivers in policymaking, exposing public entities and companies to reputational and potential litigation risks if they cause harm to them (NGFS, 2024a).

Markets: End consumers increasingly perceive water as a material issue and expect companies to take responsibility accordingly. A recent survey conducted by GlobeScan and WWF found that water pollution is perceived globally as the most serious environmental issue. Over 60% of the 30,000 people surveyed across 31 jurisdictions believe companies should support freshwater protection policies. Experts from countries in the Global North identified PFAS and nitrates/fertilizers as their top two pollution concerns. In contrast, experts from countries in the Global South considered plastic packaging pollution to be their primary national issue (GlobeScan & WWF, 2025). What this comprehensive survey shows is that not only are consumers concerned about water issues, but they also think the corporate sector and governments have a responsibility to solve them.

Technology: In recent decades cost-effective new approaches, ventures and technologies have been developed to manage water-related risks. These include rainwater harvesting techniques to manage irregular rainfall while maximizing water resources; the development of non-harmful dyes for textiles; and using nature-based solutions to mitigate flood risks while generating other co-benefits. Companies locked in outdated approaches may face rising costs or reputational disadvantages versus competitors.

TEXT BOX 7: THE FEEDBACK LOOP BETWEEN PHYSICAL AND TRANSITION RISKS

Physical and transition risks can interact and reinforce each other, amplifying financial impacts for companies and financial institutions. For example, a prolonged drought reduces a catchment's clean water availability, disrupting industrial operations, cooling processes and agricultural output. This can lead to lower revenues, asset devaluation and supply chain bottlenecks (physical risk). In response to worsening water stress, governments may introduce restrictions on water use, pricing reforms, or mandatory disclosure and efficiency requirements. Policy shifts aiming to mitigate a physical crisis can create new compliance burdens, raise operational costs or render water-intensive business models obsolete, meaning that unprepared companies risk having a range of stranded assets (transition risk). Therefore, a single underlying trend (e.g. growing water scarcity) or an acute shock (e.g. drought) may trigger both physical disruption and a regulatory response, which may potentially compound the financial effects across portfolios and value chains. For example, in the United States in 2023 the Arizona Department of Water Resources decided to restrict housing construction in Phoenix, one of the nation's fastest-growing cities, due to sharply declining groundwater tables, affecting a housing development that had been previously approved (Newburger, 2023).

Acute and chronic physical and transition risks may translate into economic and financial risks, which are reflected on the balance sheets of businesses and financial institutions via microeconomic and macroeconomic channels.

Microeconomic channels include effects on assets and liabilities, as well as the operating revenues and costs of individual firms. Macroeconomic channels include structural shifts in the economy affecting trade, growth, labour markets and overall price levels.

ECONOMIC AND FINANCIAL RISKS

Water scarcity, droughts and degraded water quality can cause operational disruptions to economic activities that are highly dependent on water availability, either directly or indirectly. Business operations can also be disrupted by too much water in the event of floods damaging manufacturing material storage or processes, disrupting labour productivity, agricultural activities and trade. Likewise, if a company's key suppliers face these issues, and substitutability or adaptation capacity is limited, downstream operations – even in distant geographies unaffected by the hydrological event – can face disruptions.

Table 4: *Microeconomic transmission channels of water-related shocks*

TRANSMISSION CHANNEL	EVIDENCE FROM EMPIRICAL STUDIES
DIRECT OPERATIONAL DISRUPTION	A study on the 2021 Wallonia floods in **Belgium** found that firms located in flood-affected areas experienced significant short-term declines in sales following infrastructure damage and production disruption. Affected firms recorded a 25% drop in sales in the first quarter after the flood and recovered only by the fourth quarter (Bijnens et al., 2026).
SUPPLY-CHAIN PROPAGATION	A study based on the 2021 **Belgium** Wallonia floods found that firms relying on flood-affected suppliers experienced persistent indirect impacts. Sales declined by 0.3% for each percentage-point increase in supplier exposure, with effects lasting up to three quarters. The study concluded that failing to account for supply chain risk transmission may result in an approximate 20% underestimation of the overall effects (Bijnens et al., 2025, 2026).
SHORT-TERM CONTRACTION AND RECOVERY	Severely flooded firms in **Pakistan** saw sales decline by 9.6% and purchases by 3.7% in the month of flooding, with recovery occurring within six months (Balboni et al., 2025). Flood-affected firms adjusted by relocating production and increasing their number and diversity of suppliers, indicating adaptive responses within production networks, although associated costs and disruptions were not quantified (Balboni et al., 2025).
GLOBAL SUPPLY-CHAIN DISRUPTION	Flood events in **Thailand** disrupted natural rubber supply chains, affecting a country responsible for roughly one-third of global production, with implications for downstream manufacturing sectors (Staporncharnchai & Siring, 2025).
ASSET STRANDING AND FINANCIAL EXPOSURE	CDP and Planet Tracker in assessment showcased how changes in water-related regulations, high levels of pollution, and community opposition have led to project suspension or project cancellation in water-intensive sectors (Lamb et al., 2022). This assessment estimated there were US$15.5 billion in assets stranded or at risk, including projects in oil and gas, electric utilities, coal, and metals and mining. Financial institutions are exposed through lending and shareholding, with the top 20 firms **globally** providing US$2.5 trillion in bond, loan and equity financing to highly water-impactful companies in the past decade.
LICENSING CONSTRAINTS AFFECTING PRODUCTION AND VALUATION	Legal challenges over groundwater extraction for Tesla's Berlin-Brandenburg gigafactory in **Germany** led to production delays and uncertainty over expansion. Following a complaint from a group of NGOs over water licensing, Tesla's share price declined by 3.1% before market opening, illustrating how water availability and regulation can influence operational timelines and investor expectations (BloombergNEF, 2024).

Water-related disruptions via different channels can adversely affect business' cost/revenue structure, asset values, loan repayments and, ultimately, investor dividends. Even when companies have risk management measures in place for water-related risks, significant chronic or acute risks affecting operations or supply chains may leave residual risks, which can lead to financial impacts on the company and potentially affect the balance sheets of its financial services counterparts (see Figure 12).

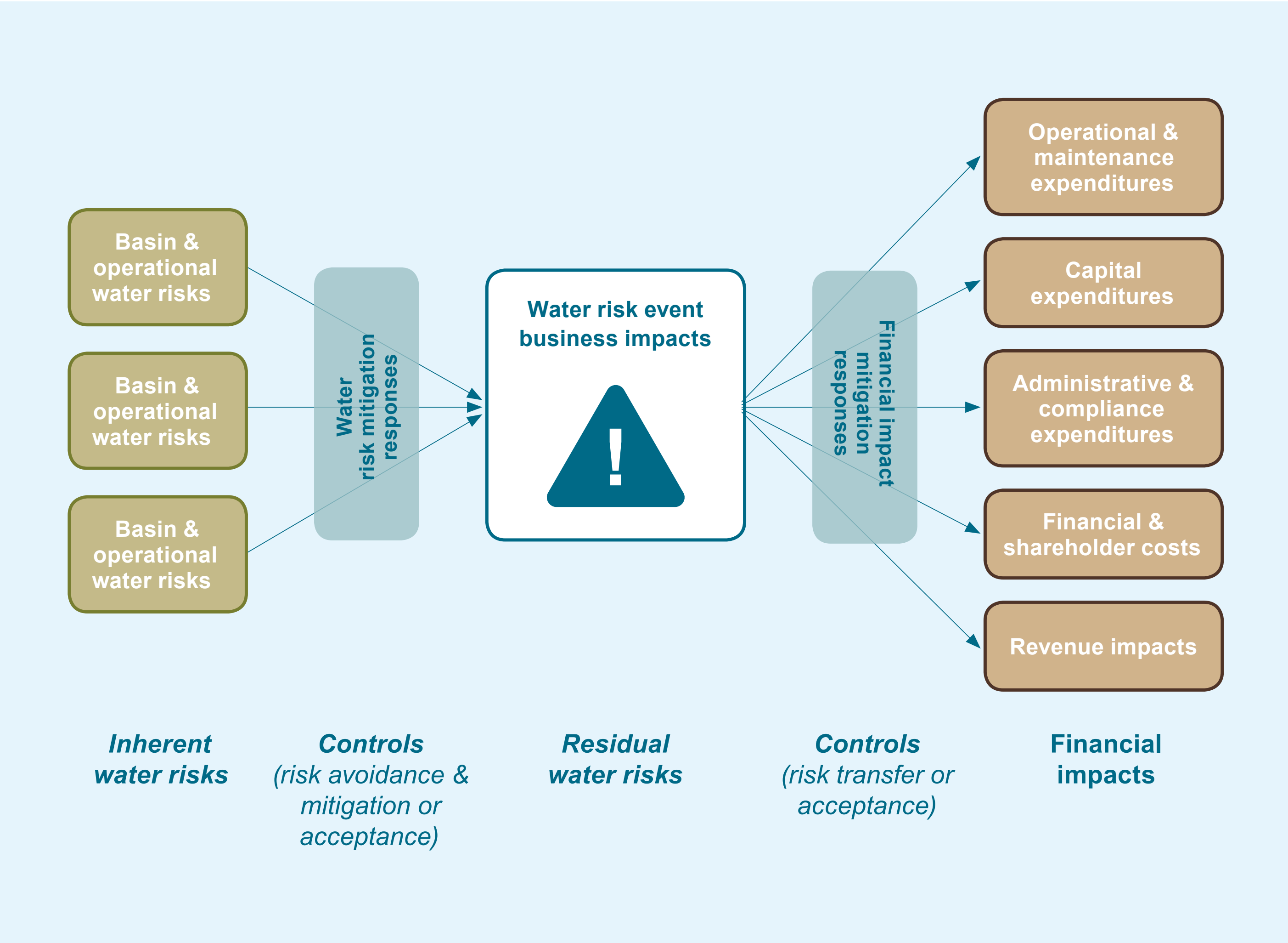

Figure 12: *A water risk-response framework. Source: Morgan (2019)*

TEXT BOX 8: THE FINANCIAL IMPACT OF FLOODS – EXAMPLES FROM EUROPE

The concepts presented above are well suited to interpret the elements presented by a European Central Bank (ECB) bulletin exploring how flooding transmits into economic and financial risk (González-Torres Fernández & Parker, 2025).

FLOOD RISK DRIVERS

Hazard: The hazards of extreme precipitation are fuelled by human-driven climate change which makes extreme rainfall more likely. In the case of the Valencia floods in October 2024, climate scientists at the World Weather Attribution found that climate change increased the likelihood by a factor of two and made the rainfall 12% heavier (WMO, 2024).

Exposure/vulnerability: Besides climate change, haphazard building in zones that are exposed to floods and freshwater ecosystems which are losing resilience are amplifying the likelihood of flood damage and disruption. Furthermore, flood-related damages mostly translate into economic losses as insurance coverage of such damages is relatively low. Only about 25% of climate-related damages are insured in Europe, and in some Member States (e.g. Italy, Hungary, Bulgaria) that share has been at or below 5%. This can have severe knock-on effects on other financial risks linked to asset valuation, operations and access to credit.

SUPPLY-CHAIN EFFECTS

Economic damages do not occur solely in the area where the flood occurred. If key upstream suppliers are located in the area affected by the flood, then companies that depend on these suppliers may feel the impact of the flood without being directly exposed in spatial terms.

Examples include:

- Manufacturing operations at the German car maker Porsche were disrupted by floods in Valais, Switzerland, which affected the supply of aluminum components that are needed in all of its vehicles. The repercussions on manufacturing lasted for several weeks, all of which were linked with a ~7% decline in share price¬ – the sharpest intraday drop since Porsche became publicly listed in 2022 (Bloomberg, 2024).
- The Swiss train line manufacturer Stadler, which has global operations, announced a drop in revenues linked to three extreme weather events that affected warehouse contents and employees' commutes to the plant, disrupting operational continuity. Stadler attributed a 10% loss in sales in comparison to the previous year to floods in Valencia (Spain), Valais (Switzerland), and Dürnrohr (Austria), justifying a drop in dividend-pay out from CHF 0.9 to CHF 0.2 per share (Stadler, 2025).

The specific physical and transition risks that impact a company are influenced by the locations of its operations, key supply-chain connections, and the company's vulnerability to such risks. This vulnerability is further shaped by the sector or industry in which the company operates, conditions in the basin, and the ability to substitute for alternatives (see Table 13 in the Annex).

Additionally, water-related risks can have a macroeconomic impact, affecting the structural foundations of entire economies. This, in turn, has indirect economic and financial implications for a wide range of stakeholders (including households, companies, financial institutions and sovereigns) (see Gardes-Landolfini, 2024; Suphachalasai et al., 2025).

Water risks may jeopardize national growth and financial stability. An ECB study found that 72% of euro area corporates and 75% of corporate bank loans are critically dependent on ecosystem services, including water-related ones such as surface and groundwater provision (Boldrini et al., 2023). A recent studying using Oxford University's nature value-at-risk (NVaR) framework found that an "extreme but plausible" drought could put 15% of euro area output at risk, with knock-on effects for agriculture, manufacturing, hydropower and shipping. Additionally, over 34% of corporate loans are exposed to such high water-scarcity risk sectors (Ceglar, Jwaideh, et al., 2025).

Water-related shocks can increase commodity price volatility and inflation (Gayle, 2025). A recent study documented how extreme weather events, including droughts, floods, and heatwaves, have been linked to food price increases across multiple countries (Kotz et al., 2025) (see Figure 13). The map shows examples since 2022 in which food price increases were reported in association with extreme climate conditions. Underlying shading represents the extent to which the associated climate conditions exceeded percentiles of the historical distribution. Heat events are shown in red, drought events are shown in brown, and heavy precipitation events are shown in blue. For each event type, the darkest shading indicates events which have no precedent in the historical record prior to 2020.

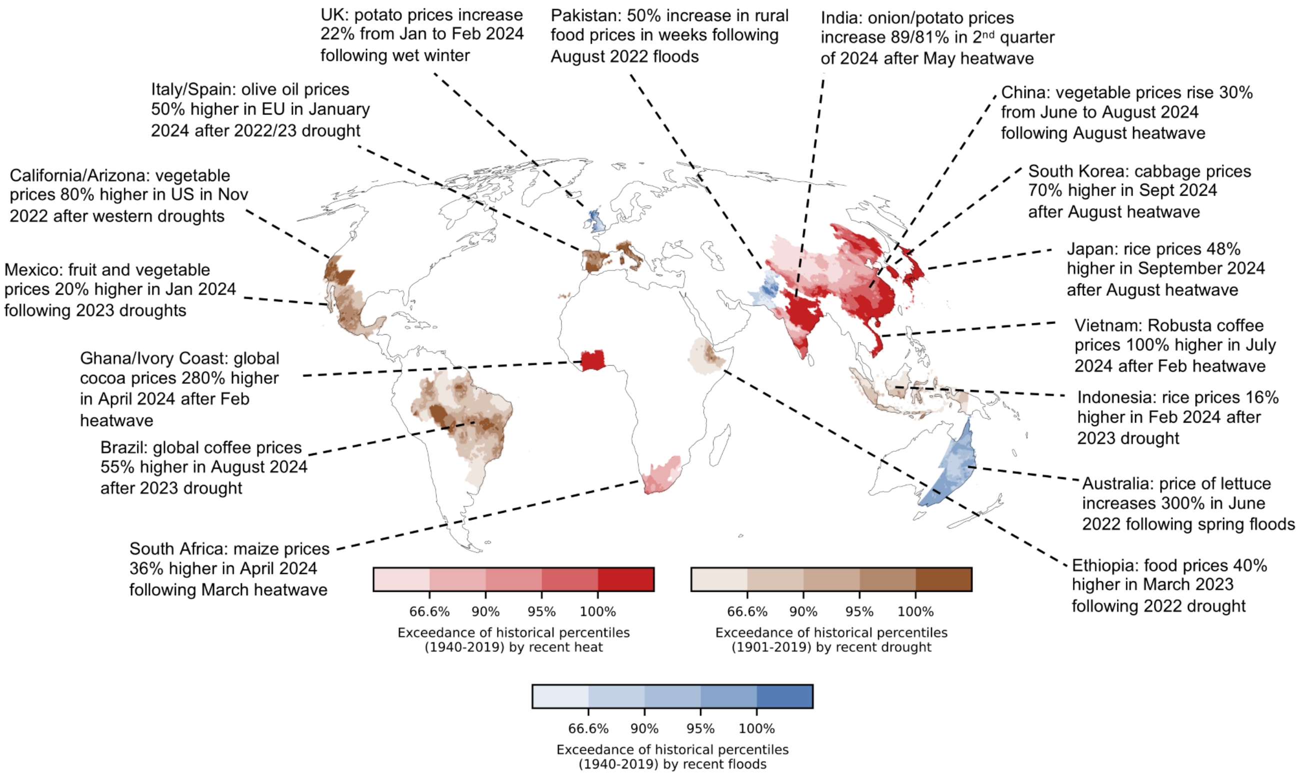

Figure 13: *The climatological context of recent climate-induced food price spikes. Source: Kotz et al. (2025)*

Key soft commodities such as cocoa (sourced from Ghana and Ivory Coast) and Carnaroli rice (sourced from Italy) are particularly exposed and susceptible to hydrological shocks such as droughts. For example, Italy's rice yields fell by 50% in 2022 due to the worst drought in 200 years affecting the Po River (Spaggiari, 2024). These shocks can be especially detrimental to countries with concentrated export dependencies on a limited range of commodities. Countries reliant on imports for essential staples may also encounter challenges. Disruptions to consumer staples or critical input materials required for economic activities pose notable risks. For instance, the Mediterranean region serves as an important source of vegetable production for the rest of Europe. In April 2023, drought conditions affected 60% of Spain's agricultural land, resulting in the destruction of 3.5 million hectares of crops. Beyond contributing to food price inflation, the simultaneous decline in the output of key soft commodities has the potential to trigger crop failures across multiple major food-producing regions, known as "multi-breadbasket failures" and jeopardize global food security (Hasegawa et al., 2022). Such developments can produce spillover effects that disproportionately impact low-income households; rising prices for certain items in consumer baskets effectively reduce consumer purchasing power for other goods and services.

It is not only the goods and services traded that can be at risk; the trade routes themselves are also vulnerable to hydrological shifts. For example, the Panama Canal, a key trading bottleneck, experienced severe droughts in 2023 that led to a 36% reduction in ship crossings; canal administrators estimated that falling water levels cost them between US$ 500 million and US$ 700 million in 2024, compared with previous estimates of US$ 200 million (Associated Press, 2024; IMF, 2022).

FISCAL BALANCES

Sovereign states dependent on water-heavy industries or where infrastructure is exposed to risk from floods and poor water quality may see lower revenues, increased emergency costs, and expensive adaptation requirements. The credit rating agency Moody's has found that one-third of assessed sovereign states already face material credit risks linked to unsustainable water management. Physical water shocks can erode fiscal space and raise borrowing costs, thereby reducing credit ratings (Environmental Finance, 2025; Reuters, 2024).

EMPLOYMENT AND LABOUR MARKETS

Droughts and heatwaves reduce labour productivity in sectors such as agriculture and construction, disrupting operations, reducing outputs and decreasing loan quality (see for example AMCESFI (2023)). Water and related infrastructure can also be a vector for public-health shocks, with antimicrobial resistance (AMR) expected to increase due to the development of drug-resistant pathogens driven by the misuse and overuse of antimicrobials in humans, animals and plants. In 2017, the World Bank released an assessment concluding that by 2050 AMR could have economic consequences equivalent to the 2008 financial crisis (Jonas et al., 2017). A global study in 2019 estimated that productivity losses attributable to AMR totalled almost US$ 194 billion (Naylor et al., 2025).

CASE STUDY

ASSESSMENT OF THE EFFECTS OF INCREASED ARIDITY ON THE FINANCIAL SYSTEM AND THE ECONOMY (AMCESFI, 2025)


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Spain is among the European countries most exposed to desertification, with nearly 75% of its territory classified as drylands vulnerable to degradation. This phenomenon, driven by both climate change and human activity, represents a chronic physical risk that is unfolding gradually over time and requires long-term analysis and policy responses.

Desertification has had not only environmental but also significant economic and financial consequences. Among its effects are the migration of households from affected areas and disruptions to local socioeconomic dynamics, which can undermine the creditworthiness of borrowers and, in turn, impact financial institutions. However, the net effect on credit is not straightforward: while credit demand may be reduced by asset devaluation, it may also increase as businesses seek financing to replace damaged physical capital or invest in climate adaptation strategies.

A study by the Bank of Spain explores how increasing aridity affects bank lending to non-financial corporations. Using granular credit data from the CIRBE database for the years between 1984 and 2019, the study constructs a municipal-level aridity index based on the ratio of annual precipitation to potential evapotranspiration. This index classifies municipalities into six climate zones ranging from hyper-arid to humid. The findings reveal a clear worsening of aridity across Spain since the 1970s, with semi-arid areas expanding from 29% to 53% of the territory. Although the trend is widespread, regional differences are notable: Almería alone accounts for 25% of Spain's arid land, followed by parts of the Canary Islands, Murcia and Valencia.

Financially, the study shows that increased aridity is associated with a decline in bank credit, particularly in the agricultural sector. A 1 percentage point (pp) rise in the aridity index leads to an average reduction of 25 basis points (bp) in agricultural credit over a 20-year period. The real estate sector is also negatively affected, though to a lesser extent, while the tourism sector demonstrates resilience, especially in humid regions where temporary benefits are observed.

The sensitivity of credit to aridity varies by climate zone. Drier regions experience credit contractions of 17bp to 24bp eight years after a 1pp increase in aridity, whereas more humid areas show greater adaptability. Sectoral responses also differ: tourism in arid zones remains largely unaffected, while in intermediate and humid zones it may even benefit temporarily. In contrast, agricultural credit declines consistently across all climate zones, underscoring the widespread vulnerability of the sector.

Beyond credit, the study examines the impact on employment, which reacts more quickly to aridity. A 4bp increase in unemployment is observed four years after aridity rises, accompanied by declines in the number of employment contracts and registered workers. These results reinforce the notion that desertification has significant economic effects, even if they emerge slowly.

The study highlights the need for proactive public policies to address chronic environmental risks like desertification. It warns against the "curse of the time horizon," whereby the slow onset of such risks leads to delayed political action. Given that the effects of desertification extend far beyond typical political cycles, long-term strategic planning is essential to mitigate its impact on the financial system and the broader economy.

ENVIRONMENTAL MATERIALITY AND ENDOGENOUS RISK: FINANCE AS AN ENABLER OF WATER-RELATED RISKS


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Water-related risks are often treated as external shocks and inevitable chronic shifts, when in reality they are a consequence of decisions made within the economic and financial system. While there is natural variability, the scale, frequency and severity of current disruptions are shaped by human activities. Economic choices are intensifying exposure to water hazards (e.g. expanding infrastructure in water-stressed areas, aquifer over-abstraction, river diversion and riverbank land-use change), increasing the likelihood of their occurrence (e.g. land-use change disrupting rainfall patterns) and weakening society's adaptive capacity (e.g. underinvestment in ecological and engineered infrastructure). Financial institutions may deem their impact on water systems to be immaterial when their portfolio exposure to companies that damage the water system is only a fraction of their overall business. However, it can be a strong proxy for an institution's exposure to transition and reputational risks, as well as its contribution to the collective build-up of physical risks both spatially (e.g. supporting diffuse pollution downstream) and in time (e.g. continued aquifer depletion beyond sustainable replenishment rates).

The 2025 Los Angeles (LA) wildfires, which resulted in US$275 billion in damages (Danielle, 2025), provide a stark illustration of this dynamic. The damages resulted partly from unsustainable urban expansion and excessive groundwater extraction for agriculture that dried the vegetation, making it highly flammable. This is particularly relevant for the cultivation of water-intensive and non-indigenous crops such as almonds, avocados and alfalfa: the regional aquifer was pumped dry and its water resources were effectively sold through the exports of these high-value crops. Financial institutions affected by the LA wildfires who supported these detrimental activities via lending, underwriting or other financial services may have found their decisions of the past impacting their own present and future portfolios.

This temporal and spatial disconnect – where financial decisions shape risks that materialize at a future point or in another location – underscores the need for forward-looking and impact-conscious risk management. In this respect it is critical to consider double materiality, i.e. both the impact of water-related risks on the financial sector and the impact of the financial sector on water systems. Crucially, financial actors' individual decisions with respect to risk mitigation on the basis of narrowly scoped quantified risk assessments may collectively increase the build-up of system risk. Therefore, the financial sector needs additional guidance and incentives to adopt precautionary measures that reduce systemic risk. With scientific evidence showing that freshwater systems are crossing important tipping points, the financial sector must confront a stark reality: continued inaction is not neutral, rather it leads toward deepening systemic instability and potentially irreversible consequences.

A global review of industries' impacts on freshwater systems identified pollution (eutrophication, metals contamination, plastic pollution), overexploitation (groundwater depletion) and landscape conversion (diversion and transfer of water) as the drivers with the largest systemic consequences. Table 5 outlines key sectors and industries with the most severe and systemic impacts on freshwater ecosystems. Unchecked financial backing of such industries – through loans, investments, underwriting and other financial services – creates a vicious cycle: as water resources become more stressed, the physical and transition risks facing financial institutions intensify. While some activities, such as food systems, are essential and must be retrofitted, others, such as oil and gas, must be phased out in light of their impact on the climate globally and the fact that there are available alternatives.

Table 5: *Sectors and industries with the most severe and systemic impacts on freshwater ecosystems and resources. Source: adapted from Famiglietti et al. (2022).*

GICS SECTOR	INDUSTRY	IMPACT PATHWAYS					
		Supply chain		**Direct operations**		**Product use/end of life**	
		Water quantity	Water quality	Water quantity	Water quality	Water quantity	Water quality
CONSUMER STAPLES	**Food products**	very high	very high	high	high	not enough information	not enough information
	Beverages	very high	very high	high	high	not enough information	very high
CONSUMER DISCRETIONARY	**Textiles, apparel and luxury goods**	high	high	medium	very high	not enough information	high
ENERGY	**Oil and gas**	high	very high	high	very high	not enough information	medium
HEALTH CARE	**Pharmaceuticals**	not enough information	not enough information	not enough information	very high	not enough information	very high
MATERIALS	**Chemicals**	high	high	medium	very high	not enough information	not enough information
	Metals and mining	high	high	high	very high	not enough information	not enough information
	Paper and forest products	high	high	high	very high	not enough information	not enough information
IT	**High-tech and electronics**	high	high	high	high	not enough information	not enough information
	Semiconductors and circuit boards	not enough information	not enough information	medium	high	not enough information	not enough information
	Battery manufacturing	high	high	not enough information	high	not enough information	high
UTILITIES	**Renewable electricity (hydropower)**	not enough information	not enough information	very high	medium	not enough information	not enough information

● = very high impact ● = high impact ● = medium impact ○ = not enough available information

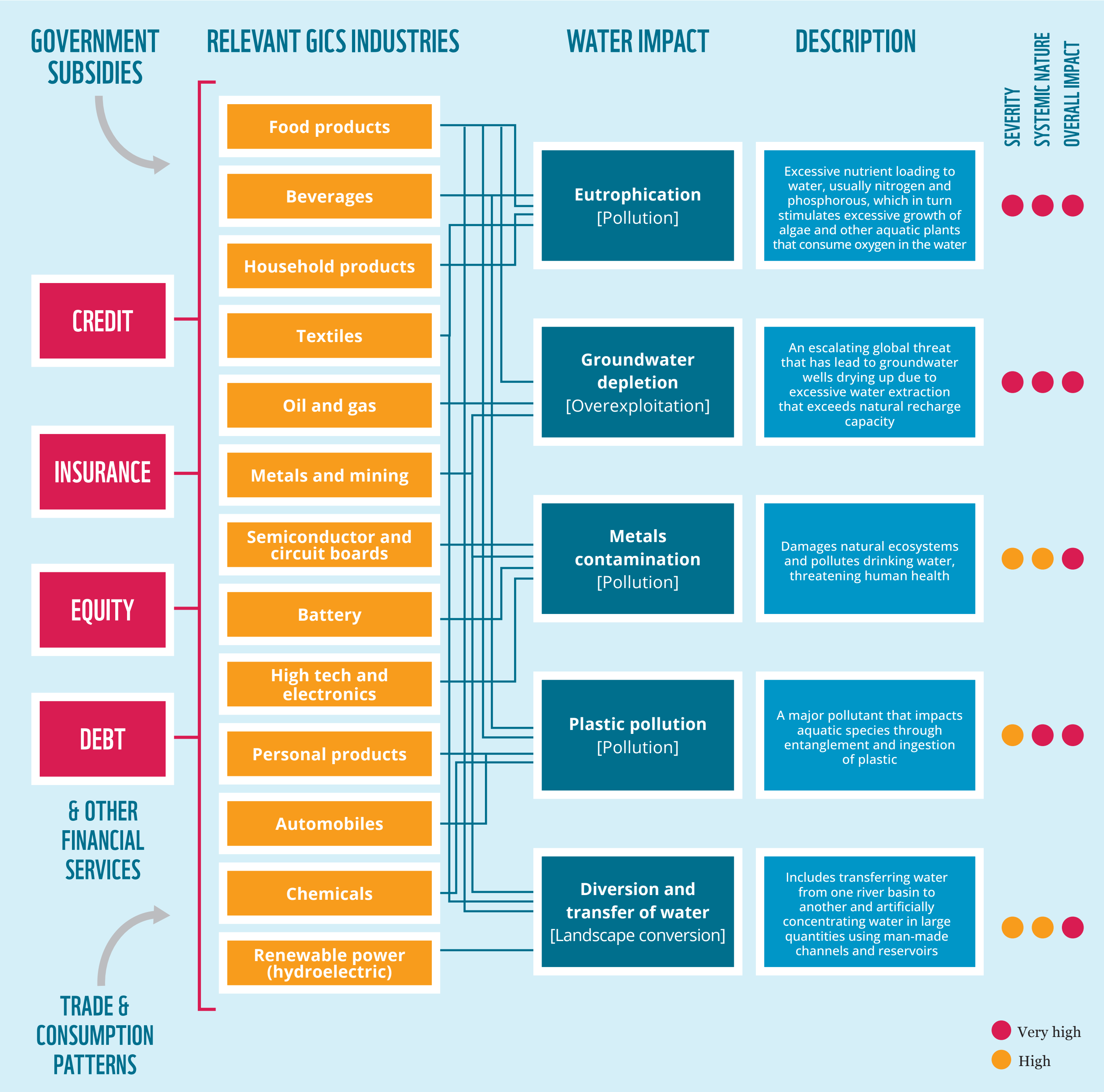


Figure 14: *Conceptual links between key drivers of freshwater systems degradation, industries and the financial sector. Source: authors' depiction based on data from Famiglietti et al. (2022)*

SYSTEMIC RISK

Systemic risk can stem from both the dependencies of economic activity on natural systems and its impact on them. Unsustainable economic practices contribute to the continued degradation of freshwater resources, thereby undermining critical foundations that support societies, economies and financial stability.

System-wide sources of vulnerability – in the natural system as well as the financial system – may turn a hazard into a disaster. Systemic risk can be driven by a slow onset of hydrological shifts affecting the health and functioning of green and grey water infrastructure (e.g. droughts), upon which all economic activities depend directly or indirectly.

NATURAL SYSTEM VULNERABILITIES

Ecosystem tipping points

Once ecosystems collapse – in cases such as irreversible river degradation, complete groundwater depletion, or lakes' transitions into dead zones – conventional monetary actions, like central banks adjusting interest rates, are not enough to restore these systems. Often, by the time traditional risk identification methods detect tipping points, it is already too late. Consequently, it is crucial to proactively incorporate precautionary measures and policy tools to prevent such risks from building up.

CASE STUDIES

FINANCIAL FLOWS DRIVING THE COLLAPSE OF INDONESIAN TROPICAL PEATLANDS AND THE AMAZON RAINFOREST

Systemic risks to an economy and financial system can arise from a collapse of crucial ecosystems that provide services critical to Earth system stability. University College London's Institute for Innovation and Public Purpose (UCL IIPP) and the University of Exeter's Global System Institute (GSI) have explored the endogenous contribution of the financial system to these risks, by tracking financial flows facilitated by banks (loans, equity and debt issuance) linked with companies associated with pressures on crucial ecosystems at the brink of collapse. Two freshwater-relevant examples are Indonesia's tropical peatlands and the Brazilian Amazon. The study findings and the implications for CBFRs are outlined below.

INDONESIAN PEATLANDS CASE STUDY

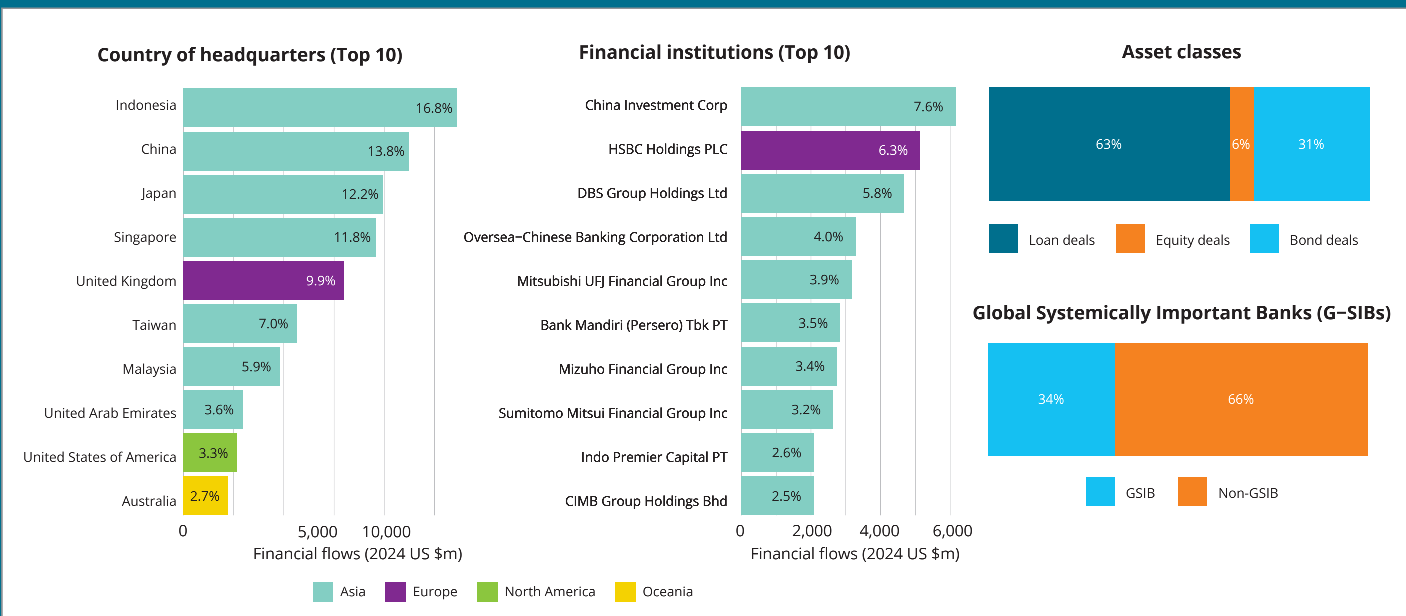
Tropical peatlands are a type of terrestrial wetland characterized by the accumulation of partially decayed plant matter, known as peat. As wetland ecosystems, peatlands play an important role in freshwater systems, supporting regional water availability, regulating water flows, and contributing to flood mitigation in the landscapes where they occur (Evers et al., 2017; Wijedasa et al., 2017). However, when peatlands are damaged, drained or dried (often through land drainage and repeated fires) their ability to regulate water flows and maintain regional hydrological stability is compromised (Wösten et al., 2008).

Peatlands are also crucial global carbon sink and important for insect biodiversity. However, degraded peatlands can become a significant source of CO2 emissions (Page et al., 2022).

As well as suffering the effects of climate change, peatlands are degrading due to land-use dynamics that include drainage, deforestation and conversion. The largest known area of tropical peatlands is situated in Southeast Asia, mostly in Indonesia. In Indonesia, agricultural expansion for purposes including oil palm and wood pulp is a major driver of peatland loss.

Between 2014 and 2023, commercial financial flows to companies potentially linked to oil palm and wood-pulp driven degradation of Indonesian peatlands totalled US$ 82.3 billion (adjusted to 2024 US$ value). Financial institutions originating these flows were primarily headquartered in Indonesia itself, followed by China, Japan and Singapore – although the second-largest contributor was UK-headquartered HSBC (Marsden et al., 2024). In aggregate, the most significant asset classes were loan deals, followed by bond and finally equity deals.

The figure below shows financial flows (2014–2023) to companies linked to drivers of nature loss, by a) country of headquarters of financial institutions originating flows; b) individual financial institutions originating flows; c) asset class; and d) GSIB status of financial institutions originating flows. In (a) and (b), the top 10 are shown – colours indicate region of headquarters and percentages indicate portion of overall flows (as such the percentages of the top 10 will sum to less than 100%). For capital markets deals (equity and bond issuances), the data identified the financial institution facilitating the deal through underwriting and other services rather than the institutions (e.g. investment firms) providing the primary capital.



Source: Marsden et al., (2025)

THE AMAZON RAINFOREST CASE STUDY

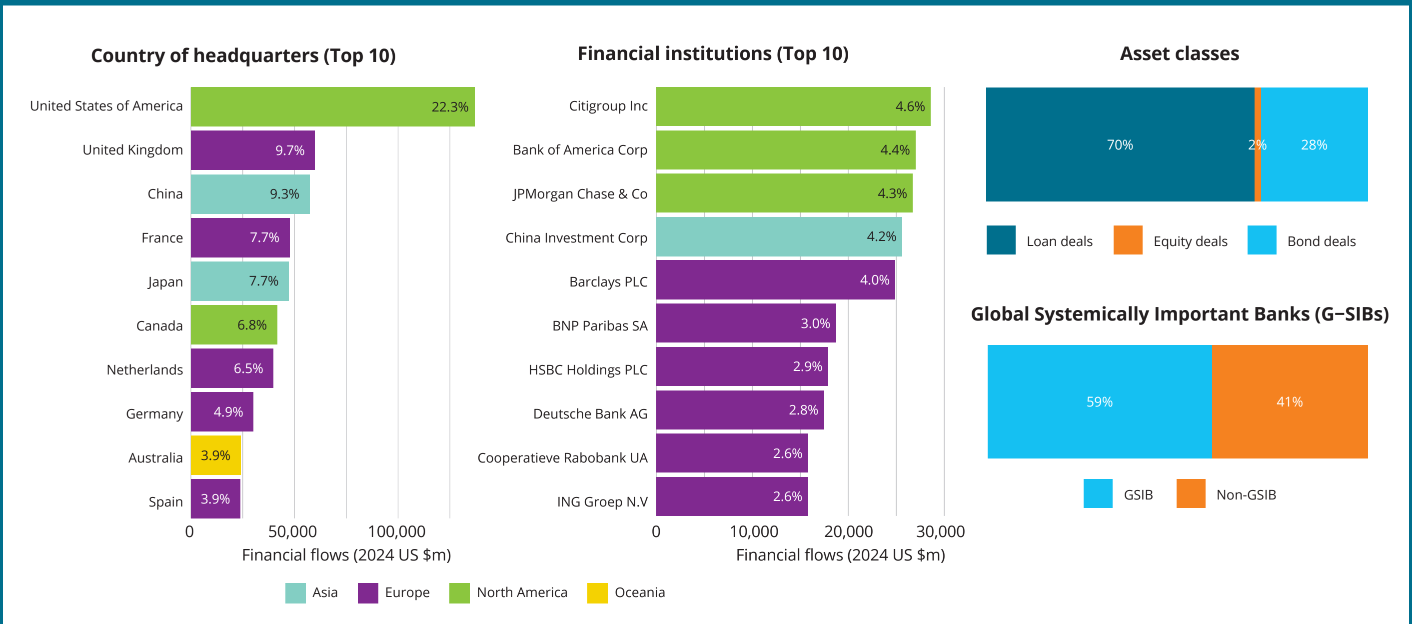
The Amazon rainforest is a key biodiversity hotspot and a crucial regulator of regional rainfall patterns. Through evapotranspiration (the release of water vapour from vegetation), it generates rainfall within the basin and supplies water to down-wind communities across Latin America and beyond. Studies have shown that the Amazon rainforest even contributes to freshwater regulation as far away as agriculturally important areas of western United States and the Tibetan Plateau (Liu et al., 2023; Medvigy et al., 2013; Wang-Erlandsson et al., 2018). Continued deforestation reduces rainfall, which in turn reduces agricultural productivity and associated revenues (Leite-Filho et al., 2021). Evidence suggests that climate change, with increasing wildfire risk, combined with land-use change, degradation and deforestation is pushing the Amazon close to the brink of collapse into a non-forested state – which would mean the loss of its core contributions to climate stability, water security and biodiversity.

Between 2014 and 2023, commercial finance provided to companies linked to deforestation for soy and beef in the Brazilian Amazon amounted to US$ 614.6 billion (adjusted to 2024 US dollar value), with flows primarily originating from financial institutions headquarters in the US, EU and UK – countries distant from the ecosystem they were impacting.

The figure below shows financial flows (2014–2023) to companies linked to drivers of nature loss, by a) country of headquarters of financial institutions originating flows; b) individual financial institutions originating flows; c) asset class; and d) GSIB status of financial institutions originating flows. In (a) and (b), the top 10 are shown – colours indicate region of headquarters and percentages indicate portion of overall flows (as such the percentages of the top 10 will sum to less than 100%). For capital markets deals (equity and bond issuances), the data identified the financial institution facilitating the deal through underwriting and other services rather than the institutions (e.g. investment firms) providing the primary capital.

Implications for financial supervisors

Financial institutions individually screening for transition-related risks linked to ecosystem tipping points may conclude they are financially immaterial, possibly because the share of their overall portfolio exposed to these tipping points is negligible. However, adding these individually "negligible" exposures together reveals a potential systemic risk, as furthering business as usual in fragile systems may push them abruptly past a point of no return. This misalignment between ecosystem resilience and financial system behaviour shows there is a crucial role for macroprudential policymakers tasked with monitoring and mitigating systemic risk. Their policies, that should promote the financial sector's transition away from fuelling tipping-points linked to systemic risk, should not be jeopardized by other financial sector interventions, such as over microprudential or monetary policy (Marsden et al., 2025).



Source: Marsden et al., (2025)

FINANCIAL SYSTEM VULNERABILITIES

Putting financial buffers in place can attenuate the materialization of systemic risk, but their effectiveness depends on the resilience of the broader systems they operate within. If compounding pressures erode that resilience over time, the loss-absorbing capacity of the financial system can weaken, allowing risks to escalate beyond their initial scope (see Text box 9 below).

TEXT BOX 9: FINANCIAL SYSTEM VULNERABILITIES AND WATER-RELATED RISKS: UNINSURABILITY

Swiss Re states that in 2025 economic damages from natural disasters reached US$ 328 billion (Chandan Banerjee et al., 2025), not including damages to nature or indirect economic effects. Banks, households and firms rely on risk transfer to cope with these impacts.

Shifting physical risk probability and severity distribution are increasingly causing insurers to withdraw from high-risk regions or sharply raise insurance premiums (European Central Bank & EIOPA, 2024). By design, insurers serve as a primary channel for absorbing the risks and redistributing losses through risk pooling and claim payments. However, when insurance is not renewed or becomes unaffordable, assets lose value, borrowers' creditworthiness deteriorates, default risk rises and banks' collateral bases (for loans and mortgages) weaken. Banks with concentrated geographic or sectoral exposures (e.g. regional lenders with real-estate-heavy portfolios) are especially vulnerable to such loops (Mitchell, 2025). In Quebec, the withdrawal of flood insurance led some banks to stop issuing mortgages in high-risk areas (Möhr et al., 2025). At the same time, without insurance, diminished resources for recovery and reinvestment after disasters put a strain on households, firms and lenders. Low insurance penetration leads to significantly longer recovery (Cambridge Centre for Risk Studies & AXA XL, 2020).

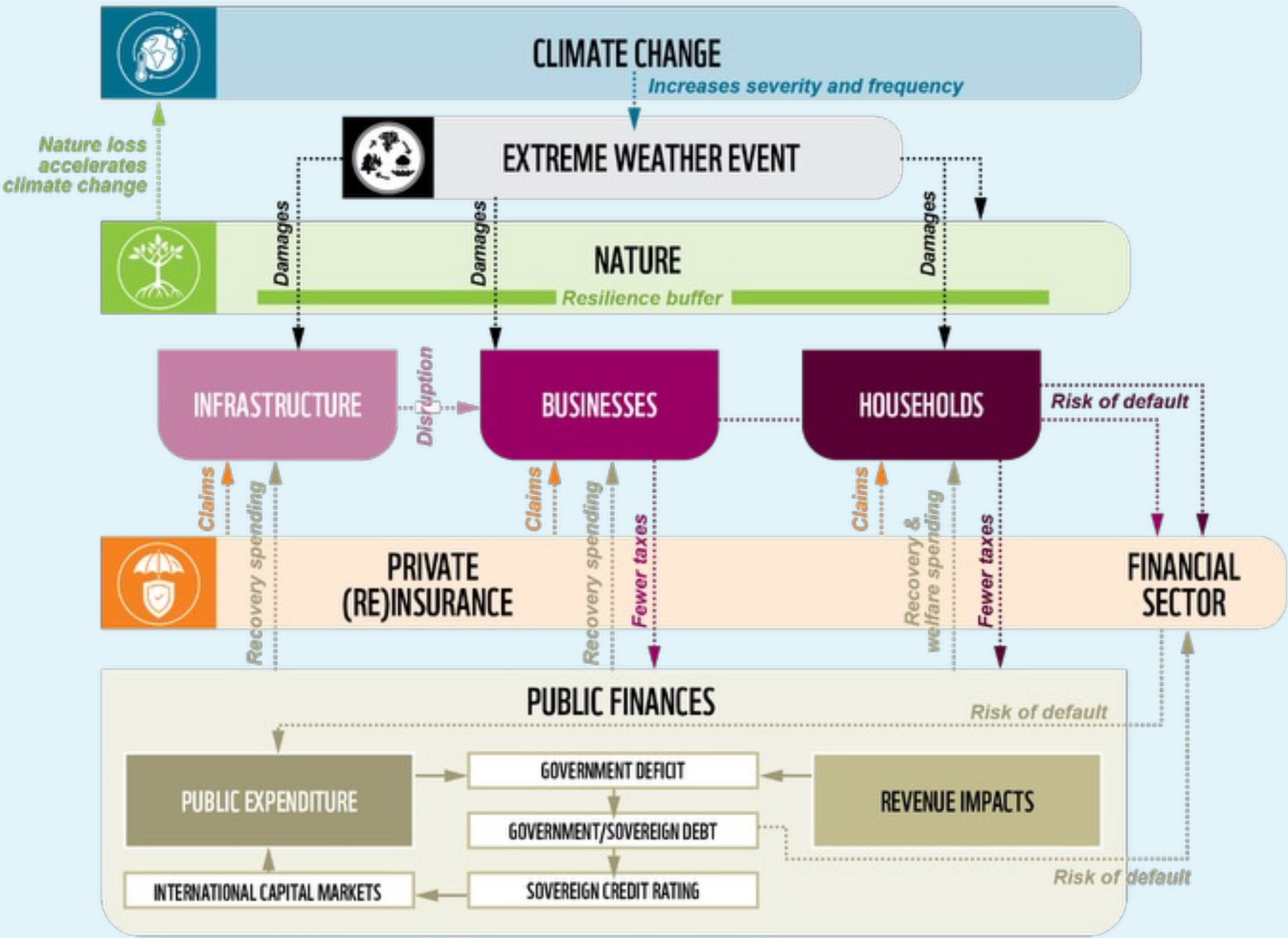
Global natural catastrophes (NatCat) premiums are expected to go up by 50% by 2030 (about US$ 200–250 billion) making coverage less affordable, particularly for low-income and more vulnerable households and SMEs (Douglas et al., 2024). When insurance is no longer accessible, available or affordable we speak of uninsurability. Uninsurability creates protection gaps (United Nations University, 2023). In 2023 and 2024, the global NatCat insurance protection gap was estimated at around 60% (Bowen et al., 2025), with protection gaps in some emerging markets and developing economies (EMDEs) exceeding 90% (South African Reserve Bank, 2025).

Widening protection gaps places severe strain on public budgets, as governments step in to cover uninsured losses and provide emergency relief (Crugnola-Humbert et al., 2026). In the United States, Bloomberg estimates that disaster-related spending since 2000 has reached US$ 18.5 trillion, with annual expenditures are now nearing US$ 200 billion, of which about 40% is covered through federal disaster relief, ultimately straining taxpayer budgets (Bloomberg Intelligence, 2025). According to Munich Re, the 2021 Ahrtal floods in Germany represent the costliest natural disaster to occur to date in both Germany and Europe, with significant damage to industrial facilities such as chemical plants as well as automotive suppliers and their supply chains. With insurance estimated to cover only 20–25% of total losses (MunichRe, 2022), the German government stepped in to provide €30 billion in public relief packages (Deutscher Bundestag, 2021).

Emerging economies are particularly susceptible to the consequences of high protection gaps, especially when disasters hit a critical economic sector such as agriculture (Möhr et al., 2025). For example, less than 1% of the losses from Pakistan's 2022 floods were insured. The disaster affected a quarter of the population and generated around US$ 30 billion in damage, recovery and reconstruction costs (Khan, 2024). Due to the high protection gap, the government had to rely on international bailouts and external funding (Moshiri, 2025). Many countries with a relatively low protection gap rely on public-private partnerships and/or risk pools to lower the maximum risk for each commercial insurance company. While such arrangements can temporarily ease the burden, they are also under more pressure as the losses from extreme weather events increase (Crugnola-Humbert et al., 2026).

Ultimately, authorities responsible for financial stability are facing an erosion of the financial system's shock-absorbing capacity. When insurance does not absorb the shock, banks' balance sheets are more exposed, especially their mortgage portfolios. And when governments accumulate debt for repeated disaster relief, the risk of sovereign debt crises increases. This creates a vicious cycle for insurance companies that face increasing losses from their NatCat portfolios as well as risks to their bond holdings (Crugnola-Humbert et al., 2026). Compounded and interlinked stresses across ecosystems and supply chains reinforce one another and escalate systemic risk (European Central Bank, 2025a).

For more information on this subject, you can consult the WWF White Paper on *Tackling the insurance protection gap* (Crugnola-Humbert et al., 2026).



Even when risks are insured, it is critical to consider potential blind spots in the coverage. For example, whether a site's flood-related insurance coverage extends to the equipment or processes within the site (container vs. equipment) will depend on the countries and types of contract concerned.[11] A recent study from de l'Estoile et al. (2025) highlights the critical distinction between firms' real estate assets and their equipment and machinery when assessing flood-related financial risks at a granular level. While much of the existing literature focuses on the impact of flooding on company headquarters, the study reveals that a substantial portion of climate-related physical risk lies in geographically dispersed production sites. These sites may be significantly more vulnerable, as the cost of repairing machinery and replacing equipment often exceeds the expense of building remediation. The findings highlight an important aspect of credit risk in the banking sector, and emphasize the crucial role of insurance coverage.

Geographic concentration risk

Systemic risk can result from concentrated geographical exposure. According to a recent MSCI and WWF study (Lei-Ravello et al., 2026), among 100 companies in the MSCI ACWI IMI with a market capitalization of over US$ 75 million and significant revenue at risk from water availability, about half generate 10–20% of their revenue from assets with high water availability risks, while 39 companies generate 20–50%. Two major IT and consumer discretionary firms earn 34% and 36% of revenue from such assets. Additionally, one large energy company makes over 90% of its revenue from just 6% of assets highly exposed to water availability risks. In the Figure 15 below, we see that there are many more companies on the left side of the 45° axis, which are companies whose revenue generation is more concentrated in a few high-risk productive assets. This systemic revenue dependency on a few assets exposed to high water availability risks (which considers the dependency of the asset on water provision and the water availability in the location in question) highlights the immense operational sensitivity of these companies to chronic water changes or acute disruptions, thus exposing not only financial institutions which back them via their lending, investments and underwriting business, but also the broader economy via trade, supply chain and possible labour market implications.

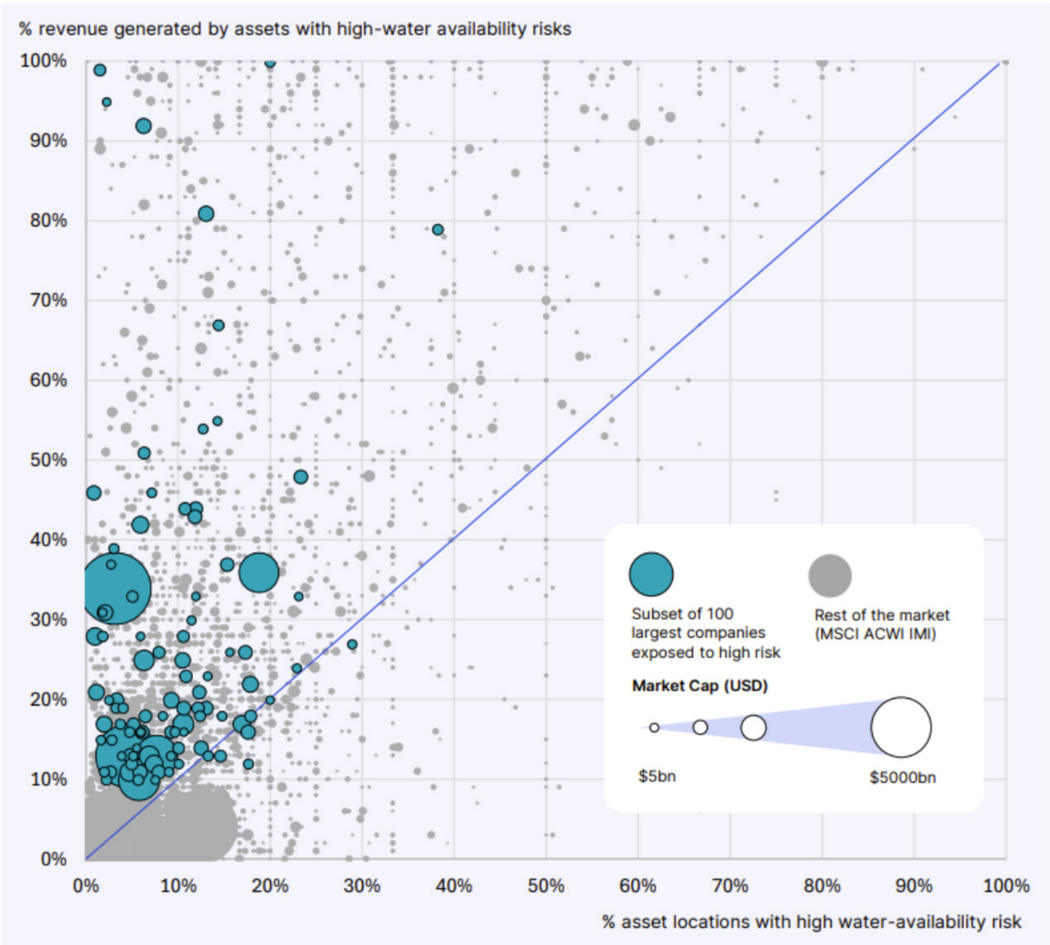


***Figure 15:** Identifying companies with amplified water availability risk due to geographic concentration of revenue generation in high risk areas. Source: Lei-Ravello et al. (2026)*

11 See EIOPA Dashboard for differences between European countries for instance.

Global Systemically Important Banks (G-SIBs)

Water-related risks can expose systemic risks via global and domestic systemically important banks (G-SIBs and D-SIBs). Given the size, complexity and global interconnectedness of G-SIBs and D-SIBs, their financing decisions can amplify both environmental degradation and the transmission of environmental shocks. If left unaddressed, concentrated exposures in these banks could escalate water-related risks into systemic crises. Strengthening prudential expectations for G-SIBs and D-SIBs would help to ensure they can withstand environmental shocks and contribute to a more resilient financial system. While some systemic banks are beginning to integrate water and nature into their risk management, action remains uneven (Saphira et al., 2024).

TEXT BOX 10: ADDRESSING WATER POLLUTION AS A MATERIAL FINANCIAL RISK

Water pollution poses a significant and potentially underestimated (systemic) risk to financial stability and economic well-being. Widespread contamination of freshwater sources by nitrates, PFAS, microplastics and heavy metals – driven by the fact that 80% of global wastewater is discharged untreated (UNESCO, 2017) – can lead to severe environmental degradation, supply chain disruptions and escalating economic and social costs. The World Bank's *Quality Unknown report* (2019) estimates that degraded water quality reduces GDP by up to one-third in heavily polluted regions: the economic costs of inaction are extremely high. Key economic sectors like agriculture, food and beverage, petrochemicals, pharmaceuticals, energy, textiles, construction and mining are heavily reliant on clean water, yet they are also major contributors to pollution. Examples include:

Agriculture: Highly hazardous pesticides enter waterways (UNEP et al., 2022).

Pharmaceuticals: Residues from medical waste contribute to antimicrobial resistance, which could potentially reduce global GDP by up to US$ 100 trillion (OECD, 2020).

Mining: Tailings storage facility failures cause environmental and economic damages worth billions of dollars (Carvalho Medeiros et al., 2025).

Textiles: Dyeing and finishing processes account for ~20% of global clean water pollution (Dutta et al., 2024; European Parliament, 2025).

Electronics: Electronics release persistent chemicals and heavy metals, often via the unregulated dumping of e-waste (Rucevska et al., 2015).

While corporate awareness of pollution risks has historically been low, momentum is growing. Back in 2019, of the 2,433 companies disclosing water-related data via CDP, just 10% identified pollution-related risks (CDP, 2019; Perveen et al., 2025). However, 2023 saw the adoption of the Global Framework on Chemicals; subsequently, in the World Economic Forum's 2025 *Global Risk Report*, pollution rose up to sixth place, before moving back to ninth place in the 2026 report.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These developments signal that pollution is increasingly recognized as a critical risk and opportunity area. Global investment in wastewater infrastructure and pollution control is critically inadequate, particularly in low- and middle-income countries. Policy frameworks often lag, lacking integrated control strategies and enforcement. This gap perpetuates water degradation, magnifying risks to health, ecosystems and financial systems. A conservative global estimate puts the annual economic burden caused by freshwater pollution at US$ 0.5 trillion, which covers expenses for water treatment and healthcare along with lost revenue from agriculture. CBFRs, mandated to ensure financial stability, should address freshwater pollution within existing frameworks as it impacts the safety and soundness of banks. Studies consistently identify freshwater resource depletion (in both quantity and quality) as a highly material nature-related risk for financial institutions. Assessments by central banks (e.g. ECB, Hungary, Spain, France) using tools like ENCORE consistently highlight surface and groundwater ecosystem services as a top dependency for the financial sector, underscoring the materiality of water-related risks, including pollution (Houben et al., 2024).

Water pollution can be financially material for financial institutions through various channels, as shown in the following table.

Table 6: *Freshwater pollution-related financial materiality. Source: Adapted from UNEP FI (2024)*

FINANCIAL MATERIALITY: HOW FRESHWATER POLLUTION AFFECTS BANKS' FINANCIAL HEALTH	
CREDIT RISK	Borrowers, especially in polluting industries, can face default due to financial losses from incidents, asset devaluation, regulatory fines and legal liabilities.
MARKET RISK	Pollution incidents can cause asset price fluctuations and shift investor sentiment towards sustainable, low-pollution practices, impacting asset values.
UNDERWRITING RISK	Increased insured losses and rising insurance costs can be direct consequences of pollution-related impacts.
OPERATIONAL RISK	Banks can face risks from accidents, spills and regulatory breaches affecting their offices, staff, servers and operations.
LIQUIDITY RISK	Pollution-related impacts can increase funding needs to cover losses or cleanup costs.
LIABILITY RISK	Banks can be held directly liable for financing harmful activities and face potential lawsuits and regulatory fines, damaging their reputations and customer relationships.

OPPORTUNITIES IN ENABLING A WATER-SECURE AND RESILIENT ECONOMY

Addressing the global water crisis and accelerating a just transition toward water security presents a strategic opportunity for the financial sector and the economy. First, water is an essential puzzle piece in accelerating climate change mitigation, and particularly adaptation. Additionally, water-centred solutions are a critical lever in halting biodiversity loss, nature degradation and furthering restoration – either because water systems themselves have been degraded or because they can support sustainable land management or coastal conservation. Equally, working with nature is essential in order to make a positive impact on water systems.

Ultimately, interventions aimed at improving water security and resilience equitably not only mitigate systemic risks but also contribute to price stability, financial stability and sustainable economic prosperity. Water security is not an environmental nice-to-have, it is an economic necessity, and a comprehensive water-centric strategy – cognizant of the interactions with climate, nature and people – can address multiple issues at once, creating synergies and minimizing trade-offs.

TEXT BOX 11: DEFINITION WATER-RELATED OPPORTUNITIES

As with TNFD's definition of nature-related opportunities, water-related opportunities can be defined as activities that generate positive outcomes for organizations and water systems (e.g. through risk reduction or new business models), or that mitigate negative impacts on the hydrological cycle and freshwater ecosystems. Water-related opportunities include both activities that avoid and reduce negative impacts on water systems and activities that have positive impacts. Water-related opportunities can manifest at the level of a single organization or even at the level of the whole economy (employment, fiscal stability etc.).

Addressing the water crisis requires the transformation of economic activities that are directly or indirectly driving water insecurity in the form of too much, too little, too dirty, broken infrastructure, and broken governance. Tackling the key drivers of each front of the water crisis presents valuable opportunities for the financial sector with important co-benefits for the broader economy (see Figure 16).

TEXT BOX 12: THE FINANCIAL IMPACT OF FLOODS - EXAMPLES FROM EUROPE

In recent history, water has been seen as a commodity or as something to push away should there be too much of it. Grey infrastructure solutions, such as dykes and walls, have been developed to narrow the water's path in order to protect people, assets and operations from its forces. However, evidence suggests that exactly the opposite attitude, of working with water and with nature, can give better results in light of the increased volatility, frequency and severity of extreme weather events seen today.

Nature-based solutions (NbS) have increasingly gained traction as a complementary approach to grey infrastructure solutions. Both are necessary for a holistic approach capable of achieving SDG 6 (Water and Sanitation). A notable example that illustrates how grey and green solutions can be combined for greater water security can be seen in New York City, where water security largely depends on the health of the Catskill-Delaware watershed system (Jeffries & Lee, 2024; M. Kane & Erickson, 2007). In many instances, large-scale river and wetland restoration have been found to have widespread environmental, economic and social benefits (Speed et al., 2026).

Ultimately, working with water and natural systems towards economic resilience and security will mitigate risks across all the negative drivers, reducing hazards, exposure and sensitivity, and improving adaptive capacity. Crucially, such interventions are proven to also increase jobs, improve public health, support fiscal stability and spur innovation, ultimately sustaining livelihoods and economic prosperity.

The latest UNEP report on The State of Finance for Nature includes compelling figures in support of this fact:

- One dollar spent on ecosystem restoration provides economic benefits 7 to 30 times greater (Verdone & Seidl, 2017).
- A review of NbS for disaster risk reduction found that they are more effective in attenuating hazards than engineering-based solutions (Vicarelli et al., 2024).
- With growing nature markets, evidence indicates that business can unlock around US$ 10 trillion in opportunities and create more than 395 million jobs by 2030 by prioritizing nature (World Economic Forum, 2020).

Nature-based solutions should be developed alongside the maintenance and improvement of traditional grey infrastructure, taking so-called "green-grey" infrastructure approaches. Investing in projects like upgrading water pipelines to improve transport and reduce leakage, enhancing water treatment facilities, and expanding access to safe drinking water and sanitation produces significant benefits across the broader economy. Research suggests that investing in water infrastructure yields an output and employment multiplier effect four times greater than comparable investments in education or health (Joseph et al., 2024). Although closing the financing gap in water infrastructure brings clear synergies, a long-term perspective is needed to minimize potential trade-offs and prevent unintended consequences. For instance, improving water efficiency can sometimes drive up overall water use, potentially offsetting those gains by depleting wells and surface sources – a phenomenon known as the "rebound effect".

While the on-the-ground change will be driven by coordination and collaboration between municipalities, regional authorities, corporates, small businesses and households, the financial sector has the power to co-design and accelerate the necessary transition via capital allocation, corporate engagement, and the integration of water concerns in credit, investment and underwriting decisions.

Both the mitigation of negative impacts and the amplification of positive impacts are needed in parallel, as together they generate positive feedback loops for one another. In this respect, it is critical for public policy and finance to be aligned in order not to distort incentives for markets, for example via harmful subsidies that lower the cost of capital for detrimental activities.

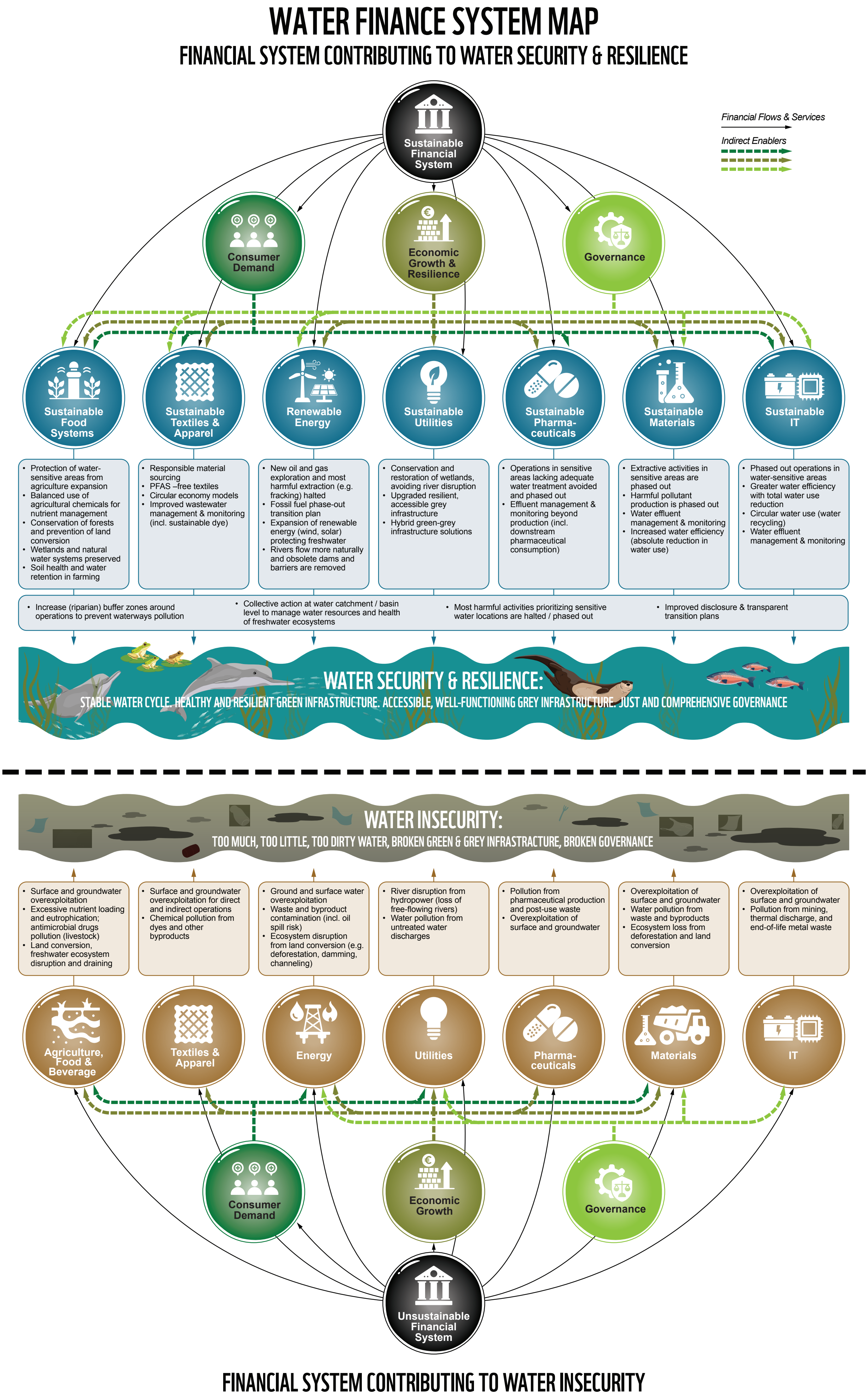

***Figure 16:** Water finance system map. Source: authors*

TEXT BOX 13: WHAT IS WATER SECURITY AND RESILIENCE?


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Water security can be defined as "the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability" (UN-Water, 2013). Water resilience can be defined as the ability of people, infrastructure, services and the economy to withstand, bounce back from and thrive in the face of chronic and acute water-related stressors. Striving for water security primarily enables the **mitigation** of hazards, as well as **reducing the exposure and increasing the adaptive capacity** of societal and economic operations, actors and assets. Water resilience ensures that residual risks can be managed as they arise. Both water security and water resilience are essential building blocks to ensure economic prosperity, equitable (business) continuity and public health.

Financial support directed towards water security has generally been growing globally in the past decade, particularly from private finance, but levels are still insufficient to close the water financing gap.

Table 7 below summarizes the latest insights on the state of finance for water security from both NbS and grey infrastructure perspectives.

Table 7: *Insights summary on the state of water finance*

FINDING	EXPLANATION
Nature-negative finance outstrips finance for NbS by a factor of 30.	In 2023, nature-negative finance – which encompasses private sector financial support for activities detrimental to water systems, as well as environmentally harmful water subsidies – was 30 times greater than financing aligned with nature-positive outcomes, as measured by financial flows to NbS. Specifically, finance negatively impacting nature reached US$ 7.3 trillion, while nature-positive finance amounted to US$ 220 billion (UNEP, 2026).
More than two-thirds of total nature-negative finance stems from the private sector, whereas financial flows towards NbS are dominated by the public sector. NbS investments need to increase by a factor of more than 2.5 by 2030.	Over two-thirds of total nature-negative finance originates from the private sector. Private sector funding with negative impacts on nature is primarily directed toward utilities, followed by industries (including technology and healthcare), and then the energy sector. These sectors are highly reliant on water ecosystem services and significantly contribute to their degradation. In the public sector, the second-largest share of nature-negative contributions occurs within the water sector, largely through the provision of harmful subsidies (UNEP, 2026). Financial flows towards nature-based solutions are dominated by the public sector at 90%, eight times more than the contributions by the private sector. Of the total public contribution of US$ 197 billion, US$ 82.2 billion are directed towards biodiversity, US$ 66.3 billion to sustainable agriculture, forestry and fisheries, US$ 15.1 billion to pollution abatement, and US$ 15 billion to wastewater management. Notably, between 2021 and 2023 NbS finance linked to wastewater management declined by US$ 620 million, despite investment needs rising with increasing pressures. Overall, NbS investments currently stand at around US$ 220 billion annually but need to reach US$ 571 billion by 2030 to meet global biodiversity and nature goals, an increase of more than 2.5 times (UNEP, 2026).

Finance for NbS addressing water security has been gaining significant traction in the past decade, although it is still dominated by public sector financing.	Worldwide investments in NbS specifically for water security reached US$ 49 billion in 2023 across 880 water catchment programmes, driven up from roughly half that in 2013 by diverse financing mechanisms. Public sources account for 97% of NbS water financing, signalling significant untapped potential for private sector participation (Smith et al., 2025).
Private sector NbS investment for water security grew by a factor of 30 in the past decade.	Despite remaining a small share overall, private sector investment in freshwater NbS grew 30-fold over the past decade, reaching US$ 345 million. More than three-quarters of private sector NbS investments were motivated by regulatory compliance rather than being voluntary actions (Smith et al., 2025).
Global NbS investment for water security is heavily concentrated, with more than half coming from a single country.	In 2023, 54% of global NbS investment for water security came from China, with 99.8% of China's contribution provided by the public sector. While Africa and the rest of Asia (excluding China) still contribute the least overall, they have seen the fastest growth in the past decade, increasing by a factor of 5 and 3.4 respectively (Smith et al., 2025).
It is estimated that up to US$ 7 trillion will be needed by 2030 and US$ 22.6 trillion by 2050 to close the finance gap to reach water security. To this end, while grey infrastructure is far better supported than NbS for water, it is still grossly underfunded, especially in emerging markets.	Conventional engineered water infrastructure still dominates investment decisions, while NbS remain niche and face major financing barriers, including a lack of dedicated instruments and investor familiarity. At the same time, global water infrastructure is severely underfunded: up to US$ 7 trillion is estimated to be needed by 2030, with developing countries needing to almost triple their current water sector spending, particularly in Sub-Saharan Africa and South Asia. Structural and institutional constraints in emerging markets further limit access to commercial finance for water and sanitation, leaving both conventional and nature-based water solutions substantially underfinanced (Joseph et al., 2024; Khemka et al., 2023).

More traditional investors are taking an interest in grey infrastructure investment and integrating it in their processes. Certain market segments – primarily in Global North contexts – have seen an increase in financial products aligned with this rising interest among private financial institutions. For over two decades, a growing number of mutual funds and exchange-traded funds (ETFs) targeting water-related equities have given investors opportunities to make water investments, with an annualized performance of around 10% and volatility of around 12% (Lei-Ravello, 2020). These vehicles typically cover a universe of around 250 publicly-listed water stocks, spanning small- and mid-cap companies across water infrastructure, industrial equipment, utilities, and water treatment chemicals. Over the past decade, startup activity in this sector has surged, particularly in digital water technologies and treatment solutions. These ventures face difficulties in scaling, due to the conservative procurement practices of utilities and the long technology adoption cycles, which range from 11 to 16 years (O'Callaghan, 2020). To bridge this innovation gap, venture capital has increasingly stepped in with water-related VC deals rising sharply in the past six to seven years (Dealroom, 2024).

Several, and to an extent similar, obstacles continue to impede the financing of Nbs. These include limited ticket sizes and inadequate aggregation which make investment challenging, while water resources remain undervalued and underpriced. Financial decisions frequently focus on short-term outcomes, and the co-benefits of NbS are not sufficiently recognized. Projects often require longer stabilization and return periods, with procurement practices remaining conservative and utility adoption cycles extended. Risk-mitigation instruments have yet to be sufficiently developed, and policy coordination across relevant sectors is weak. Although capital costs for NbS are generally lower compared to purely grey solutions, high political costs persist due to the larger spaces typically needed for their implementation, which are often challenging to implement in urban settings (Anderson et al., 2022).

Nevertheless, emerging solutions and instruments continue to grow to address some of these challenges. For NbS finance, financing models and incubator programmes are laying the foundation to crowd-in investments and accelerate project development. Notable examples include the NatureWise Facility (WWF, n.d.), a grant and investment facility to support early-stage NbS projects, including on water resilience. The facility takes an integrated green-grey infrastructure approach, aiming to bring them to a financial close, and ultimately act as a bridge between projects and investors.

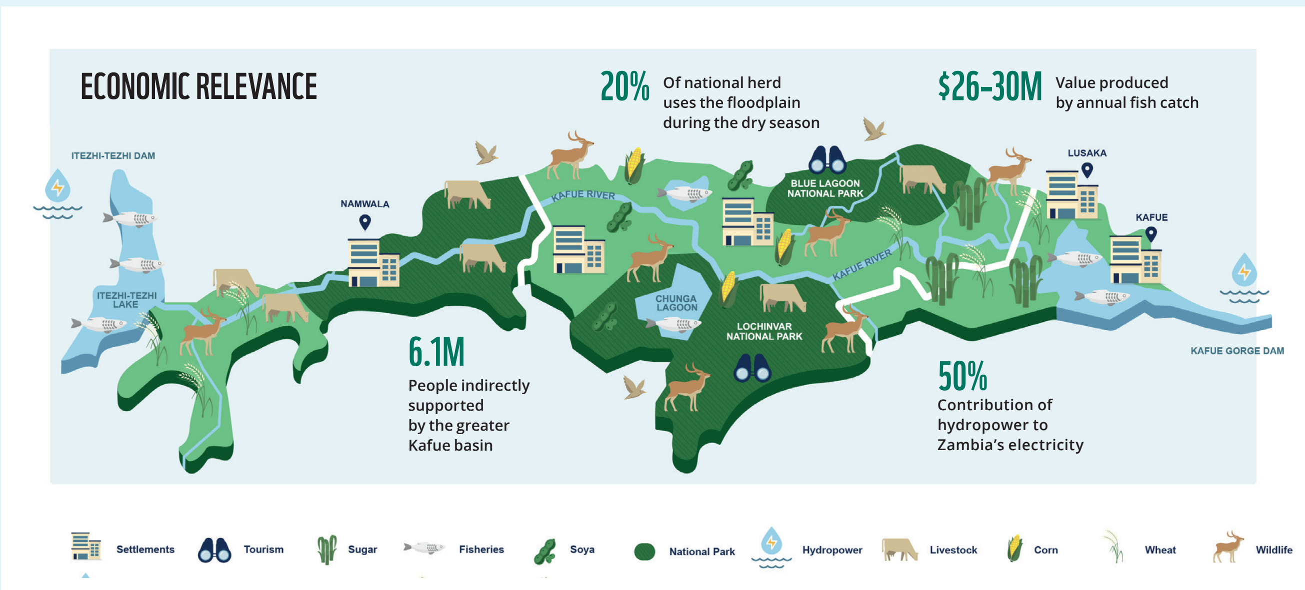
Specific financing instruments which are growing in importance include debt-for-nature swaps for river and catchment conservation (e.g. El Salvador's green bond for freshwater (Furness, 2024)) and sustainability-themed bonds linked to wetlands and forest protection (e.g. Blue Forest Conservation's Forest Resilience Bond (BFAM, 2026)).

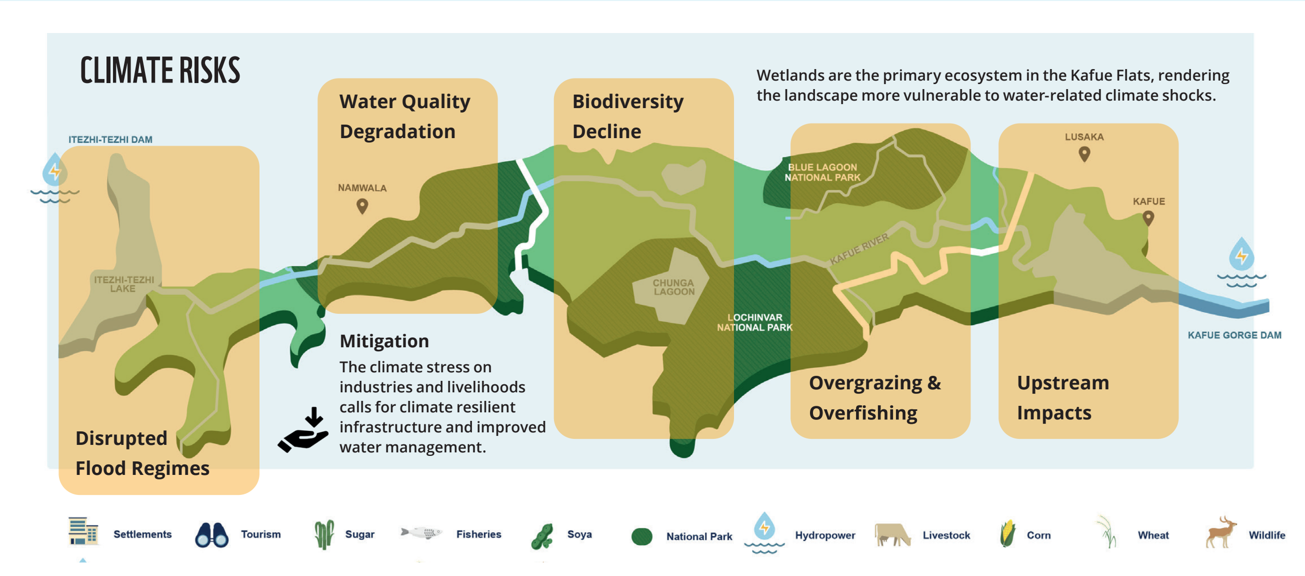
A whole-of-landscape approach across entire catchments is vital for effective water management and can help address persistent challenges in NbS financing. This method accounts for the larger ecosystem (e.g. from source-to-sea, or at designated catchment boundaries) as well as the interplay between people, nature and the economy by involving a range of stakeholders – particularly those most affected – in the planning, execution and upkeep of interventions. By considering impacts at the landscape level, these approaches help prevent negative downstream effects and uncover solutions that benefit the landscape more broadly. An example of such landscape thinking is reflected in a research piece from the EU Joint Research Centre (JRC) indicating that without Europe's wetlands filtering pollutants, nitrogen levels flowing into the seas would be 25% higher. Furthermore, the same study found that restoring historical wetlands could further decrease nitrogen pollution with minimal impact on agriculture (European Commission, 2025).

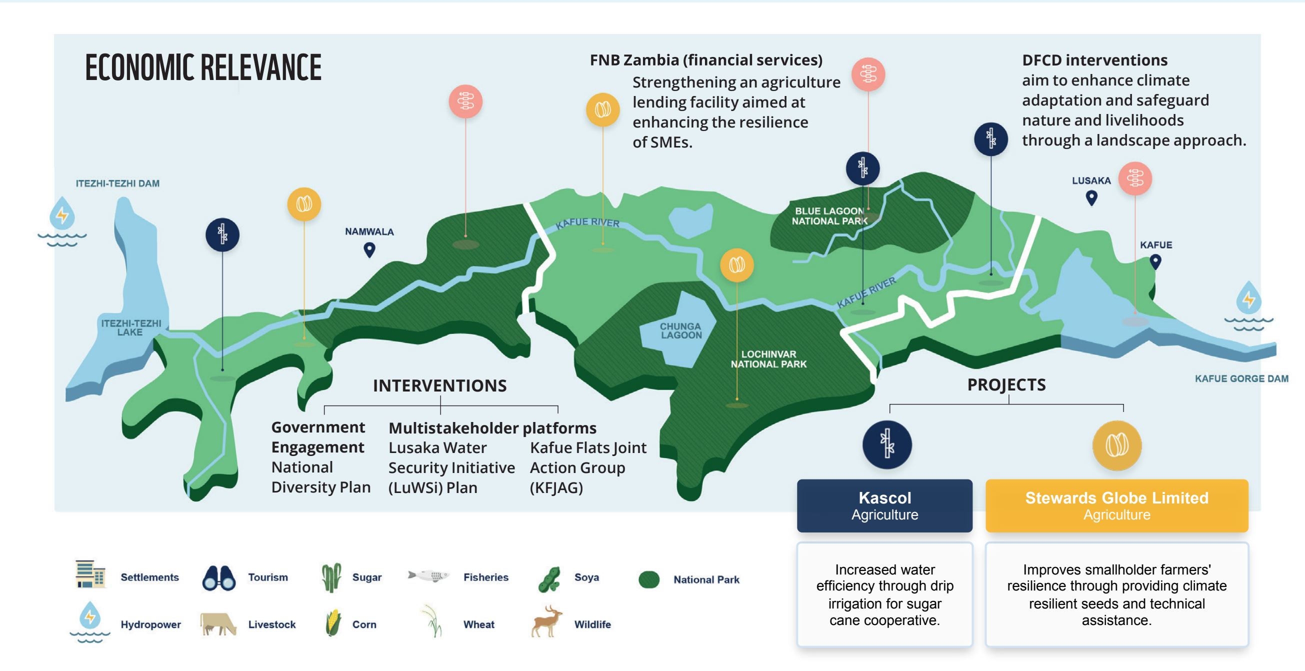
Such comprehensive landscape thinking is especially important in the financial sector, since institutions could have distinct clients who are interdependent within a given landscape and impact each other through diffuse effects like pollution or water overexploitation. Financial institutions are therefore well positioned to coordinate among diverse clients, encouraging collective action and participation in landscape-level initiatives.

TEXT BOX 14: WWF LANDSCAPE FINANCE APPROACH

WWF's Landscape Finance Approach Guide offers place-based guidance to enhance capital for nature and the alignment of existing financial flows with nature-positive outcomes, by convening stakeholders under a joint action and investment plan in landscapes (WWF, 2025). It helps investors and other financial stakeholders to overcome many of the persistent barriers to NbS; as such, the approach supports aggregating opportunities and capital, aligning priorities and reporting frameworks while establishing inclusive, accountable governance mechanisms. The handbook provides practical case studies to illustrate how the Landscape Finance Appproach can be applied. The images below showcase the example of the Kafue Flats, a biodiversity-rich landscape in South Central Zambia that covers 6,500 km2. The wetlands in this landscape are under climatic pressures, while being an essential source of livelihoods for 300,000 residents. The maps below show the opportunities that are revealed by overlaying economic relevance, climate risk and possible interventions in a spatially explicit manner across a landscape (WWF, 2025).







Another example is the case of South Africa's Working for Water programme, operational since 1995, which has long tackled invasive alien plants that threaten freshwater resources. Recent advancements, however, have introduced verifiable impact metrics. For example, the removal of 269 hectares of invasive black wattle at Port Jackson in the Eastern Cape recovered 844,711 cubic meters of freshwater – an amount equivalent to the annual water use of 16,000 households according to the Roundtable on Sustainable Biomaterials (RSB) (2025).

These outcomes are now being translated into water impact claims through frameworks developed by RSB and WWF-South Africa, enabling private-sector investment in invasive plant removal. By monetizing ecosystem services such as water recovery and biodiversity gains, South Africa is creating a scalable model for "invasive plant bonds." Such instruments could attract capital by demonstrating tangible, quantifiable benefits, particularly in water-stressed regions.

In summary, a Landscape Finance Approach:

- Addresses spatial mismatches (downstream pollution, upstream overextraction).
- Aligns multiple actors across geographies and sectors.
- Supports collective action among clients/investees.
- Reduces systemic risks that cannot be solved asset by asset.
- Ensures NbS and grey infrastructure are integrated effectively.
- Prevents trade offs between land use, water and biodiversity.

Whole-of-landscape approaches aimed at improving the health and resilience of a basin represent a rich but underutilized private sector finance frontier. An emerging set of technologies exist and continues to develop, there is evidence of NbS successes, investor appetite has been growing (albeit too slowly and remaining niche, rather than galvanizing the mainstream financial sector to partake), and the risks of inaction are increasingly clear.

Further, the current analyses show the siloed approaches in furthering water security. The financial sector – public and private – altogether remains limited to the water utility sector or nature-based investments, and is not driving broader transformational changes in other economic areas (e.g. metals and mining, energy, food systems) to achieve a just, secure and resilient water system for the broader public good. In other words, it is not taking what (Mazzucato & Zaqout, 2025) termed a "a mission-driven approach to water finance".

Central banks and financial supervisors are well positioned to support the mainstreaming of financial practices that are currently niche within public and private financial institutions.

By addressing key challenges, they can help unlock opportunities and facilitate the transition of financial capital and related services to align with the goal of establishing water security to support a stable financial system. To start, conveying to governments the destabilizing economic risks posed by water insecurity supports the argument for phasing out subsidies that harm water resources. Prudential regulations can influence investment decisions by altering the risk-return profiles of future investments. If CBFRs require financial institutions (and, indirectly, private companies) to more thoroughly assess and incorporate water-related risks, investments in sectors that degrade freshwater will become less appealing, while those in activities or projects that enhance water security will appear more favourable. As a result, CBFRs can help boost private investment in the water sector. Increasing investment in water security subsequently reduces systemic risks related to water. Additionally, CBFRs play a crucial role in bringing together financial actors to build capacity and foster understanding of NbS.

Policy coherence and a whole-of-government approach is indispensable to mitigate water-related (systemic) risks and transition towards a water-secure and resilient economy. Ensuring policy coherence is essential for integrating water considerations across climate, energy, food, industrial and financial policies to prevent the transfer of risks between sectors – particularly by accounting for the possible trade-offs that measures in one sector may impose on another. Presently a comprehensive evaluation of potential trade-offs and synergies associated with proposed actions is lacking, resulting in fragmented decision-making, unintended outcomes and inefficient resource allocation. This fragmentation can compromise genuine efforts to pursue water security and resilience, as policies formulated without coordination may intensify water stress, create distorted incentives, or redistribute vulnerabilities across various sectors and regions.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KEY MESSAGES TO CENTRAL BANKS, FINANCIAL SUPERVISORS AND REGULATORS

01 WATER-RELATED RISKS ARE DEEPLY INTERTWINED WITH WIDER SOCIOECONOMIC RISKS.

They amplify food insecurity, inequality, supply chain disruption and conflict, making them central drivers of the accelerating polycrises that are directly linked to the core mandate of central banks.

02 WATER-RELATED PHYSICAL, TRANSITION AND SYSTEMIC RISKS EMERGE AS THE MOST MATERIAL SOURCE OF NATURE-RELATED RISKS, DIRECTLY THREATENING ECONOMIES AND FINANCIAL SYSTEMS.

They transmit through microeconomic and macroeconomic channels, affecting financial risk categories (such as credit, underwriting and liquidity risk) as well as economic growth, price levels, fiscal balances and employment. Local shocks can propagate globally via trade, supply chains and financial spillovers.

03 WATER RISKS ARE ENDOGENOUS – ENABLED BY "BUSINESS-AS-USUAL" IN THE ECONOMY AND FINANCIAL SECTOR.

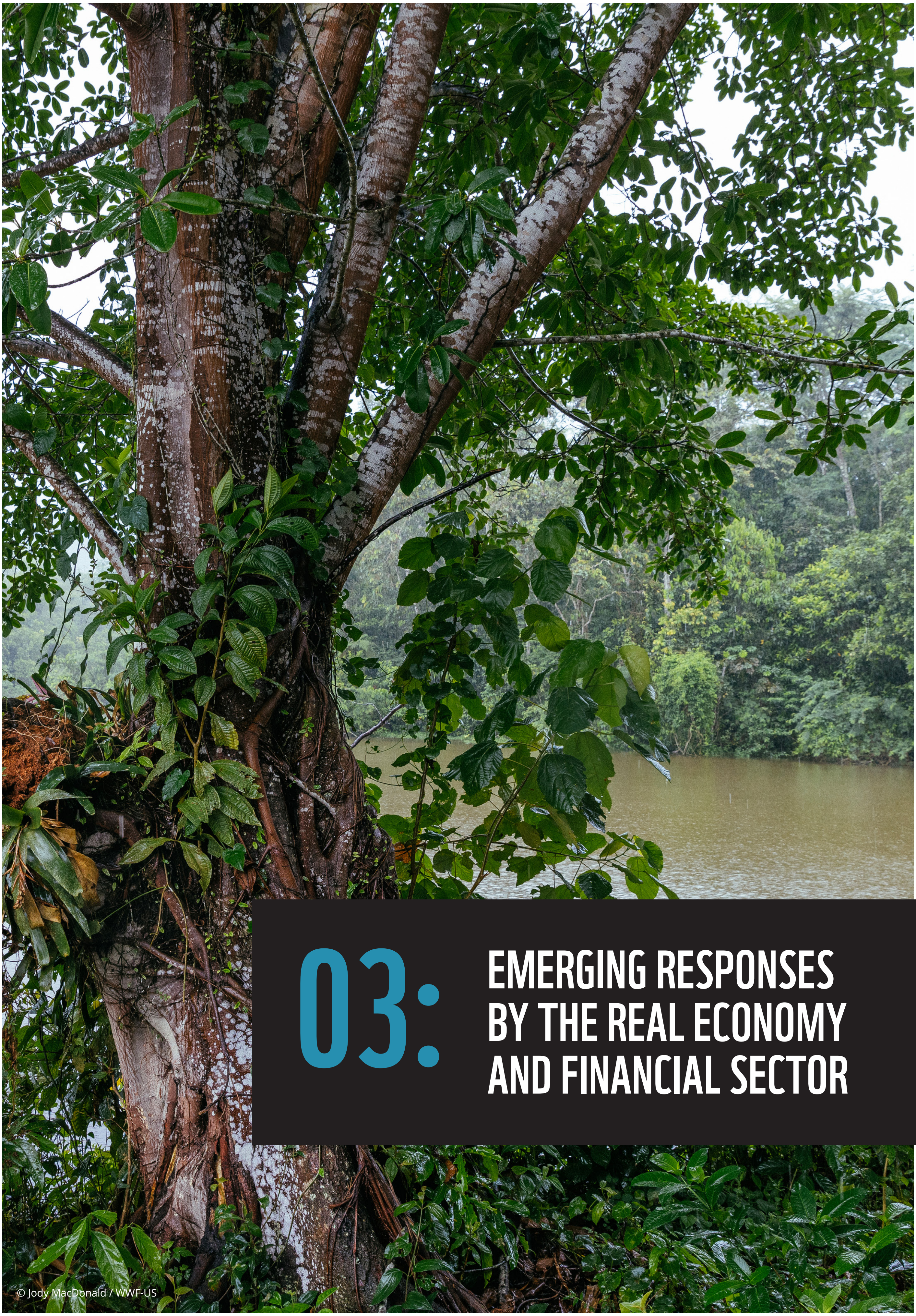
Human-driven pressures such as over-abstraction, pollution and land conversion are often financed by loans, investments and insurance. This creates a feedback loop where financial flows accelerate the very risks that threaten their business, price and financial stability.

04 WATER RISKS ALSO PRESENT OPPORTUNITIES.

Addressing the water crisis can mobilize innovation and finance for NbS, resilient infrastructure and water-efficient technologies, with positive repercussions on economic prosperity through a growth in jobs and lower inflationary pressures in the long term. CBFRs can play a role in crowding-in private capital and ensuring the transition is just, water-secure and economically stabilizing.

05 CBFRS HAVE RESPONSIBILITY IN MITIGATING WATER-RELATED (SYSTEMIC) RISK AND LEVERAGE IN ENABLING THE FINANCIAL SECTOR TO BE CONDUCIVE TOWARDS THIS END.

Through supervisory, monetary and policy tools, particularly in coordination with fiscal and industrial policy, CBFRs can ensure water risks are properly valued in risk management and mobilize private finance towards catchment-wide solutions that safeguard long-term financial and price stability.



03: EMERGING RESPONSES BY THE REAL ECONOMY AND FINANCIAL SECTOR

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SECTION 03:
EMERGING RESPONSES BY THE REAL ECONOMY AND FINANCIAL SECTOR

INTERNATIONAL AND MULTILATERAL RESPONSES

The abundance of initiatives targeted at addressing the various facets of the water crisis demonstrates a shared commitment among different actors to tackle it (see Table 14 in the Annex).

These initiatives, coalitions and frameworks have different scopes, types of members and purposes. Their variety reflects the fact that the water crisis is complex and covers various sub-challenges, and therefore in and of itself cannot be addressed by steering towards one quantified metric – as can be done globally with the 1.5°C threshold for climate change mitigation, for example.

Nonetheless, there are unified signposts on which countries have collectively agreed, such as Sustainable Development Goal 6, which encompasses six targets relating to water quantity, quality and access, freshwater ecosystems, and governance. Additionally, the Paris Climate Agreement establishes a legally binding goal on climate adaptation which is largely rooted in water resilience; and the Kunming-Montreal Global Biodiversity Framework (GBF) aims to ensure that by 2030 at least 30% of degraded inland waters will be under restoration, and that at least 30% of inland water areas – especially those important for biodiversity – will be conserved under effective and equitable governance systems. Furthermore, there are notable framework conventions – such as the Ramsar Convention on Wetlands and the UN Watercourses Convention – which provide signatory states with overarching structured pathways on the key considerations for the management and protection of such landscapes. The recently launched UN-endorsed Freshwater Challenge aims to restore 300,000km of degraded rivers and 350 million hectares of wetlands by 2030, thereby strengthening cross-border coherence in freshwater conservation efforts (Freshwater Challenge, 2023). This initiative establishes a global framework for project development, investment and regulatory alignment, making it particularly relevant to financial institutions seeking bankable, water-positive opportunities.

The financial sector remains on the fringes of such initiatives, if it is there at all. Although the financial sector holds the potential to facilitate and accelerate the transition towards a just, water-secure and resilient future, it remains only marginally engaged in tackling the full spectrum of water-related issues.

With multilateralism increasingly under attack, most of these initiatives – whether voluntary or mandatory – are susceptible to political fluctuations, limited oversight of implementation, and inadequate enforcement. Consequently, it is essential for the financial sector to contribute to and shape multi-stakeholder initiatives, particularly those established by intergovernmental conventions and frameworks.

There remains a significant shortage of substantive resources and political attention to match the scale, severity and urgency of the global water crisis.

CORPORATE RESPONSES

The tools available to non-financial corporates to redesign their interaction with water systems – such as water-related materiality assessments, target-setting and landscape action – continue to be deployed in a fragmented manner. These tools should be understood not as isolated response types, but as connected components of strategic organizational planning. Companies cannot rely solely on incremental operational adjustments; instead, they must fundamentally transform their business practices to effectively contribute to the transition toward water security and resilience. In practice, this means translating improved understanding of impacts, dependencies, risks and opportunities into clear objectives, time-bound action plans and accountability mechanisms that evidence how an organisation is responding and contributing to the Global Biodiversity Framework (GBF), the Paris Agreement, SDG 6, and other targets.

It is important to note that while global corporate water assessments primarily focus on large multinational companies, small and medium sized enterprises (SMEs) remain significantly underrepresented, despite forming the backbone of most economies and underpinning livelihoods worldwide. Collectively, SMEs can exert substantial pressure on water systems through their direct operations and supply chain activities—particularly in water intensive sectors—while at the same time being acutely exposed to water related risks due to their reliance on local water resources, supply chain dependencies and limited adaptive capacity (Allianz Care, 2025a, 2025b; Fatica et al., 2024).

Materiality assessments (dependencies and impact)

According to CDP's latest corporate health assessment, which utilizes reported data from 2025 and includes responses from 10,397 companies spanning multiple industries, organizations remain aware of physical risks that carry substantial financial consequences for their operations. The aggregated estimated impact of these disclosed physical risks totals US$1.47 trillion, with 26% of companies who reported exposure anticipating that such risks will materialize in the short term. This amount could be significantly higher should more companies provide comprehensive disclosure and quantification of their physical risk exposures (CDP, 2026).

Ceres's latest corporate benchmark focusing on water-intensive sectors found that commonly used tools for risk assessments include the WWF Risk Filter Suite as well as the WRI Aqueduct tool, either used separately or in combination (Perveen et al., 2025). Various case studies, available on the WWF Risk Filter Suite site, showcase how companies use these assessments to inform their water stewardship strategies (WWF Risk Filter Suite, 2025a).

Water targets

Companies that set water targets mostly focus on either efficiency or replenishment (restoration) targets, aiming to return the same volumes of water to the environment that were used in their operations, particularly in high-stress areas. Yet, most efforts remain concentrated on enhancing water-use efficiency, reducing consumption intensity, achieving absolute reductions in freshwater use and withdrawals, and water replenishment or 'water positive' initiatives. There is only limited attention being paid to water quality, pollution prevention, and long-term broader water system resilience or governance at catchment level (Perveen et al., 2025).

A small number of early adopters are beginning to set science-based targets for freshwater via the Science Based Targets Network (SBTN), offering a more standardized and verifiable approach, collecting data and models to determine targets and communicating them. However, such targets for the moment are only limited to direct and upstream operations focusing on water quantity (surface and groundwater) and water quality (nutrient pollution) that can be set for specific sites only. Companies following such target-setting processes include Kering, Holcim and GSK. These targets currently focus on water quantity, and for quality consider only nitrogen and phosphorous-based pollution. Companies who have set targets via the SBTN framework and publicly disclosed them have only done so for water quantity-based targets (SBTN, 2024).


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Ceres found that of the companies assessed, 83% have set time-bound targets for direct operations and/or supply chains, marking a slight increase since their last assessment in 2023 (Perveen et al., 2025). However, only about half of companies have contextual or risk-differentiated targets for direct operations. When considering contextual factors in water risk assessments for setting targets, the majority focus on water availability while largely overlooking the water quality considerations.

Companies can align incentives and pricing with water protection by implementing internal measures. According to CDP's latest assessment, 78% of 'water leader' companies link executive pay to water-related performance, compared to only 18% of other non-leader companies. Additionally, 32% of 'water leaders' use internal water pricing to guide efficiency, investment decisions and strategic planning, while just 4% of the remaining companies of the sample do so (CDP, 2026).

Although CDP identified an exposure of US$1.47 trillion, just 9% of the assessed companies reported physical adaptation investments in the past year (US$84.5 billion total), revealing a significant financing gap (CDP, 2026).

Companies – increasingly aware of their impacts and their clients' preferences – are expanding technology solutions and seizing opportunities. For example, L'Oréal, the France-based beauty products company, bought a startup specializing in water-saving showerheads that it rolled out to its hair salon clients. Similarly, IKEA has leaned in heavily to making water-saving fixtures a core part of its water strategy. However, there are still too few companies who are seeing water as an opportunity rather than simply as an operation's input or risk.

Collective Action

Site-level adherence to standards such as the Alliance for Water Stewardship (AWS) is rising, but large-scale uptake has not yet been achieved and broader coordination at the catchment level remains nascent. Such standards also entail expectations of proactively collaborating with other key stakeholders in a catchment to work on broader water resilience beyond companies' own operational needs. Despite growing awareness, few companies engage in landscape-level or collective action – a gap that severely limits effectiveness in shared water catchments. Such approaches are crucial to ensure broader water security and resilience, and to avoid unintended consequences from taking a site-only approach.

Collective action projects designed to address basin-level challenges are frequently not linked to specific water targets. Strategic collaboration at the basin level can deliver co-benefits for water availability, quality, access and ecosystem health, while driving large-scale impact and accountability – particularly when these efforts are aligned with corporate commitments. In the absence of such alignment, collective action projects may become ad hoc, less relevant to overarching corporate strategies, and less likely to achieve measurable water outcomes (Perveen et al., 2025). Collective and basin level approaches also offer a pragmatic entry point for SMEs, enabling shared action, pooled resources and alignment with larger actors operating in the same catchments.

The pace and direction of corporate water action are significantly shaped by financial incentives. With heavily subsidized water pricing, and often entirely free use of water for agricultural water users (who are responsible for over 70% of total abstractions), there are few incentives to focus on water. Current capital flows often support business-as-usual models that contribute to unsustainable water use and increased system vulnerability. The financial sector, through its capital allocation and risk-pricing decisions, as well as public sector water tariffs and subsidies, collectively hold a critical lever to accelerate corporate water stewardship.

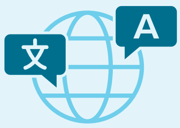
Strategic integration of water considerations into investment criteria, credit risk analysis and corporate engagement can incentivize deeper transformation. These efforts not only benefit water systems, but also enhance economic resilience, price stability and long-term value creation – making water action a core financial materiality issue.

TEXT BOX 15: TRANSMISSION CHANNELS OF NON-FINANCIAL CORPORATES' UNMANAGED WATER-RELATED RISKS TO CENTRAL BANKS

How non-financial corporates manage their water-related impacts and risk is important to CBFRs not only because of the transmission channel via the financial sector, but also because of their direct relationship to the real economy:

- **Collateral frameworks:** Collateral pledged by banks to access liquidity from the central bank may have been originally issued by non-financial corporates exposed to unmanaged water-related risks, creating indirect exposure on central bank balance sheets. The value of collateral on central bank balance sheets may be overstated and vulnerable to sudden repricing.

- **Asset purchase programmes:** Central banks' direct asset purchases and sales of assets in open market operations expose them directly to the water-related risks of the non-financial corporates subject to the programme.



- **Foreign exchange reserves or non-monetary policy portfolios:** Central banks may be directly exposed to decisions by corporates without financial system intermediaries via foreign exchange investments in corporate equity or bonds, or through their own non-monetary policy portfolios.

FINANCIAL SECTOR RESPONSES

Corporate awareness of risks and opportunities has trickled through the financial sector, including banks, insurers, and asset owners and managers. This is evident in the answers to CDP's latest water survey by financial institutions, which covers topics such as risk management, strategy, client engagement, and target setting (CDP, 2025). The findings from 2024 are drawn from 348 financial institutions participating in the water survey and demonstrate differing degrees of maturity among these organizations in the relevant areas (see Table 8).

Water-related risk assessments

Out of 348 responding financial institutions to the water survey, 39% have stated that they carry out water-related risk or opportunities assessments for their portfolios. Conversely, only 19% state to carry out water-related impact assessments of their portfolios (see Table 8). Overall, compared to the previous year there is absolute growth in numbers of financial institutions considering double materiality (CDP, 2023a).

However, given the urgency and criticality of the water crisis, as a supervisor to have a holistic picture of the possible risk build-up in the system, more financial institutions should carry out both risk and impact assessments.

Financial institutions that do assess water risks in their portfolios are increasingly measuring and evaluating potential water-related economic losses. The maximum potential financial impact due to water risks reported by participating institutions in the 2022 CDP survey reached US$6.4 billion (CDP, 2023a). Some financial institutions are also providing general assessments exploring the exposure of certain industries to water-related risks, such as the recent study by Robeco on the pharmaceutical industry (da Costa-Bulthuis & Kerai, 2026).

Examples show that some banks are responding when they find water risk materiality in their own portfolios. For example, Barclays, BNP Paribas and First Financial Holdings have all adopted policies specific to water issues as a prerequisite for business (see Text box 16).

TEXT BOX 16: EXAMPLES FROM BANKS RESPONDING TO WATER-RELATED RISKS (CDP, 2023B)

Barclays, UK: Credit/lending policy, publicly available, 100% portfolio coverage. Complying with criteria is a prerequisite for business. Covers certain energy sectors involved in water-intensive practices, including hydraulic fracturing and oil sands activities. Barclays's climate change statement includes water-related consideration as part of its client enhanced due diligence.

First Financial Holding Co, Taiwan: Credit/lending policy, 100% portfolio coverage, publicly available. Complying with criteria is a prerequisite for business. Commit to WASH in workplace, comply with all applicable water regulations, disclose water-related information publicly. Set targets for reduction in water withdrawals and water pollution.

BNP Paribas, France: Investment policy/strategy, agriculture sector policy, publicly available. Complying with water-related criteria is a prerequisite for business. Comply with all applicable water regulations, engage/support suppliers to minimize negative water impacts, monitor and reduce water withdrawals and consumption, and reduce/eliminate water pollution. If a client contravenes the policy's requirements BNP Paribas will engage in dialogue directly with the client. If the dialogue is unfruitful, BNP Paribas may decide not to pursue any new business with the client and will place existing business under review or exclusion.

Insurers are also assessing water-related risks, largely on the basis of ENCORE, WWF Water Risk Filter and/or WRI Aqueduct, and some identified water as a material issue for their investment and underwriting business, such as Achmea (2026), Tokyo Marine (2025) and Allianz (2025). The depth of such analyses varies and the translation of materiality identification into concrete policies appears nascent and still largely work-in-progress.

Engaging with investee companies or clients can be an effective risk management strategy for the financial sector alongside supporting needed transition efforts. Some notable examples exist from insurers such as Achmea, stating that as part of their thematic engagement programme they are engaging directly with 14 companies on water and deforestation risks (Achmea, 2026). Further, CDP data shows that 16% of responding financial institutions use shareholder voting rights on water-related issues (see Table 8). Some investors are collectively engaging in companies that are detrimental to water systems, such as through the Valuing Water Finance Initiative, launched by Ceres in 2022. This investor-led program, representing over US$18 trillion in assets under management, engages 71 companies (Ceres, 2025) and urges them to meet six science-based expectations aligned with the UN's 2030 Sustainable Development Goal for Water (SDG6) and the Ceres Roadmap 2030 (Ceres, 2026).

CASE STUDY

SPAIN: PROGRESS AND CHALLENGES IN INTEGRATING WATER-RELATED FINANCIAL RISK INTO THE BANKING SYSTEM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Spain is among the EU countries most structurally exposed to water stress, due to climatic conditions and its strong economic reliance on water-intensive sectors such as agriculture, agri-food, tourism and parts of the energy sector. Given that approximately one quarter of corporate lending in Spain is concentrated in sectors with high or very high water dependency (European Central Bank, 2022; funcas, 2022), this exposure makes water scarcity, water pollution, droughts, floods and ecosystem degradation materially significant financial risk drivers for banks, through impacts on borrowers' cash flows and debt-servicing capacity, collateral depreciation of irrigated land, increased insurance costs transferring risk to bank balance sheets, reduced asset values, and impacts on regional economic performance. Mediterranean river basins, which account for the bulk of water stress in Spain (PHN, Segura River Basin Authority, WRI Aqueduct), also host a large share of the agricultural and tourism activity financed by the banking sector, creating a potential source of geographic risk concentration.

THE STUDY AND METHODOLOGICAL APPROACH

A recent study conducted by the University of Alcalá de Henares, in collaboration with WWF, analyses how water-related risks are currently identified, assessed and integrated into banking practices and supervisory frameworks in Spain.

The methodology used combines a systematic and comparative review of relevant sources for the 2020–2025 period, structured around four main pillars:

- A systematic review of supervisory and institutional work (Banco de España, ECB/SSM, EBA, NGFS, AMCESFI)
- An identification of emerging practices in Spanish commercial banks, including internal risk tools, sectoral analyses and geographic exposure mapping
- An assessment of specialized water-risk tools (e.g. WRI Aqueduct, WWF Water and Biodiversity Risk Filter, ENCORE)
- A review of academic and sectoral literature on the economic and financial impacts of droughts, water scarcity and ecosystem degradation

KEY FINDINGS

The study shows that water risk is already recognized conceptually and is financially relevant to the Spanish banking system, but it is still largely treated as a generic physical climate risk, rather than as a distinct risk driver with specific transmission channels. Banco de España has shown methodological leadership within the European context through pioneering empirical analyses linking drought indices to bank credit dynamics and regional economic impacts. The institution has undertaken analyses on topics such as droughts, desertification and local environmental degradation linked to agricultural pollution, which provide concrete insights on transmission channels between water stress and financial variables.

Its 2024–2025 work provides methodological inputs that could inform the future development of water-specific stress scenarios that consider basin-level risk assessment. However, these analyses have been carried out on an ad-hoc basis and still need to be systematically integrated into a comprehensive prudential framework, including dedicated water-stress-testing exercises.

Within Spain's dual supervisory architecture, Banco de España combines direct supervision of less significant institutions with methodological pilot development, while the ECB's Single Supervisory Mechanism (SSM) supervises significant banks. AMCESFI (Spain's macroprudential authority) provides systemic risk assessment from a cross-sectoral perspective, evaluating how water risks interact with broader financial stability concerns.

Banking practices remain heterogeneous in their treatment of water-related risks. Some institutions have incorporated tools such as WRI Aqueduct, WWF's Water Risk Filter, or ENCORE into climate risk management frameworks, while others are in the process of identifying risks. Some have developed internal tools to identify exposure or use sectoral screening processes. However, their consistent translation into probability of default (PD), loss given default (LGD), collateral valuation or credit pricing remains limited and mostly exploratory. This variation in methodological approaches may create opportunities for competitive differentiation, but also potential systemic vulnerabilities, highlighting the importance of supervisory convergence. It is also identified the need for Pillar 2 capital requirements and collateral haircut mechanisms can provide material financial incentives beyond voluntary ESG disclosure, creating potential regulatory leverage for supervisory action on water-related risks.

KEY TAKEAWAYS FOR BANKS

- Water risk becomes financially material at sufficient geographic granularity, particularly at the basin or local level.
- Portfolio concentration in water-intensive sectors or flood-risk-prone areas is a key driver of materiality, with households and tourism (in specific contexts), and agriculture and agri-food showing the clearest transmission channels through direct crop losses reducing farm income and debt-servicing capacity, collateral depreciation of irrigated land, increased insurance costs, and regional GDP contractions affecting multiple portfolios simultaneously.
- Qualitative approaches are a first step, often preceding full quantitative adjustments through expert judgement and sectoral heatmaps.
- Credit origination (for economic activities and households) can offer an effective entry point for embedding water-risk considerations into banking processes.
- Client engagement is a critical risk-management lever, enabling mitigation and transition even in the absence of full quantification.

KEY TAKEAWAYS FOR SUPERVISORS

- Ad-hoc empirical analysis can be highly informative and serve as an initial learning laboratory.
- Water-specific risk drivers should be distinguished from broader physical climate risks, with dedicated assessment of hydrological transmission channels.
- Supervisory expectations can provide an effective entry point, which requires guidelines and methodologies to operationalize analysis and indicators.
- Scenario design needs to reflect hydrological realities, including basin-level stress and non-linear impacts (thresholds beyond which agricultural viability collapses).
- Cross-institutional coordination between Banco de España, ECB/SSM, environmental ministries (MITECO) and river basin authorities to establish common sources can improve the availability, consistency and analytical relevance of hydrological and economic data for supervisory purposes.

KEY INSIGHT

The study highlights that, while methodological challenges remain, existing data and tools already allow for meaningful progress in the analysis of water-related financial risk. Tools like the WWF Water Risk Filter and WRI Aqueduct provide baseline exposure mapping, but critical gaps persist: limited integration of physical and transition risks; insufficient spatiotemporal granularity for individual credit decisions; and lack of standardized conversion protocols from environmental indicators (drought indices, basin stress levels) to financial risk parameters (PD, LGD adjustments). These gaps represent areas requiring urgent methodological development, but they should not be treated as obstacles to immediate preventive action with currently available tools.

The Spanish experience demonstrates that water risk is not a future concern requiring perfect methodologies before action, but a present financial reality requiring immediate measures with currently available – albeit imperfect – analytical frameworks. Financially material impacts can be identified even in the absence of fully standardized methodologies, with the main challenge being the systematic translation of existing empirical evidence of water risks into financial risks with comparable practices across institutions. Parallel progress on methodological refinement and preventive risk management is both necessary and feasible.

For further information see Gómez et al. (2026)

Water-related opportunities & target setting

Besides addressing water-related risks, financial institutions are starting to seize opportunities. For instance, the latest CDP water survey shows that 22% of responding financial institutions have existing products and services that support clients mitigate water insecurity (see Table 8). In this direction, some financial institutions have published reports on the criticality and possibilities of investing in water (see Impax Asset Management (2026)) or report on supporting innovation in furthering water resilience (BNP Paribas, 2026). Concrete examples include BBVA's launch of a water footprint loan aimed at supporting companies reduce their water footprint (BBVA, 2022). For insurers, SwissRe Corporate launched FLOW, a parametric insurance product for companies in Europe affected by too high or too low river water levels (SwissRe, 2019). AXA in collaboration with other actors, has launched investment and impact funds with the aim of accelerating the transition to regenerative agriculture, and protecting and restoring critical ecosystems including forests and peatlands (AXA, 2024). Allianz has established a water hub to support SMEs with knowledge-sharing and expertise in their journey to becoming water-resilient and supporting the transition to water sustainability (Allianz, 2026).

Beyond individual product innovation, setting portfolio level targets remains an extremely nascent practice, evident by only a fraction of reporting financial institutions to the CDP water survey reporting on these (see Table 8). Possible examples include Bancolombia's target of COP 1 trillion by 2030, equivalent to roughly US$ 280 million in 2026, for 'blue finance' including for the Panama Canal watershed management (Bancolombia, 2023) and Banco Bradesco's commitment of BRL250 billion, equivalent to roughly current US$ 50 billion, to sustainable projects including water initiatives (Bradesco, 2024). Water target-setting approaches that cover the entirety of a financial institution's activities remain in their early stages. Unlike deforestation commitments, few institutions have established specific, quantitative and time-bound targets for improving water security across their portfolios. Additionally, many of the developed frameworks for target setting, e.g. SBTN, are not designed for application by financial institutions.Ultimately, these financing commitments, initiatives and product innovation represent progress, they remain limited in scope compared to the scale of financial system-wide water risk exposure.

While recent efforts show that financial institutions are increasingly assessing water-related risks and opportunities, setting targets for selected portfolios, and engaging on the subject with clients, it is still treated as a fringe topic. Fragmented assessments, limited impact measurement, underreporting and inadequate impact mitigation are creating a dangerous accumulation of water-related systemic risk within the financial system. Addressing these systemic vulnerabilities requires coordinated action to transform water risk management from being a voluntary practice into a core component of micropudential and macroprudential frameworks.


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Table 8: *Overview of CDP water survey responses for financial institutions in 2024 out of total 348 disclosing financial institutions of the water survey. Source: authors on the basis of CDP (2025)*

AREA	SUB-AREA	NUMBER OF FIS (OR %)	BREAK DOWN BY BUSINESS TYPE[12]			
RISK AND OPPORTUNITIES	Assess portfolio's exposure to water-related risks and/or opportunities	135 (or 39%)	Number (or share in %) of Banks	Number (or share in %) Insurers (underwriting)	Number (or share in %) Asset managers	Number (or share in %) Asset owners
	Consider water-related information about clients/ investees as part of due diligence/risk assessment	139 (or 40%)	87	14	64	47
	Portfolio impact on water	65 (or 19%)	87	10	58	41
BUSINESS STRATEGY	Existing products and services enable clients to mitigate water insecurity	75 (or 22%)	34	4	29	17
	Policy framework for portfolio activities includes water-related requirements that clients / investees need to meet	101 (or 29%)				
	Public availability of policy framework	See breakdown by business type	(Public: 84% Not public: 16%)	(Public: 100%)	(Public: 97% Not public: 3%)	(Public: 86% Not public: 14%)
ENGAGEMENT	Exercise voting rights as a shareholder on water-related issues	56 (or 16%)				
TARGETS	Organizations setting targets for water-secure lending, investing and/or insuring	For water-secure investments: 1 (or 0.3%) For water-secure lending: 10 (or 2.8%) Other: 14 (or 4%)				

FINANCIAL REGULATORY AND CENTRAL BANK RESPONSES

Despite their important role, financial regulatory frameworks still do not adequately address water-related risks within the financial system. This section examines the extent to which central banks, financial supervisors and financial regulators address water-related risks, highlighting significant progress, challenges and opportunities for more detailed and actionable frameworks. The insights are gained on the basis of results from the WWF Sustainable Financial Regulation (SUSREG) Tracker 2025.[13]

Overview

The SUSREG 2025 assessment reveals a significant gap in regulatory frameworks concerning water-related risks. In both banking and insurance supervision, on both macroprudential and microprudential levels, no supervisory authority achieved a full score in addressing water-related risks. This indicates that while supervisors acknowledge freshwater risks in numerous regulatory frameworks (hence receiving a partial score), they do not provide detailed expectations or specific requirements for financial institutions to effectively manage these risks.

12 The numbers do not correspond exactly to the total number of financial institutions, as an institution may have responded for multiple categories of business due to having more than one business line.

13 The Sustainable Financial Regulation and Central Bank Activities (SUSREG) is an annual report to assess how central banks, financial supervisors and regulators integrate climate, broader environmental and social considerations in their practices.

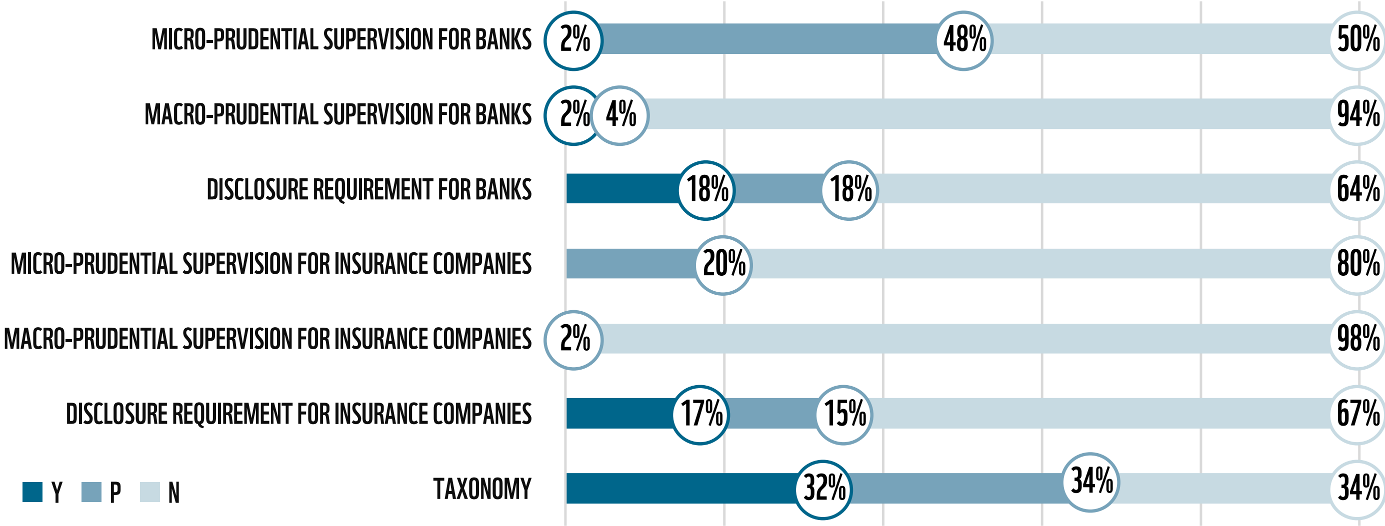
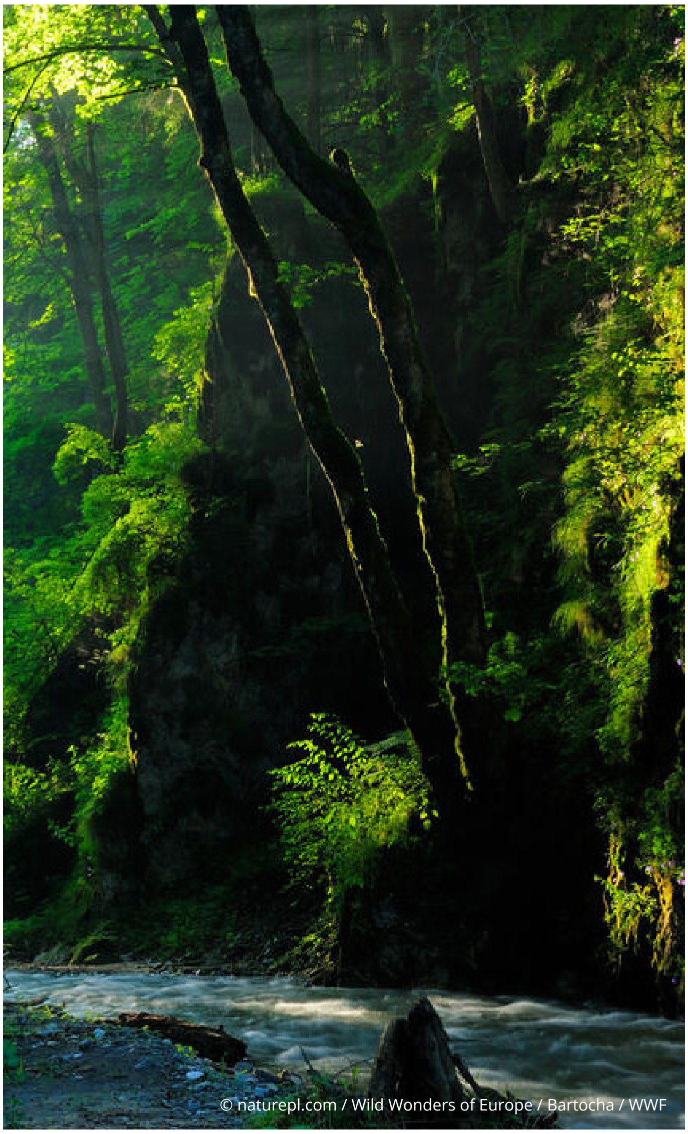


Figure 17: *Average achievement of 50 countries on select water indicators on SUSREG thematic assessment*

Microprudential & macroprudential supervision

Freshwater is increasingly recognized across jurisdictions' supervisory frameworks. In most cases, it is treated as an illustrative example of broader environmental risks and is rarely accompanied by detailed requirements. One of the few concrete microprudential expectations is found in Bangladesh's Guidelines on Environmental & Social Risk Management for Banks and Financial Institutions, which require compliance with an environmental and social due diligence checklist for water use and conservation, generating a risk rating that can trigger mitigating actions. Under these guidelines, banks must apply mandatory environmental and social due diligence screening when lending to activities linked to environmentally harmful practices, including groundwater contamination and water pollution. The guidance specifies water-related risk categories such as water use and conservation, wastewater and water quality, and embeds water criteria into product governance through sustainable finance eligibility requirements, including water management, water use efficiency, and effluent treatment management. This moves beyond high-level encouragement and integrates freshwater into enforceable risk management and lending processes.

At the macroprudential level, some central banks have assessed exposures to water-related risks, such as the Central Bank of Hungary (MNB) and Mexico's central bank (Banxico). In Hungary's case, the MNB in partnership with the OECD assessed nature-related physical risks linked to dependence on surface water and groundwater and connected these dependencies to corporate lending exposures, estimating that EUR24.4 billion (43%) and EUR23.3 billion (41%) of corporate lending are respectively exposed. The assessment also identified key vulnerable sectors, including agriculture, forestry and fishing, manufacturing, and real estate activities, and extended the analysis to transition risks affecting water-use and water-polluting sectors.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TEXT BOX 17: DNB GUIDE TO MANAGING CLIMATE- AND NATURE-RELATED RISKS

In 2025, De Nederlandsche Bank updated its cross-sector guide to managing climate- and nature-related risks, adding explicit coverage of nature, including water risks (De Nederlandsche Bank, 2025). Firms are encouraged to treat water scarcity, extreme precipitation and groundwater level change as material risk drivers and integrate them across strategy, governance, risk management and disclosures.

The Guide prompts scenario thinking (e.g. tightening water-use regulation); encourages assessment of impacts on assets, clients and collateral; and highlights good practice where institutions set portfolio-level targets, such as achieving a water-neutral portfolio by 2030. Progress can be tracked using KPIs, including water consumption in scarcity areas per €1 million invested, and linked to stewardship, exclusions and financing levers to reduce absolute withdrawals in high-stress basins.

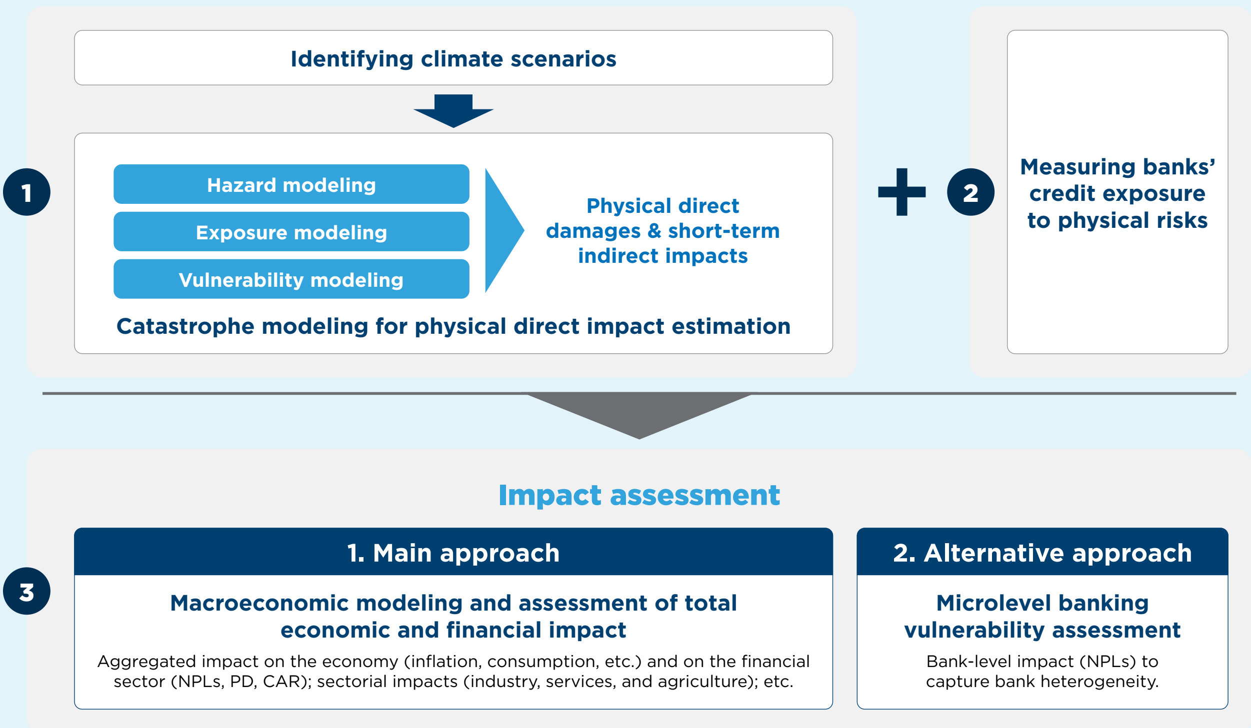
While these assessments represent meaningful progress, most studies have evaluated water in the context of climate-related hazards (floods and droughts) without due consideration of other drivers, focusing mostly on quantity-related freshwater metrics rather than quality and broader ecosystem health, and only tangentially considering the endogenous role of the financial system. However, there are some noteworthy best practices in the explored water-related risks, and in the way in which CBFRs are teaming up with freshwater specialists (see Text box 18).

TEXT BOX 18: EXAMPLE OF MACROPRUDENTIAL RISK ASSESSMENTS

MOROCCO: DOUBLE TROUBLE? ASSESSING CLIMATE PHYSICAL AND TRANSITION RISK FOR THE MOROCCAN BANKING SECTOR (WORLD BANK, 2024)

This World Bank-led study explores the key transmission channels of physical and transition-related risk for Morocco's banking sector, and identifies the banking sector's exposure to geographies and sectors that are susceptible to the effects of climate change (see methodological building blocks below).

Overview of the approach for assessing climate physical risks for the financial sector

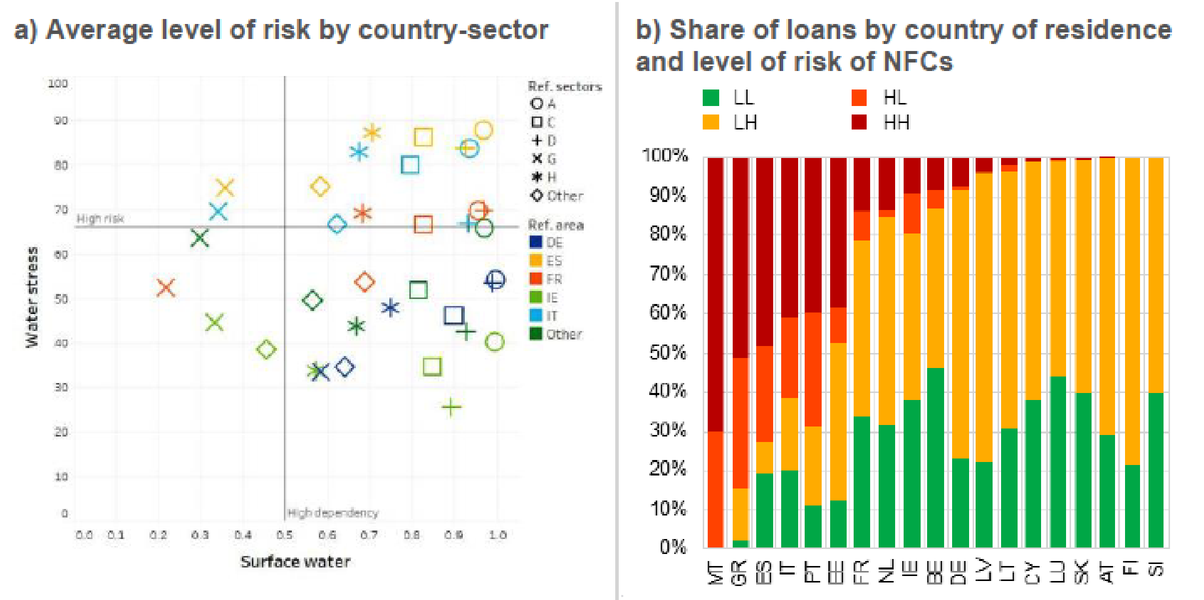


The study finds that the credit portfolios of Morocco's banks are geographically concentrated in a few regions, with some banks also showcasing high sectorial concentration. Around one-third of sectoral banking lending is exposed to high physical risk, which accounts for drought and flood risk combined. Some banks have a high credit concentration in the agriculture sector, which is directly susceptible to drought. However, banks that are exposed to sectors that operate downstream of the agricultural value chain, such as food processing and tourism, may be adversely affected too. Catastrophe modelling shows that climate change will likely exacerbate the economic and financial impact of droughts and floods, for both frequent events and more extreme rare events. The study highlights the fact that climate-related risk management by banks remains a niche area despite the growing evidence of the materiality of the issue. Since this study is rooted in identifying climate-related risks it does not account for other drivers that may exacerbate the hazard (e.g. water resource overexploitation), or conversely how freshwater ecosystems and their services may attenuate potential risks (e.g. healthy floodplains reducing flood risk).

EUROSYSTEM: THE IMPACT OF THE EURO AREA ECONOMY AND BANKS ON BIODIVERSITY (CEGLAR ET AL., 2023)

The European Central Bank (ECB) has advanced its understanding of nature–climate interactions by assessing water dependency alongside climate hazards such as droughts, and flood and storm regulation in relation to flood risks. This approach goes beyond simple ecosystem service dependency analysis to estimate the percentage of outstanding loans potentially facing compounded nature–climate-related risks. In this study, the ECB found that non-financial corporates in susceptible sectors operating in the Mediterranean region experience high risks on both climate and nature fronts, with high dependency on water as well as on areas at higher risk of droughts. By extension the financial institutions with exposure to these non-financial corporates, also based in Mediterranean countries, are also more exposed to the consequences of these risks.

Physical risk from climate and nature space – example of drought risk (water stress) and dependency on surface water provision



Sources: AnaCredit, EXIOBASE, Orbis, iBACH, Alogoskoufis et al. (2021).
Notes: Panel A shows the average level of water stress risk for 2031-2040 (y-axis) and the average dependency score on surface water (x-axis) by country-sector (NACE level), with the following level of granularity: DE, ES, FR, IE, IT and Other for the reference areas; A (Agriculture, Forestry and Fishing), C (Manufacturing), D (Electricity supply), G (Wholesale and retail trade), H (Transport and storage) and Other for the reference sectors. The water stress score measures the projected changes in drought-like patterns over time. Panel B illustrates, for each euro area country, the share of loans to euro area NFCs based on their combined climate and nature risk levels: Low climate risk – Low nature risk (LL), Low climate risk – High nature risk (LH), High climate risk – Low nature risk (HL), and High climate risk – High nature risk (HH).

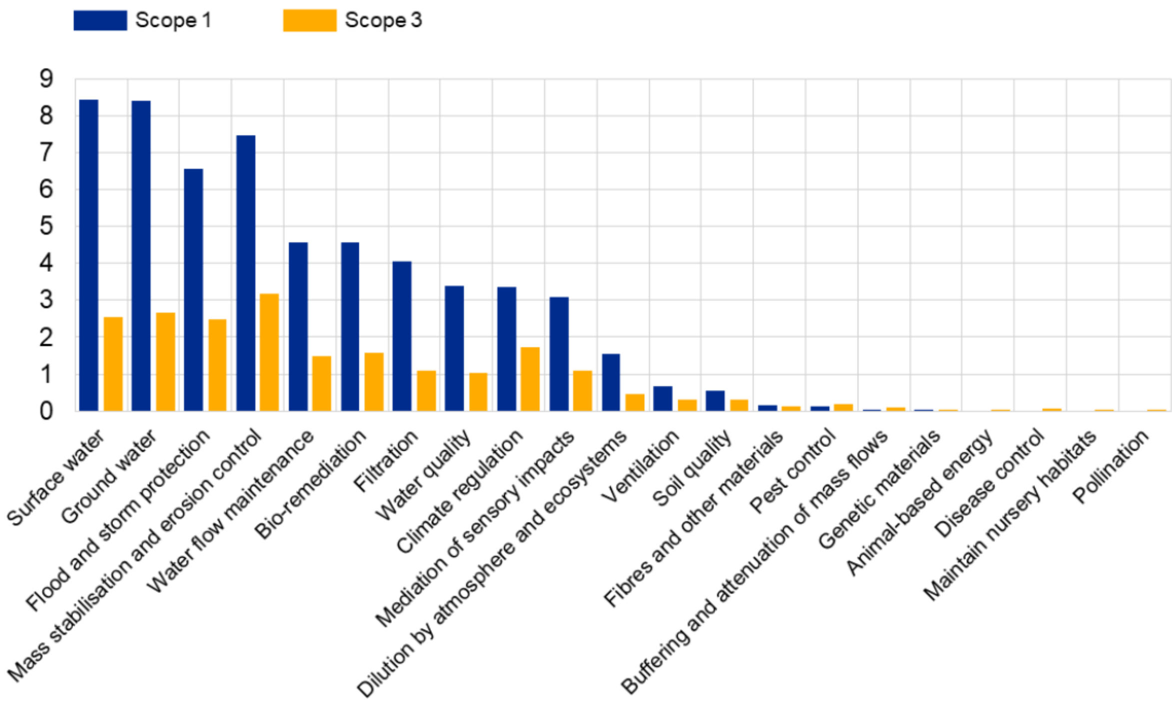
NATURE AT RISK: IMPLICATIONS FOR THE EURO AREA (CEGLAR, JWAIDEH, ET AL., 2025)

An analysis conducted by ECB found that "too much water, too little water or polluted water pose the most urgent risk to economic output in the euro area from a value-added perspective", with surface water scarcity alone potentially putting up to 24% of euro area economic output at risk. Using AnaCredit data covering about €4.4 trillion of bank loans, 19% are exposed to surface water scarcity, rising to 22% when also considering groundwater scarcity, with real estate, manufacturing and trade the most affected sectors.

The same analysis also examines endogenous risk, assessing the overlap between ecosystem-service dependency and ecosystem degradation within bank lending portfolios. Using ENCORE materiality ratings, the analysis calculated the share of loan value that both depends on and impacts the same ecosystem service. Scope 1 captured risks arising from borrowers' direct operations, while Scope 3 extended the assessment to upstream supply chains using EXIOBASE input-output data. This approach made it possible to quantify how banks' own-financed activities increase their exposure to nature-related risks, both domestically and through global value chains.

Endogenous-risk exposure of euro area banks from their own direct operations and from supply chains

(percentages)



Source: Endogenous-risk score data layers, AnaCredit database, EXIOBASE3 input–output data, and the ENCORE (Exploring Natural Capital Opportunities, Risks and Exposures) knowledge base.
Notes: Scope 1 (direct operations) relates to exposures linked to corporate assets and loan portfolios that rely directly on local ecosystem services, while Scope 3 (supply chains) captures indirect monetary flows through global value chains. The endogenous-risk score was based on the framework developed in O'Donnell et al. (2025).The endogenous-risk exposure metric measured the share of loan value where both a borrower's dependence on a given ecosystem service and the degradation of that same service financed by the portfolio coincide. The ecosystem services shown are those used in the ENCORE knowledge base.

The results show that water-related services are the dominant endogenous-risk transmission channel in euro area bank portfolios. Around 8% of aggregate loan value was exposed to surface-water dependency risk in counterparties' direct operations, amplified by over-abstraction and pollution financed through those portfolios. Manufacturing accounted for the largest share of endogenous risk in both direct operations and upstream supply chains, reflecting its high dependence on process water and its significant impacts through abstractions and effluents. The findings reveal material feedback loops between ecosystem degradation and financial risk, and highlight water-flow maintenance, water quality and filtration as systemically important services where targeted mitigation could reduce future portfolio vulnerability (Ceglar, Jwaideh, et al., 2025).

Best practices in research governance

Various formats of interdisciplinary research collaborations have emerged that are particularly necessary in meaningfully understanding and acting upon potential water-related risks. Central bank researchers are teaming up with other research bodies with expertise in ecology and hydrology. In certain instances, these projects involve or are also coordinated by international organizations that can provide technical assistance and support in translating the language from nature science to economics, and vice versa. Finally, government authorities, which hold deep knowledge about national datasets, are also often involved. Notable examples include the Green Finance Institute study which explores nature-related risks to the UK economy across different multidisciplinary work packages (Ranger et al., 2024). These include designing scenarios related to antimicrobial resistance and water scarcity. Another recent example is the UNDP/Biofin study, conducted in collaboration with the Zambian central bank, which examined nature-related risks to Zambia's financial system and identified water-related services as the most critical (UNDP, 2025).

Although substantial research has been conducted on the origins and potential manifestation of systemic water-related risks, central banks and financial supervisory authorities have not, to the best of the authors' knowledge, modified macroprudential policies in response. This is despite consistent evidence highlighting the macro-critical significance of water and the corresponding systemic risks involved.

Disclosure frameworks & taxonomies

Disclosure frameworks and taxonomies are more advanced, but implementation remains uneven and partial. The European Sustainability Reporting Standards (ESRS) E3 require water-specific reporting on policies, actions and resources, targets, water consumption and anticipated financial effects covering both impacts and dependencies. China's sustainability disclosure standards require enterprises to disclose water resource use and management plans, and South Africa's Johannesburg Stock Exchange Sustainability Disclosure Guidance encourages water-related metrics where material. Taxonomies increasingly incorporate freshwater ecosystems in their objectives and technical screening criteria, including the EU Taxonomy and the Singapore-Asia Taxonomy, though many green taxonomies remain focused primarily on climate mitigation and adaptation.

Overall, binding water-related requirements in financial supervision and regulation remain the exception rather than the rule. This underscores the need for clearer guidance on identifying and managing water-related risks in a spatially explicit and forward-looking manner, particularly in high-water-stress catchments (see De Nederlandsche Bank (2025)).

Central banks' own portfolio impact disclosures

Central banks are encouraged to lead by example by establishing clear benchmarks and embedding water-related concerns in their decision-making processes, signaling their commitment to the market. In this regard, water issues are increasingly being disclosed by central banks as part of the environmental impacts which are associated with their investment portfolios. In May 2025, Banca d'Italia published its Annual Report on Sustainable Investments which demonstrates the bank's integration of ESG considerations into its investment practices. The report provides insights into specific environmental metrics such as the Weighted Average Water Intensity. Banque de France also took a pioneering step by disclosing biodiversity impacts in its equity and bond portfolios using the Corporate Biodiversity Footprint method. This method quantifies biodiversity impacts in multiple areas, including water pollution, to provide valuable insights into the freshwater-related implications of Banque de France's investment activities.

While progress has been made in recognizing and addressing water-related risks, significant challenges remain. Central bank portfolio disclosures on water remain fragmented: water appears as one element within broader ESG or biodiversity metrics rather than as a standalone risk category with dedicated targets or thresholds. A concrete step forward would be for central banks to adopt water-specific KPIs in their portfolio reporting (see Chapter 4), creating a measurable baseline against which progress can be tracked.

Monetary policy

Although the exact mandates of central banks differ, one of their common goals is to ensure price stability and influence money flows in the economy via monetary policy. Central banks use different tools to influence relative prices, such as conducting foreign exchange investments, setting baseline interest rates, and short-term and long-term targeted refinancing lines and their collateral frameworks that govern the rules in determining loan conditions for commercial banks.

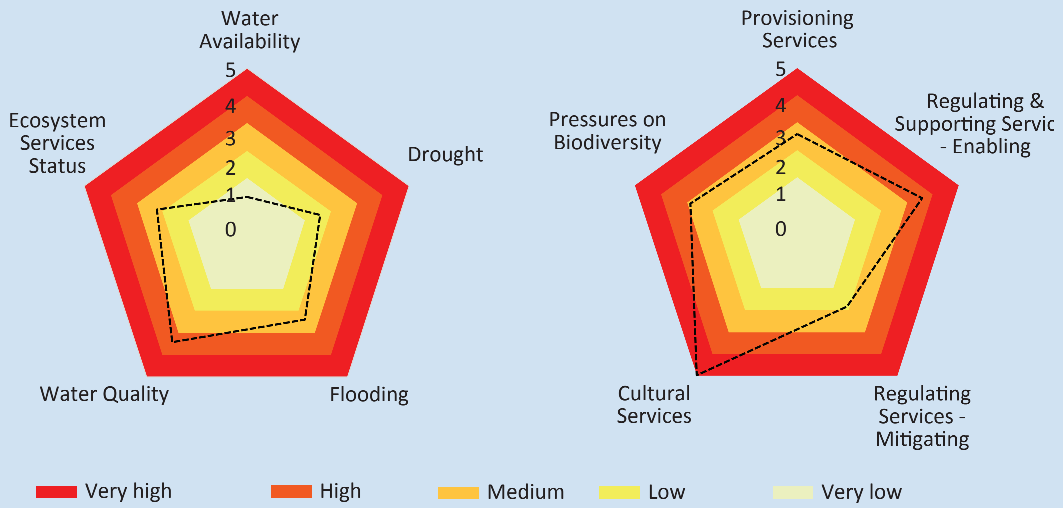
Monetary policy has only recently begun to address the broader set of sustainability-related concerns. Where there are actions, these are often with respect to climate-related factors only. In this respect there are important overlaps with water.

Monetary policy portfolios

TEXT BOX 19: USING THE WWF RISK FILTER SUITE TO ASSESS WATER-RELATED RISKS FOR MONETARY POLICY PORTFOLIOS

The Central Bank of Hungary (Magyar Nemzeti Bank/ MNB) applied nature-risk screening tools to assess its monetary policy portfolios and identify material exposures (Magyar Nemzeti Bank, 2025). Using the WWF Risk Filter Suite, the MNB analysed country-level biodiversity and water-related risks within its portfolio. The Biodiversity Risk Filter provided a high-level assessment of biodiversity loss, while the Water Risk Filter enabled deeper analysis of risks such as water scarcity and water quality.

Portfolio exposure by risk category



Source: WWF Biodiversity Risk Filter, MNB calculations   *Source: WWF Water Risk Filter, MNB calculation*

For portfolios held for monetary policy purposes, Hungary's analysis highlighted specific risk channels rather than broad systemic fragility. WWF Risk Filter results indicated water-related risks primarily in water quality and flood categories, while broader risks from ecosystem decline appeared mainly under cultural services, reflecting dependencies in sectors such as tourism, real estate and education. These findings suggest that although aggregate sovereign risk levels were not acute, certain ecosystem-service dependencies and water-related pressures could affect asset values and sectoral performance, underscoring the relevance of nature-risk screening within monetary operations. The MNB example provides a replicable template for other central banks beginning to integrate nature-related and water-specific risk screening into their monetary policy portfolio disclosure frameworks, an area where practice remains at an early stage globally.

Collateral frameworks

Studies show that events such as flooding are devaluing asset values, which can carry adverse implications for banks holding such assets as collateral for accessing central bank lending (Fatica, 2025). A few central banks are recognizing this and have adopted measures to account for it in the collateral framework. For example, the Bank of England has integrated physical climate risks, in particular flood risk, into its collateral framework for residential mortgage collateral under the Sterling Monetary Framework (Bank of England, 2024). Using flood-risk projections from a natural catastrophe risk modelling firm, the bank estimates potential increases in insurance premia and applies additional discounts to property prices in high-flood-risk regions, incorporating these effects into its existing haircut models. As a result, mortgage pools with a larger share of properties in flood-prone areas tend to face higher haircuts, helping protect the bank against potential financial losses arising from the physical impacts of flooding (Bank of England, 2024).

Therefore, central banks – much as with the climate factor introduced by the ECB, or the Bank of England's flood risk integration – could start calibrating for water-related risks in eligibility and haircut regimes. Transition risk calibration (applying higher haircuts to assets exposed to tightening water-use or water pollution regulation) offers a complementary risk management lever. Separately, preferential eligibility or haircut treatments for water-resilient assets or issuers with credible water management plans could serve an incentive function, steering bank balance sheets toward reduced water-related exposure over time. Overall, it can be argued that the relative influence on the real economy of central bank lending depends on whether the central bank is pursuing an expansionary or contractionary monetary policy. However, regardless of economic conditions, central bank policies and financial market lending conditions are an important signal to all market participants.

Refinancing lines

A growing number of central banks are experimenting with targeted refinancing facilities to encourage financial institutions to expand lending aligned with sustainability objectives. So far, these instruments have focused largely on climate mitigation and transition finance. For example, the Bank of Japan's Funds-Supplying Operations to Support Financing for Climate Change Responses, the People's Bank of China's targeted relending programmes, and Bank Negara Malaysia's Low Carbon Transition Facility.

Similar approaches could be adapted to promote investments that strengthen sustainable water management at the catchment level. Water-adjusted targeted refinancing operations could vary in their eligibility criteria, maturity structure, pricing incentives, reporting requirements and verification mechanisms, allowing calibration to domestic market conditions while ensuring alignment with sustainable water management outcomes. Such flexibility enables central banks to tailor water-related refinancing instruments to policy objectives while remaining within existing monetary policy frameworks.

KEY MESSAGES TO CENTRAL BANKS, FINANCIAL SUPERVISORS AND REGULATORS

01 THERE ARE INTERNATIONAL RESPONSES AIMED AT ADDRESSING THE WATER CRISIS,

but they are largely voluntary with little involvement of mainstream finance. The voluntary nature of existing international responses, in the context increasing uncertainty and volatility, strengthens the case for further regulatory intervention.

02 NON-FINANCIAL COMPANIES ARE INCREASINGLY EXPERIENCING WATER-RELATED RISKS.

Production losses, supply chain disruptions and pollution impacts are being reported, yet corporate responses remain fragmented and uneven across sectors. Water-related risks are already materializing in the real economy, creating financial exposure that CBFRs cannot ignore.

03 SOME COMPANIES ARE BEGINNING TO SET FRESHWATER TARGETS.

Early adopters are piloting science-based targets through the SBTN process and using standards such as AWS, though targets are mostly limited to water quantity and direct operations. CBFRs can accelerate progress by requiring financial institutions to assess and disclose the water target credibility of their borrowers and investees, creating demand for more comprehensive corporate action.

04 CATCHMENT-LEVEL AND COLLECTIVE ACTION BY CORPORATES REMAIN LIMITED.

While site-level water management is expanding, few companies engage suppliers or collaborate with other basin stakeholders, reducing effectiveness in sustainably managing shared water systems. CBFRs can reinforce catchment-level thinking by requiring financial institutions to assess geographic concentration of water-related exposures at the basin or catchment level rather than only at the asset or sector level.

05 PORTFOLIO-LEVEL IDENTIFICATION OF WATER-RELATED RISKS AMONG FINANCIAL INSTITUTIONS IS EMERGING BUT NOT YET WIDESPREAD.

Some financial institutions are beginning to incorporate water data into underwriting risk or credit risk analysis, lending policies and/or investment strategies. Portfolio-level water risk integration should be included in supervisory expectations, accelerated through disclosure requirements, supervisory guidance, and scenario analysis frameworks that explicitly address water.

06 IMPACT ASSESSMENT BY FINANCIAL INSTITUTIONS IS FAR LESS PROMINENT THAN FINANCIAL MATERIALITY RISK ASSESSMENTS.

Measurement of double materiality remains limited, leaving gaps in understanding of how financial portfolios contribute to water insecurity. CBFRs should require double materiality assessment as part of water-related risk disclosure frameworks.

07 CBFRS HAVE STARTED TO RECOGNIZE WATER-RELATED RISKS, BUT MOSTLY WITHIN BROADER CLIMATE AND ENVIRONMENTAL RISK CATEGORIES.

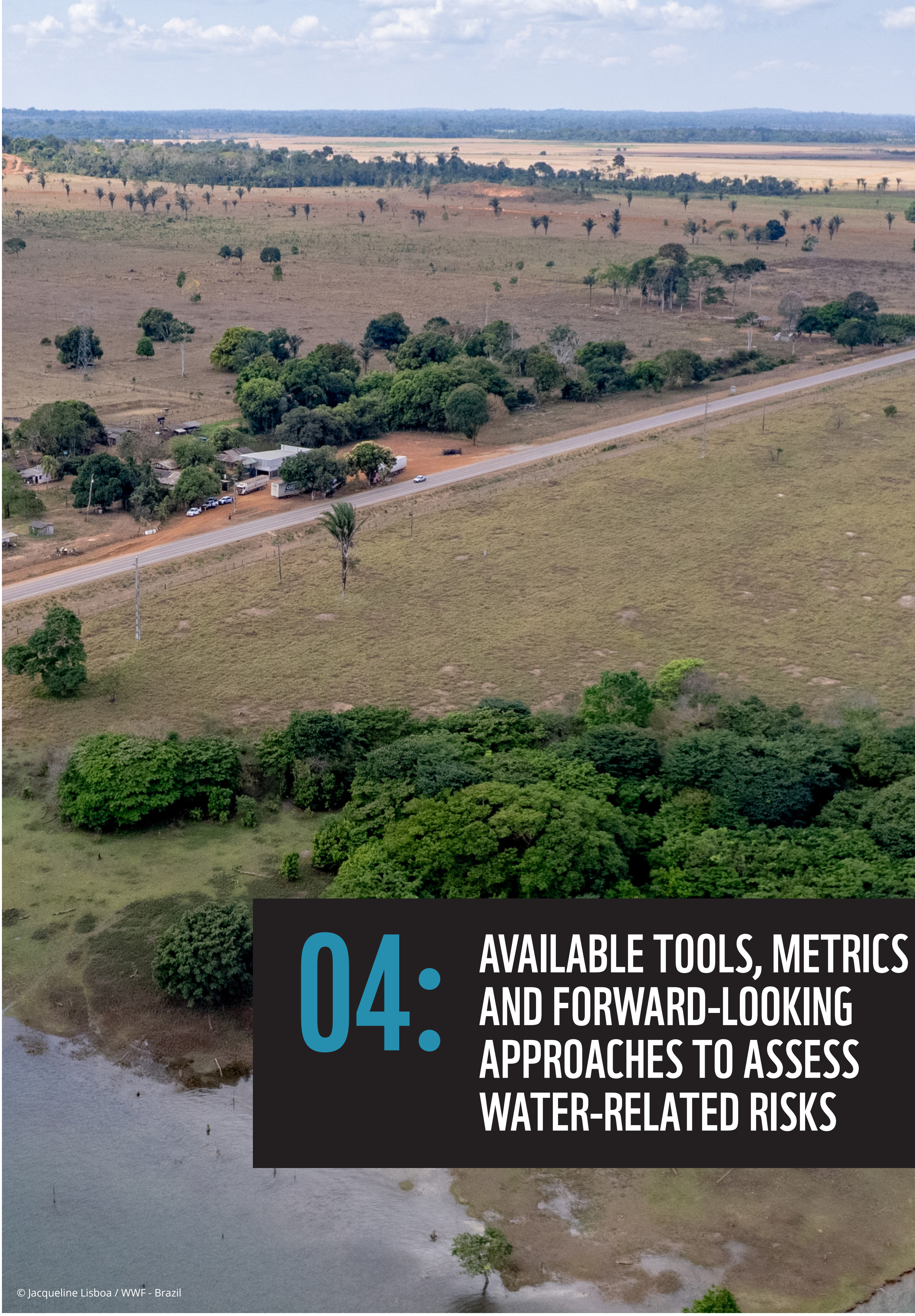
Water is often addressed under climate or environmental risks, with limited specific guidance for financial institutions on how to address water systems as a whole. CBFRs should develop water-specific expectations rather than relying on climate frameworks to capture water risk by default.

08 INITIAL REGULATORY AND SUPERVISORY INITIATIVES PROVIDE USEFUL ENTRY POINTS THAT CAN BE FURTHER DEVELOPED AND TAKEN AS INSPIRATION FOR FURTHER MEASURES.

Examples include EU CSRD/ESRS disclosure requirements, Bangladesh's ESRM guidelines and early macroprudential studies by the ECB, Morocco and the Netherlands.

09 CENTRAL BANKS ARE ONLY BEGINNING TO EXTEND WATER-RISK INTEGRATION INTO THEIR MONETARY POLICY OPERATIONS.

Collateral frameworks can be progressively calibrated to account for water-related risks (starting where modelling is most mature, as the Bank of England has done for flood risk) and extended to broader water risks as methodologies develop. Targeted refinancing operations offer a complementary lever, directing preferential financing toward water-resilient investments in high-water-stress catchments.



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04: AVAILABLE TOOLS, METRICS AND FORWARD-LOOKING APPROACHES TO ASSESS WATER-RELATED RISKS

SECTION 04:

AVAILABLE TOOLS, METRICS AND FORWARD-LOOKING APPROACHES TO ASSESS WATER-RELATED RISKS

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Water is already a component of many existing climate and nature frameworks, meaning CBFRs do not need to start from scratch in better understanding how the financial sector's impact and dependencies on water systems translates into financial risks. Freshwater systems and their associated ecosystem functions, including flood protection, groundwater and surface water, are consistently identified as highly material in assessments of nature-related risks (Visentin, 2026). Hence, CBFRs can build on these existing frameworks rather than having to develop entirely new methodologies.

However, water-related risks are often treated in fragmented ways across these frameworks – and the tools, depending on the scope of the research, have real limitations particularly around data access, spatial resolution, and integration into financial risk processes. Addressing these risks in a more integrated manner remains a challenge, but emerging efforts to align climate–nature approaches offer a window of opportunity for CBFRs to assess water-related risks and dependencies more holistically. When it is done mindfully, building on existing methodologies can yield valuable insights into exposures both at company and systemic level.

Current metrics and tools for assessing water-related risks have several limitations that constrain their use by CBFRs. For example, many rely on coarse global models with limited local validation, while critical data (such as groundwater levels, water quality and abstraction rates) are often missing or proprietary (Davies & Martini, 2023). While mapping assets to catchments is in principle possible, challenges remain: data access, spatial resolution, and integration in financial risk management processes. CBFRs and financial institutions often do not have a comprehensive overview of their counterparts' asset-level locations, and many water datasets are only available at broad basin level and are often presented in non-interoperable formats.

Despite these current limitations, CBFRs do not need to wait for perfect data or models to begin addressing water-related risks. Where data gaps exist, CBFRs can take practical steps to address them. This includes engaging national hydrological and environmental agencies to access basin-level monitoring data; drawing on open-source satellite data to track water availability and land-use changes; requiring water-related disclosures from supervised institutions to improve portfolio-level visibility; and advocating for greater disclosure regulation for the real economy to strengthen data quality and comparability across sectors. These incremental steps can help build the evidence base needed for more robust risk assessment over time.

WHERE TO BEGIN?

CBFRs do not need perfect data and methods to start the process; there are many possible entry points depending on institutional capacity, academic landscape and expertise, the economy, supply chain composition, and national water priorities. Examples of different starting points include:

- Assessing water dependencies in own-account investment portfolios. De Nederlandsche Bank's TNFD pilot (Tiems et al., 2024) focused on the electric utilities sector and identified significant dependencies on groundwater and surface water.
- Screening which economic sectors depend on or impact freshwater. Central banks in the Netherlands (van Toor et al., 2020), France (Svartzman et al., 2021), Brazil (Calice et al., 2022), Malaysia (Bank Negara Malaysia & World Bank, 2022), and many other countries have conducted such assessments using the ENCORE tool.
- Analysing flood risk to mortgage portfolios, as demonstrated by De Nederlandsche Bank (Caloia & Jansen, 2021).

The key is to select an entry point that aligns with existing supervisory functions, available data infrastructure, and the specific water challenges facing the jurisdiction – whether drought exposure in agricultural regions, flood risk in coastal economies, or water stress in industrial and energy sectors.

The NGFS principle-based risk assessment framework for nature-related financial risks (see Figure 18) provides a useful phased structure that can be applied to water-related risks, moving from identifying sources of risk, to assessing economic impacts, to assessing risk to, from and within the financial system. The framework includes an illustrative case on the Colorado River Basin which demonstrates how the approach can be applied to freshwater ecosystems. **Phase 1** focuses on identifying sources of physical and transition risk by analysing exposures to impacts and dependencies on freshwater, considering forward-looking scenarios, accounting for both local and systemic dimensions, and examining the climate–nature nexus. **Phase 2** assesses economic risks by exploring direct and indirect effects, examining micro, sectoral/regional and macro level effects, and considering the extent to which ecosystem services can be substituted. **Phase 3** assesses risks to, from and within the financial system by examining how economic risks transmit to traditional financial risk categories, analysing potential contagion within the financial system, and recognizing the endogenous nature of risk – that is, how the financial system's own activities may contribute to the water-related risks it faces.

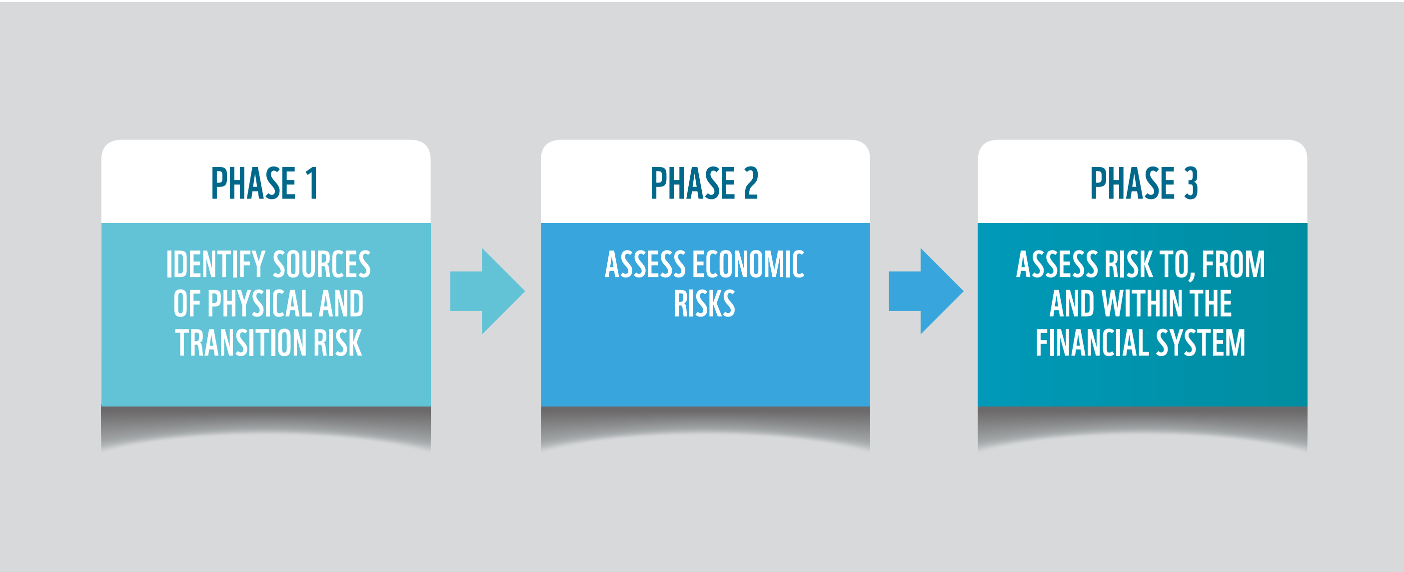


Figure 18: *NGFS principle-based risk assessment framework (NGFS, 2024b)*

AVAILABLE TOOLS

This section lays out various tools that central banks and financial regulators can use to assess water-related financial risks across their various functions, such as mapping sectoral dependencies, assessing water-related risks at various geographic scales, modelling water-related financial impacts, and providing data for potential supervisory use. The tools are categorized by type (such as modelling tools, data portals, risk exposure analysis tools, assessment and ranking services, guidance frameworks, and impact measurement tools) to help users quickly identify the nature of each resource. The table outlines each tool's central bank use case (that is, how CBFRs might apply the tool in practice) and maps them to the NGFS assessment phases described above as well as to the TNFD LEAP framework (Locate, Evaluate, Assess, Prepare). These mappings help CBFRs identify which tools may be relevant at different stages of their analysis. It is important to stress that the objective is not to endorse specific tools, but to cover those that are most widely used and applicable to central bank and financial supervisor functions.

Table 9: *Non-exhaustive overview of water tools, models and databases*

#	TOOL/ DATABASE	DESCRIPTION	CATEGORY	CFBR POTENTIAL USE CASE*	NGFS ASSESSMENT PHASE			
					Phase 1: Identification of sources of physical and transition risk	**Phase 2:** Assessment of economic risks	**Phase 3:** Assess risk to, from and within the financial system	**TNFD LEAP approach step (L, E, A, P)**
1	CDP Corporate Water Data	World's largest corporate water dataset collecting company-reported information on water management, governance, use and stewardship. Provides data on water withdrawals, consumption, targets and water-related incidents to investors, customers and policymakers.	Data portal	Corporate disclosure database providing benchmark data on water withdrawals, targets and incidents that CBFRs can use to assess disclosure quality from supervised institutions and identify sectoral reporting gaps.	✓			**L, E**
2	CDP Water Watch	Ranks more than 200 industrial activities within 13 industry sectors according to their potential impact on water resources in terms of quantity and quality. Generates impact rankings from 0 (no impact) to 18 (critical impact) for activities across value chain stages.	Assessment and ranking service	Qualitative sector-level assessment of value chain water impacts, supports preliminary scoping of which sectors and activities pose material water-related risks and may require enhanced supervisory attention.	✓			**L**
3	Ceres Investor Water Toolkit	Comprehensive resource helping investors evaluate and act on water risks in investment portfolios. Developed with 40+ institutional investors; includes guidance, databases, case studies and tools for pension funds, endowments and asset managers.	Guidance framework	Guidance framework on investor water stewardship that CBFRs can reference when developing supervisory expectations for institutional investors' water risk management, also applicable to central banks' own investment portfolios.			✓	**P**

#	TOOL/ DATABASE	DESCRIPTION	CATEGORY	CFBR POTENTIAL USE CASE*	NGFS ASSESSMENT PHASE			
					Phase 1: Identification of sources of physical and transition risk	**Phase 2:** Assessment of economic risks	**Phase 3:** Assess risk to, from and within the financial system	**TNFD LEAP approach step (L, E, A, P)**
4	Ceres Valuing Water Finance Initiative Benchmark Method-ology	Framework with scoring methodology for evaluating company water stewardship against six corporate expectations for valuing water. Provides metrics and indicators for assessing governance, targets, collective action, water quality, water-related ecosystems, and WASH access.	Framework	Benchmark framework providing practical guidance on metrics and indicators that CBFRs can reference when setting supervisory expectations for portfolio companies' water-related risk assessments, targets and actions, supports driving greater ambition and consistency across supervised portfolios.		✓		**E, A, P**
5	Ecolab Water Risk Monetizer/ Smart Navigator	Financial modelling tool that monetizes water scarcity risks by assessing incoming/ outgoing water risks and potential revenue at risk. Provides site-level risk assessments and Water Maturity Curve to guide facility-level water management improvement	Impact measure-ment/ analysis and modelling tool	Converts local water scarcity into financial cost estimates (shadow pricing), provides reference methodology that CBFRs can use when setting expectations for how firms should quantify water-related operational risks.		✓		**E, A**
6	ENCORE	Maps more than 200 economic activities to their dependencies on and impacts to freshwater ecosystem services. Enables screening of portfolios for exposure to water-dependent sectors with materiality ratings across value chain stages.	Risk exposure analysis	Sectoral dependency and impact mapping tool linking 200+ economic activities to freshwater services, enables CBFRs to screen lending and investment portfolios for exposure to water-dependent sectors and identify activities with high water impacts.	✓			**L**
7	Equarius-water (proprietary)	Proprietary factor model linking basin-level water stress to company equity beta. Demonstrates how water stress in river basins can be incorporated into equity risk metrics.	Modelling tool	Factor model demonstrating how basin-level water stress can be incorporated into equity risk metrics, offers illustrative approach for integrating water risk into market risk models.			✓	**A**

#	TOOL/ DATABASE	DESCRIPTION	CATEGORY	CFBR POTENTIAL USE CASE*	NGFS ASSESSMENT PHASE			
					Phase 1: Identification of sources of physical and transition risk	**Phase 2:** Assessment of economic risks	**Phase 3:** Assess risk to, from and within the financial system	**TNFD LEAP approach step (L, E, A, P)**
8	GLOBIO	Integrated global biodiversity model linking water, land use and climate pressures to biodiversity loss outcomes. Provides global and regional scenario outputs showing systemic risk transmission channels across environmental pressures	Modelling tool	Integrated global model linking water, land and climate pressures to biodiversity outcomes, helps CBFRs understand systemic risk transmission channels, cross-sectoral spillovers and long-term compounding effects across nature-related risks.	✓	✓		**L, E**
9	Maplecroft Water Stress Index (proprietary)	Subscription-based service providing sub-catchment-level water stress data based on ratio of withdrawals to available supply. Enables assessment of location-specific risks at granular geographic scale.	Assessment and ranking service	Sub-catchment water stress data that CBFRs can use to assess whether supervised institutions adequately capture location-specific risks in due diligence and to identify geographic concentrations of water stress exposure in portfolios.	✓			**L**
10	UNEP-FI Drought Stress-Testing Tool	Scenario tool converting drought events into credit risk impacts on lending portfolios. Provides off-the-shelf approach mapping drought scenarios into standard credit risk metrics (PD/LGD).	Modelling tool	Ready-to-use scenario tool converting drought events into credit risk impacts, provides off-the-shelf approach for CBFRs to conduct initial stress tests on lending portfolios exposed to water-dependent sectors.		✓	✓	**A**
11	Water Footprint Assessment Tool	Web-based platform quantifying blue, green and grey water consumption across product lifecycles, processes and organizations. Based on Global Water Footprint Standard, calculates and maps operational and supply chain water footprints.	Impact measure-ment and analysis	Quantifies water consumption across supply chains (blue/ green/grey water), supports analysis of trade finance exposures and sector-wide water dependencies, helps identify indirect water risks embedded in value chains.	✓	✓		**L, E**

#	TOOL/ DATABASE	DESCRIPTION	CATEGORY	CFBR POTENTIAL USE CASE*	NGFS ASSESSMENT PHASE			
					Phase 1: Identification of sources of physical and transition risk	**Phase 2:** Assessment of economic risks	**Phase 3:** Assess risk to, from and within the financial system	**TNFD LEAP approach step (L, E, A, P)**
12	Water-LOUPE (Deltares)	Interactive basin-level dashboard tracking factors affecting freshwater availability with 30-year forward projections. Version 2.0 includes scenario modelling to quantify water shortage, risk reduction, and the economic consequences of mitigation measures.	Data portal and modelling tool	Interactive basin-level dashboard with 30-year forward projections of water scarcity, demand and vulnerability, enables CBFRs to assess future water stress in geographies where supervised institutions have concentrated exposures.	✓	✓		**L, E**
13	WWF Water Risk Filter	Screening tool generating physical, regulatory and reputational water risk scores at site, portfolio, country and sub-national levels. Provides heat maps and risk matrices to visualize spatial distribution of water risks.	Risk exposure analysis	Screening tool generating physical, regulatory and reputational water risk scores at site, portfolio, country and sub-national levels; provides heat maps to prioritize geographic and sectoral areas for deeper supervisory assessment.	✓	✓		**L, E**
14	WRI Aqueduct Country Rankings	National and sub-national composite water stress scores aggregating multiple indicators including baseline stress, variability, groundwater stress and drought severity. Provides quick screening with global coverage at country and province-level granularity.	Assessment and ranking service	National and sub-national water stress composite scores, offers quick screening for macroprudential surveillance, reserve management decisions, and sovereign risk assessment related to water stress.	✓	✓		**L**
15	WRI Aqueduct Floods	Flood hazard mapping and cost–benefit analysis covering river and coastal flooding under current and future climate scenarios. Includes exposure values and economic impact estimates to support property portfolio risk assessment.	Data portal	Flood hazard mapping and cost–benefit data for river and coastal flooding; supports assessment of physical climate risks to property portfolios and provides background data for catastrophe model validation.	✓	✓		**L, E**
16	WRI Aqueduct Water Risk Atlas	Global water risk mapping tool using peer-reviewed methodology to create high-resolution maps of physical, regulatory and reputational water risks. Provides customizable risk scores at asset, facility and portfolio levels with future projections to 2030 and 2040.	Risk exposure analysis and data portal	Portfolio-level water risk scoring covering physical, regulatory and reputational dimensions; enables mapping of lending and investment exposures to high-water-stress regions and supports sovereign risk assessment.	✓	✓		**L**

* CBFR relevance is illustrative, not prescriptive; actual suitability depends on analysis purpose, data access and priorities. For general nature tool mapping (that follows the TNFD LEAP approach), the recently launched UNEP-WCMC Nature Tool Compass Guide can be consulted (UNEP & WCMC, 2026).

EXAMPLE APPLICATIONS OF WATER RISK ASSESSMENT TOOLS

The following examples illustrate applications of water risk assessment tools across different contexts and scales. They demonstrate that assessment approaches can be tailored to match the specific analytical objective and institutional capacity.

These cases demonstrate the range of available approaches – from standardized screening to bespoke spatial modelling – and confirm that rigorous water risk assessment is achievable with existing tools.

CASE STUDY 1 MACRO-ECONOMIC ASSESSMENT USING WWF WATER RISK FILTER (SOUTH AFRICA)

CONTEXT

A 2023 study by the Agence Française de Développement (AFD) and South African National Biodiversity Institute (SANBI) aimed to evaluate nature-related socioeconomic risks in South Africa through spatially-explicit assessment of water scarcity impacts. South Africa faces significant water stress, with projections indicating a 17% gap between freshwater demand and availability by 2030. Understanding the economic implications of water scarcity at municipal and regional levels is critical for policy planning and macroprudential oversight.

TOOL USED

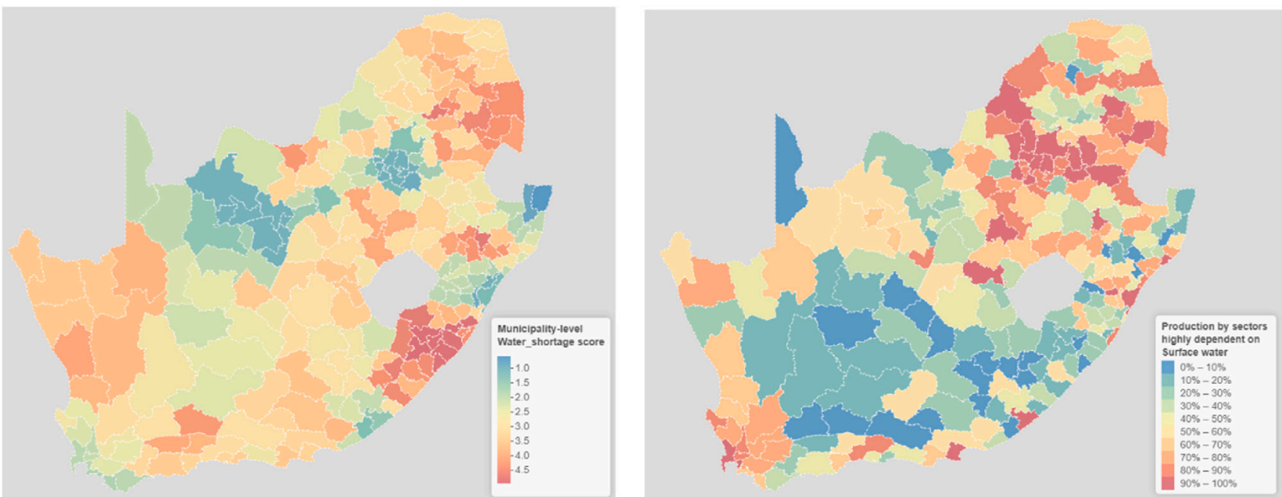
WWF Water Risk Filter with high-resolution South African datasets.

APPLICATION

The WWF Water Risk Filter assessed water scarcity risk across South Africa's 234 municipalities on a 1-5 scale, identifying 113 water-sensitive municipalities (scored 3 or above). These spatial risk scores were integrated with local economic production data across sectors to quantify potential impacts on production, employment, wages, exports, and tax revenues.

INSIGHT

The integrated assessment revealed that 22.7% of South Africa's net exports are generated in water-scarce municipalities, with mining and manufacturing particularly exposed. Agriculture accounts for 40% of vulnerable employment. The analysis identified Mpumalanga, Eastern Cape, Limpopo, and Free State as regions where water-related economic vulnerabilities concentrate.



Water-shortage municipal risk scores (left) and activities dependent on surface water by decile of production value (Hadji-Lazaro et al., 2023, 2024)

CASE STUDY 2

PORTFOLIO SCREENING USING THE WWF BIODIVERSITY RISK FILTER (DE NEDERLANDSCHE BANK)

CONTEXT

De Nederlandsche Bank (DNB) piloted the TNFD LEAP approach to explore nature-related financial risks in its own investment portfolios, comparing two portfolios: the passively managed Broad-Market Fund (BMF) and the actively managed Paris-aligned portfolio (PAM).

TOOL USED

WWF Biodiversity Risk Filter (incorporating water-related risks).

APPLICATION

DNB assessed nature-related dependencies and impacts for both portfolios, conducting a deep dive into electric utilities using company asset coordinates. The analysis combined sector-level dependencies (via ENCORE) with location-specific biodiversity and water risk data.

INSIGHT

The assessment revealed that significant portions of both portfolios have high or very high dependency and impact on nature. Notably, improvements in climate risk profiles did not necessarily translate into lower nature-related financial risk, highlighting the need for separate nature risk assessment frameworks. The results enabled DNB to engage with external asset managers on targeted nature risk management strategies.

AREA	BMF	PAM
INPUT IN PHYSICAL RISK Percentage of plants in locations with high or very high risk of water scarcity	16%	0%
INPUT IN REPUTATIONAL RISK Percentage of plants in locations with high or very high risk of proximity to protected areas	41%	79%
% OF TOTAL ELECTRICITY PRODUCTION Combustion Hydropower Solar & wind	 73% 11% 16%	 56% 16% 27%

Source: Tiems et al. (2024)

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CASE STUDY 3

INVESTMENT ESG INTEGRATION USING WATERLOUPE AND THE WWF WATER RISK FILTER (BRIDGE PROJECT)

CONTEXT

The BRIDGE project, led by Deltares in partnership with WWF-NL and institutional investors (Achmea IM, NN Group and SCOR), aimed to improve how water risks are assessed and integrated into ESG investment frameworks, focusing on water-stressed regions in Chennai (India) and São Paulo (Brazil).

TOOL USED

WaterLOUPE (Deltares) and the WWF Water Risk Filter.

APPLICATION

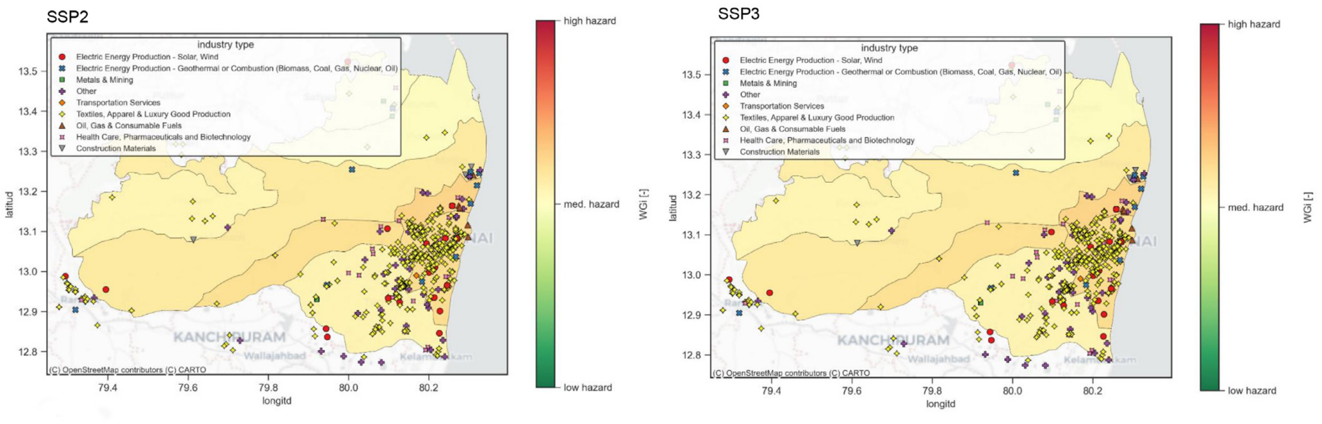
WaterLOUPE assessed water scarcity risks across sectors and scenarios using shared socioeconomic pathways (SSPs), while the WWF Water Risk Filter provided basin-level risk scores based on physical, regulatory and reputational factors. The analysis included sector-specific assessments of companies in the textile, manufacturing and energy sectors, examining water-use patterns, monthly water gaps, and future projections.

KEY FINDINGS

- Both basins face significant water gaps under future scenarios, with risks varying across sub-basins and peak months.
- High-water-use sectors are often located in the most water-stressed areas, increasing vulnerability.
- The two regions show different water risk profiles: scarcity is more acute in Chennai, while São Paulo faces a mix of water quality and safety issues.
- Current corporate reporting does not fully capture local and future water risks, despite some company efforts.

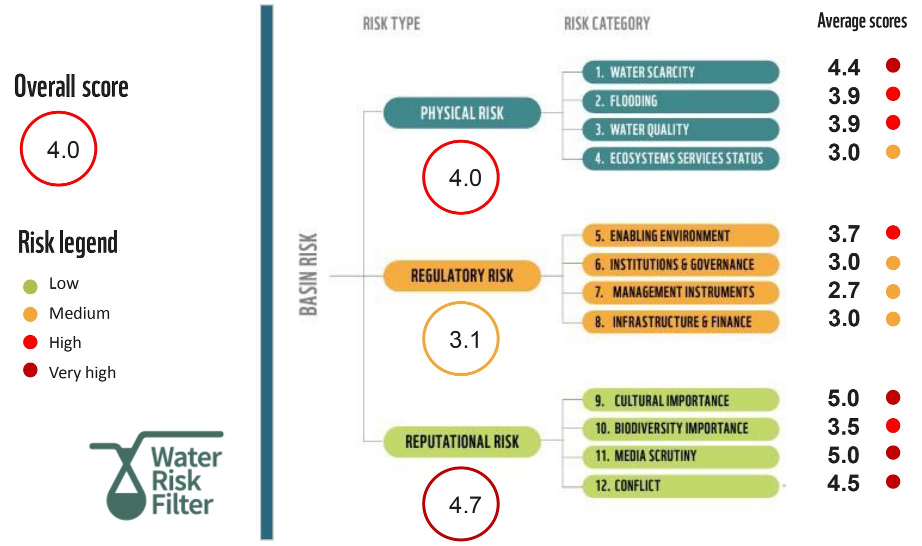
INSIGHT

The case demonstrates the value of using location-specific and forward-looking data to support investment decisions. Combining basin-level scenario modelling with site-level risk screening enables more granular assessment of how water risks vary geographically and by sector, supporting better-informed capital allocation and corporate engagement strategies.



Source: Cavalcanti et al. (2024)

RESULTS CHENNAI RIVER BASIN



Source: Cavalcanti et al. (2024)

CASE STUDY 4

ASSET-LEVEL BIODIVERSITY IMPACT ASSESSMENT USING SPATIAL MODELLING (NATURALIS MINING MODEL)

CONTEXT

Financial institutions require methods to trace environmental impacts from specific economic activities to biodiversity outcomes and attribute these to individual corporate actors for risk screening purposes.

METHODOLOGY

Researchers from Naturalis Biodiversity Center implemented a spatial modelling framework to map the potential impacts of mining-related pollution on freshwater biodiversity. The approach integrates satellite images of mining sites, hydrographic maps and species distribution data to identify where freshwater biodiversity is most at risk from mining pollution.

DATA AND METHODS

- Mining extraction areas (more than 145,000 km²) compiled from multiple sources and matched with the SNL Metals & Mining database, covering 11 key commodities
- Using HydroRIVERS, pollutant dispersion (arsenic, copper, lead, zinc) modelled downstream from mine sites
- Biodiversity threats assessed by linking 928 IUCN-listed freshwater species to contaminated catchments using HydroBASINS dataset

APPLICATION

Coupling this spatial analysis with asset-level data allows these biodiversity footprints to be attributed to specific companies (Le Lann et al., 2025), thereby supporting risk screening for financial institutions. The framework enabled site-level attribution of pollution risk to specific mines, species and corporate owners, producing a ranking of 1,192 corporate entities by the number of freshwater species potentially threatened by their mining operations.

INSIGHT

This methodology provides a scalable and transparent way of tracing pollution risks from mining to biodiversity threats and corporate actors. It equips financial institutions with asset-level data to better understand nature-related dependencies and exposures in their portfolios. The approach demonstrates how combining environmental monitoring data with asset-level corporate databases can support more precise risk assessment than sector-level screening alone.

GOING DEEPER: WHAT TO CONSIDER IN THE CHOICE OF METRICS

This sub-section describes the metrics – the underlying indicators and data points – that central banks and supervised institutions need to track water dependencies, impacts and exposures. The tools described in the previous section provide standardized methodologies for assessing water-related risks. Some of these metrics serve as inputs to those tools (such as facility locations or water withdrawal volumes), while others are tracked independently to support disclosure, risk monitoring, and supervisory assessment.

Water-related risks cannot be fully understood through firm-level metrics alone, given the inherent socioecological complexity of freshwater systems. Water knows no boundaries and impacts can dissipate widely, for example where upstream pollution or water abstraction can affect downstream water quality and quantity. Furthermore, water systems often span multiple jurisdictions and involve different user groups and pressures, all while management responsibilities are fragmented, which can result in inconsistent policies, underinvestment and gaps in accountability. These challenges are exacerbated by the transboundary nature of many catchments.

Water-related metrics should be interpreted as indicators that require contextualization against local hydrological conditions rather than as standalone measures of risk. In the process of identifying metrics suitable for the scope of the risk assessment, it is helpful to consider several complementary analytical frames that can guide metric selection and interpretation:

- **Basin and catchment perspective:** Water-related metrics should be explicitly conditioned on the basin and catchment context rather than assessed at the individual company level alone. Water risks manifest at the watershed scale, where multiple users compete for shared resources and upstream activities affect downstream conditions. A company's water use that appears modest in absolute terms may be material if it is concentrated in a water-stressed basin, while the same volumes might pose negligible risk in a water-abundant region. Basin-level ecosystem indicators (such as wetland health, aquifer recharge rates, or ecological flow requirements) help CBFRs understand whether a borrower's activities occur in basins approaching or exceeding sustainable thresholds.
- **Hazard, exposure and vulnerability framing:** Water-related metrics can be mapped to the hazard–exposure–vulnerability framing to help CBFRs structure risk assessment systematically. Hazard can be proxied by metrics capturing the severity and likelihood of water-related stresses (e.g water stress indices, drought frequency, flood recurrence intervals, pollutant concentrations). Exposure can be proxied by metrics quantifying the extent to which activities or assets are subject to these hazards (e.g. company water withdrawals in high-stress catchments, assets in flood-prone zones, supply chain concentration in water-scarce regions). Vulnerability can be proxied by metrics assessing adaptive capacity (e.g. participation in water stewardship initiatives, credible transition plans, investment in water efficiency technologies).

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- **Forward-looking metrics:** While backward-looking metrics (historical water withdrawals, past pollution incidents) provide important baselines, forward-looking metrics are critical for assessing whether companies are credibly managing transition risks and adapting to future water stress. These include capital expenditure (CapEx) directed toward water-related risk mitigation; operational expenditure (OpEx) trends indicating whether companies face escalating pressures or achieve efficiency gains; water-related targets with credible action plans and interim milestones (such as context-based targets aligned with local basin limits); and transition plan quality articulating how companies will adapt to future water constraints.

Within these analytical frames, CBFRs can use several metric types across three categories: physical flow-based, activity-based and project-based (Dafermos et al., 2024).

Figure 19 below summarizes the features of each category, provides examples and relevant databases, and illustrates their application in monetary and financial policy tools.

METRICS CATEGORIES	FEATURES	EXAMPLES OF METRICS	DATABASES/CLASSIFICATIONS FOR SUPPORTING THE DEVELOPMENT OF METRICS	EXAMPLES OF USE IN MONETARY AND FINANCIAL POLICY TOOLS
Physical flow-based metrics (Measure in physical units the impact that companies have on water stress)	(1) Report absolute or relative performance (2) Capture past environmental performance (backward-looking) and transition plans and commitments (forward-looking) (3) Capture direct and indirect impacts (supply chains) (4) Report physical flows both in net and gross terms	Extent of freshwater use change (km2); water pollutant emissions (m3); total water pollutant emissions/million per revenue (m3 per USD); water discharged (m3); water withdrawal (m3); water recycled (m3); total water use/million per revenue (m3 per USD); water intensity reduction targets; water use target; freshwater withdrawal (m3); water withdrawal in stressed regions (m3); water consumption (m3)	• Refinitiv Eikon (e.g. water use target) • Bloomberg (e.g. water recycled; freshwater withdrawals; water consumption; wastewater; percentage of water withdrawn in regions with high or extremely high baseline water stress) • SBTN (e.g. targets about freshwater) • MSCI (e.g. water stress, geographic exposure) • CDP (e.g. water intensity reduction targets)	**Monetary policy tools** • Collateral framework (e.g. haircut adjustment based on physical flow-based metrics, concentration limits on water-related environmentally harmful activities) • Asset purchases (e.g. tilting based on physical flow-based metrics, exclusion of always environmentally harmful activities)
Activity-based metrics (Capture environmental impact by distinguishing between 'green' and 'dirty' activities)	(1) In defining dirtiness, they distinguish between (i) always environmentally harmful and (ii) environmentally harmful activities. (2) Define green activities as those activities that reduce negative environmental impacts (3) Can be binary or continuous	**Green binary metric:** Specifies whether the main activity of a company is green or not. **Always harmful activity binary metric:** Specifies whether the main activity of a company is always environmentally harmful or not. **Green continuous metric:** Specifies the proportion of the activities of a company that are green. **Examples of green activities (based on TRBC):** Water & Sewage Construction (5220102018); Sewage Treatment Facilities (5910301012); Water & Related Utilities (NEC) (5910301010) **Examples of always environmentally harmful activities (based on GICS):** 'Mountaintop Removal and Open-Pit Mining' within 'Coal & Consumable Fuels' (10102050); 'Fracking and tar sands' within Oil & Gas Exploration & Production (10102020); Large-Scale and Intensive industrial agriculture within 'Consumer Staples' (30202010) **Examples of environmentally harmful activities (based on GICS):** Fertilisers & Agricultural Chemicals (15101030); Water Supply & Irrigation Systems (5910301011) **Location-based harmful activities:** Mountain-top removal in Key Biodiversity Areas, fracking operations in Ramsar Sites, Industrial agriculture expansion in Protected Areas **Conduct-based metrics:** Human rights violation index (based on Global Atlas for Environmental Justice), Indigenous rights compliance (free, prior, informed consent). Stakeholder conflict indicators at catchment level	• EU Taxonomy (green water-related activities) • Urgewald's Global Coal Exit List and Global Oil and Gas Exit List (environmentally harmful activities) • WWF Risk Filter (environmentally harmful activities) • CERES (2022) (environmentally harmful activities)	• Refinancing operations (e.g. differentiated interest rates based on activity-based metrics for bank loans) • Reserves tiering (e.g. the threshold for the remuneration of reserves can be adjusted based on activity-based metrics for bank loans). **Financial policy tools** • Capital requirements (e.g. higher capital requirements for environmentally harmful activities) • Credit guidance (e.g. credit floors for water-related green activities)
Project-based metrics (Capture environ-mental impact by identifying 'green' projects)	(1) Can be used for classifying financial instruments related to specific projects (2) Are binary (3) Require a verification process	**Green binary metric:** Specifies whether a certain financial instrument (e.g. water bonds or loans) finances a project that reduces negative water-related environmental impacts	- LSEG Eikon (e.g. green bonds related to water projects) - ICMA (social bonds for clean drinking water, sewers, sanitation)	

Figure 19: *Water metrics overview. Based on Dafermos et al. (2024).*

INCORPORATING FORWARD-LOOKING APPROACHES

Once exposures have been identified and metrics selected, scenario analysis is the next step in building a fuller picture of future water-related risks. Incorporating freshwater-related risks into existing scenario analysis as well as designing water-relevant scenarios is essential for anticipating potential future disruptions and stress points in the financial system. While most available scenarios stem from climate science and focus on hazards such as droughts and floods, they offer a useful – albeit partial – foundation for exploring future water risk trajectories.

Water issues in scenario analysis currently appear most prominently in climate-related scenarios, which explore hydrological physical hazard pathways under different climate conditions. Commonly-used scenarios in the financial sector include the NGFS long- and short-term climate scenarios (NGFS, 2026). The NGFS scenarios consist of two datasets: transition pathways and macro-economic damage estimates (developed using integrated assessment models by IIASA), and physical impact data from the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP). These datasets are aligned by global warming levels to provide a coherent framework. The NGFS scenarios incorporate physical impact data from ISIMIP, which uses global hydrological models including WATERGAP2 and CWatM for water sector projections.

These tools provide important insights into future climate-driven changes in water availability or stress. ISIMIP outputs, for instance, include projected changes in river flows, which can serve as proxies for water availability under NGFS-aligned climate pathways. These physical signals can be linked to first-order economic effects, such as declining agricultural yields, increased industrial input costs, or rising insurance claims. Current available and commonly used climate scenarios, such as the ones by the NGFS, provide information on individual hydrological hazards and possible chronic changes such as droughts, extreme precipitation, and riverine discharge.

Current scenarios do not yet fully capture compound and cascading risks, such as droughts coinciding with heatwaves, or extreme rainfall following periods of drought, or 'multiple breadbasket' failures. Nor do these scenarios account for other major drivers of hydrological disruptions, such as water resource overexploitation, large-scale micro-pollutant pollution, disruptions of freshwater ecosystems, or even policies targeted at managing water use. Most scenarios focus on physical hazard likelihood as a function of climate change only, disregarding these additional pressures that can interact with climate hazards to accelerate depletion of water reserves and increase the likelihood of systemic stress. Furthermore, climate scenarios are not suitable for capturing water transition risks, as these focus primarily on greenhouse gas emissions-related regulatory shifts. These generally remain significant analytical gaps and show why relying on current climate scenarios is only likely to lead to underestimated water-related risks.

Given current methodological limitations, it is important to continue developing water-related scenarios and to use them as exploratory tools rather than as precise forecasts. To address existing gaps, CBFRs can build on existing NGFS scenarios by layering in catchment-level or sector-specific water stress data. Where supervisory exposure data is available, physical and economic impacts can be mapped to lending portfolios, sovereign reserves or property risks to assess financial vulnerabilities. Developing such scenarios may require new partnerships and data sources, including collaboration with hydrological agencies, statistical offices or academic institutions. Historical analogues of water-related disruption can also help to calibrate the severity of shocks and validate model assumptions.

Recent work by the Green Finance Institute (Ranger et al., 2024) illustrates how narrative-led approaches can complement quantitative modelling. By combining domestic and international drivers of nature risk, including chronic water scarcity, acute hazards and supply chain disruptions, such scenarios provide a structured way to engage stakeholders on complex, systemic and compounding risks that standard climate models may overlook.

In parallel, approaches such as 'reverse stress testing' can be deployed as an analytical shortcut to better assess possible water-related pathways that could have led to the collapse of the banking or insurance systems. Such approaches can help unveil concentration risks, compounding risk and tail-risk events under deep uncertainty and limited data to construct exploratory forward-scenarios. Reverse stress testing identifies the adverse water-related conditions – such as prolonged droughts, severe flooding or widespread water contamination – under which institutions would face significant distress. These approaches are particularly useful where data constraints limit bottom-up assessments, helping to clarify potential breaking points and strengthen resilience against future water-related disruptions. Such types of approaches are commonly being used to better understand risk transmission channels under uncertainty (European Central Bank, 2025b).

TEXT BOX 20: BANQUE DE FRANCE'S APPROACH TO WATER STRESS SCENARIOS

Banque de France has identified water-related risks as one of the main nature-related physical risks in France. One limitation of existing tools to model nature-related risks has been shown to be the high elasticity between the factors of production. In order to circumvent this limitation, and to get a first-order estimation of the economic impact on industries, Banque de France identified sectors that are highly dependent on water to produce goods, based on CDP's Water Watch assessment. For companies in those sectors, it assumed that water was non-substitutable in the short term, meaning that a decrease of 1% in water consumption leads to the same decrease in value added. Then, Banque de France projected water restrictions in a water stress scenario for 2025, based on river flow data from Météo-France, the French meteorological institute, and computed the direct impact of those restrictions on value added at the company level. In a last step, an input-output model was used to better understand how water-related shocks could propagate via sectoral linkages. This ongoing work is only a first step in assessing water-related risks for the French economy and financial system, as it is focused solely on the effect of water restrictions on the industrial sector, therefore ignoring many aspects of water stress – for instance the impact on agriculture and energy production.

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KEY MESSAGES TO CENTRAL BANKS, FINANCIAL SUPERVISORS AND REGULATORS

01 CENTRAL BANKS AND FINANCIAL SUPERVISORS CAN BUILD ON EXISTING FRAMEWORKS.

Water is already embedded in climate and nature frameworks, and perfect data is not a prerequisite for getting started.

02 THE NGFS THREE-PHASE FRAMEWORK PROVIDES A STRUCTURED ENTRY POINT.

It guides assessment through identifying sources of physical and transition risk, assessing economic impacts across scales, and evaluating risks to, from, and within the financial system.

03 A WIDE RANGE OF TOOLS EXIST FOR DIFFERENT ASSESSMENT NEEDS.

Tools range from rapid sectoral screening (ENCORE) to basin-level scenario modelling (WaterLOUPE) and detailed portfolio analysis (WWF Water Risk Filter, WRI Aqueduct). No single tool addresses all needs; CBFRs should select based on their analytical objectives and data availability.

04 WATER RISK ASSESSMENT IS ALREADY BEING APPLIED IN PRACTICE.

Approaches span different scales and methodologies, from portfolio screening (DNB) to macro-economic assessment (South Africa) and asset-level spatial modelling, illustrating the diverse approaches available.

05 DATA GAPS CAN BE ADDRESSED THROUGH PRACTICAL STEPS.

Where data gaps exist, CBFRs can engage national hydrological and environmental agencies, draw on open-source satellite data, require water-related disclosures from supervised institutions, and form partnerships with academic institutions.

06 WATER METRICS SPAN PHYSICAL FLOWS, ECONOMIC ACTIVITIES, AND INVESTMENTS.

These include physical flows of water (withdrawals, discharges), economic activities and dependencies (sectoral water use, supply chain linkages), and project-level investments (CapEx and OpEx for water infrastructure).

07 BASIN AND CATCHMENT CONTEXT IS CRITICAL.

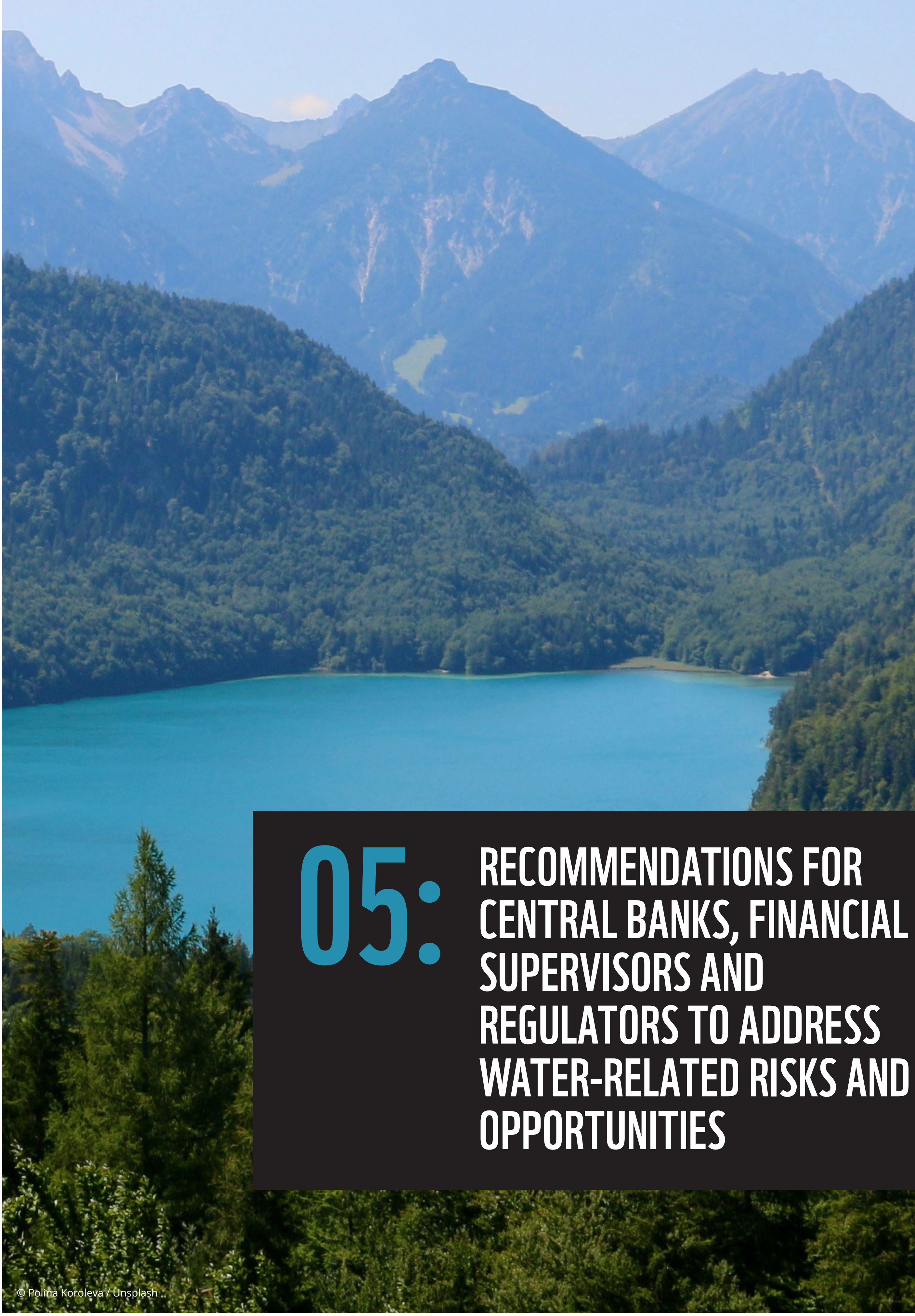
Water risks manifest at the watershed scale, where upstream activities affect downstream conditions and multiple users compete for shared resources. The same water use can be negligible in one location and material in another.

08 WATER METRICS CAN BE INTERPRETED THROUGH THREE COMPLEMENTARY ANALYTICAL FRAMES.

These frames include basin and catchment perspective (considering local hydrological conditions), hazard–exposure–vulnerability structure (separating risk components), and forward-looking indicators (CapEx, OpEx, targets, and transition plans).

09 CURRENT CLIMATE SCENARIOS PROVIDE A FOUNDATION BUT CAN BE ENHANCED.

While they miss compound risks (such as droughts coinciding with heatwaves), non-climate drivers (such as overexploitation and pollution) and water-specific transition risks, CBFRs can strengthen them by layering in catchment-level data, using narrative-led approaches, and deploying reverse stress testing.



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05: RECOMMENDATIONS FOR CENTRAL BANKS, FINANCIAL SUPERVISORS AND REGULATORS TO ADDRESS WATER-RELATED RISKS AND OPPORTUNITIES

SECTION 05:
RECOMMENDATIONS FOR CENTRAL BANKS, FINANCIAL SUPERVISORS AND REGULATORS TO ADDRESS WATER-RELATED RISKS AND OPPORTUNITIES

The water crisis holds risks but also opportunities for the financial sector. To mitigate the former and seize the latter, CBFRs play a linchpin role. Existing evidence is clear: water-related (systemic) risks are increasingly materializing and accumulating, certain economic activities are not future-fit for a water-secure world, more and more locations face water insecurity, and nature is our greatest ally in addressing water insecurity and climate change. However, such awareness is not (yet) being met with adequate action by policymakers, the real economy and CBFRs.

While financial institutions are starting to address water-related risks, a system-wide approach will yield more (and faster) progress than individual voluntary initiatives – this is needed to prevent an abrupt disorderly transition and irreversible changes in hydrological regimes. In this respect CBFRs within their remits hold both the responsibility (as guardians of the financial system) and an array of tools to support broader economic, financial and government efforts to enable water resilient economies in a precautionary manner.

To ensure a coherent policy approach, CBFRs should strive to mainstream water concerns across all of their tools. Because the water crisis poses a systemic risk, macroprudential policymakers have a responsibility to mitigate this risk as far as possible. Microprudential policy and monetary policy should be coherent in enabling macroprudential goals alongside the fulfilment of their own goals that are directly affected by the water crisis.

To get started, CBFRs could take a brief "pulse check" to find where they currently sit on the broader journey of addressing water-related risks (see Table 10). It is of paramount importance for CBFRs to apply precautionary measures across all available tools, given the extensive evidence on the potential risks involved.

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Table 10: *Checklist water-related risk status*

		QUESTIONS	YES/NO/ PARTIAL	EXPLANATION
How is the financial system affected by and coping with the water crisis?	**Financial sector risk analysis**	Have you carried out an assessment of how the financial sector is exposed to nature-related risks, and has water come out as one of the key dependencies?		
		Have you assessed what financial institutions are doing to manage the possible water-related risks?		
		Have you evaluated the robustness of your materiality assessments and those carried out by financial institutions? Are there sufficiently conservative margins in place to ensure that the analysis is tested for sensitivity both at the biophysical level of assumption and in consideration of potential financial system vulnerability (e.g. risk transfer sustainability, sources of concentration risk)?		
		If you answered "no" or "partial" for any of the above: If no assessment has been carried out or there is limited capacity focus on the counterfactual; to prove that water-related risks are *not* material.		
	Stress testing at systemic level	Have you tested if the financial system is able to withstand water-related shocks and chronic shifts? Or have you tested under what conditions a financial crisis could occur as a result of freshwater hazards and chronic changes?		
		Have you stress tested according to plausible tail risk (worst case) scenarios?		
		Have biophysical and financial system tipping points been factored in adequately?		
		Have the spillover effects within the financial system (e.g. rising premiums, insurance fall-out) been considered?		
		If materiality thresholds appear low, have you conducted the counterfactual: how can water-related risks *not* be material?		
How is the financial system contributing to the water crisis?	**Endogenous risk (proxied via environmental materiality)**	Have you evaluated what possible negative impacts on water security and water resilience your supervised institutions could have, nationally and abroad?		
		Have you mapped the key drivers (climate change, overexploitation, pollution, invasive species, land/water conversion) supported by the financial sector? How are they enabling risk accumulation for their clients via their financial services?		
		Have you evaluated where and how these risks could shape the broader systemic risk profile of the future?		
		Have you assessed which key freshwater ecosystems (e.g. Ramsar wetlands, terrestrial forests key for the hydrological cycle, World Heritage sites) are subject to harmful activities that are facilitated by financial institutions (even via general corporate finance leverage)?		
		Have you mapped the policies that the financial institutions already have in place to mitigate potential harmful impacts? And where there are critical gaps?		
		Have you assessed the extent to which supervised financial institutions are supporting water-related adaptation measures?		

To that end, this guide, aligned with previous guides and international frameworks, recommends the following pathways to CBFRs. Each is distinguished by varying levels of urgency and feasibility:

- **URGENT ACTIONS**
  should be implemented in the coming months.

- **SHORT-TERM ACTIONS**
  should be implemented within the next year.

- **MEDIUM-TERM ACTIONS**
  should start within a year and be implemented by 2030.

2026 is a crucial year for water with important conferences coming up, including COP17 on Convention to Combat Desertification in August, COP17 on Convention on Biological Diversity in October, COP31 on Climate Change Conference in November, and the UN Water Conference in December. This is a unique window of opportunity for the CBFR community to step up their commitments, walk the talk, and engage within and beyond established forums on mainstreaming water-related risks in their work to ensure price and financial stability.

Readers are advised to consider the contextual relevance of the recommendations presented in this chapter and to prioritize them based on their jurisdictional requirements. All recommendations are aligned, at minimum, with the mandates set forth by central banks and financial supervisors – including price and financial stability, as well as proper financial market functioning. Depending on organizational responsibilities within specific jurisdictions, certain readers may determine that a particular recommendation requires collaboration among multiple institutions rather than implementation by a single entity. We encourage you to establish these connections and work collectively to implement the recommendations. We also, where appropriate, provide further suggestions linked to water pollution based on the UNEP FI deep dive on water pollution risk presented in Text box 10, Chapter 2.


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URGENT ACTIONS

LEADERSHIP

Acknowledge the water crisis and its macrocriticality, and communicate it to the government, the public and the market. Be a science-based voice highlighting the interdependencies between nature degradation, climate change, biodiversity loss and water insecurity, as well as economic prosperity, signalling that both integrated policy and market action are necessary.

Coordinate with other policymakers to design the necessary whole-of-government approach by collectively mapping existing polices, their synergies and trade-offs. Engage government representatives, including from the Environment, Water and Infrastructure, to assess the existing strengths and weaknesses of prevailing policies and economic incentives which affect the real economy, banks and insurers. Evaluate how these factors contribute to adverse impacts on water systems, and identify priority areas for improvement.

MACROPRUDENTIAL POLICY

Allocate resources and build capacity to begin exploring water-related risks and opportunities within the jurisdiction's financial system, including how the financial sector contributes to water insecurity (endogenous risk). It is crucial to incorporate neglected water issues such as pollution, freshwater ecosystem degradation, nature-related and economic feedback effects, tipping points and sector-specific insights into these assessments. If data is limited, you can start with a back-of-the-envelope style assessment and reverse stress testing approaches to prioritize further deep-dive assessments as needed. Team up and engage with multidisciplinary academic and scientific research institutions and civil society organizations that can provide technical assistance to build such internal capacity.

SHORT-TERM ACTIONS

LEADERSHIP

Lead by example, establish a plan, and communicate how water-related concerns will be integrated in your existing plans, adjusting the suite of policies to account for the water crisis. If there is no climate/nature plan in place, consider water-related intersections from the outset. Make use of existing national, regional or international plans – e.g. Nationally Determined Contributions (NDCs), National Adaptation Plans (NAPs), National Biodiversity and Action Plans (NBSAPs), and national/regional/international water strategies - as reference guides.

Communicate to governments the impacts that water insecurity has on your jurisdiction's economic, financial and price stability, and outline and discuss necessary actions.

Increase capacity on neglected yet critical areas – such as increasing understanding of NbS and their bankability in the private sector for example – by convening roundtables, workshops, seminars, dialogues between multidisciplinary stakeholders from academia, (local) government, (multilateral) development banks, the real economy and the financial sector. This can help to ensure that institutions supporting landscape projects are not penalized in systems which reward short-termism (see Mazzucato & Kühn Von Burgsdorff (2025)).

MICROPRUDENTIAL POLICY

Mainstream and specify integration of water-related risks in supervisory expectations and related guidance to cover requirements, such as risk management processes/policies, transition plans and risk appetites. If supervisory expectations regarding climate- and nature-related risks exist, provide additional guidance and specification on how to proceed where water is identified as a material issue. Provide guidance specifically for high-risk sectors. If such supervisory expectations are not in place, then when drafting them clearly factor in the interlinkages between water, nature and climate from the outset, to make it clear that banks and insurers are expected to assess water-related risk. Such expectations should also clarify supervisory reporting requirements, which the supervisor should enforce. Extend supervisory expectations to cover critical issues such as pollution:

- Explore how prudential frameworks can reflect material risks from inadequate water pollution controls or wastewater treatment.
- Encourage banks to include untreated wastewater exposure in stress tests, especially for high-dependency sectors and regions with poor infrastructure.

- Encourage enhanced reporting by financial institutions on portfolio exposure to clients with inadequate wastewater management, aligned with TNFD and the Global Framework on Chemicals.
- Expect financial institutions' impact on water security to be integrated within their climate/nature transition plans.

Note on expecting banks and insurers to adopt a precautionary approach: a margin of conservatism/precautionary expectations are embedded throughout supervisors' expectations and guidelines. It is expected that financial institutions, in an absence of data and information, assume risk wherever reasonable (e.g. for engagement with high-water-impact sectors). Here consider reversing the burden of proof – rather than financial institutions having to prove that they are jeopardizing water security and resilience, the onus is on them to prove that the risk is not material and to showcase what safeguards they have in place to monitor the risk. This also applies to the development of financing mechanisms.[14]

Mainstream and specify the integration of water-related risks in disclosure requirements (including in transition plans). Advocate for equivalently robust disclosure requirements for real-economy actors. Financial institutions and corporates within existing climate and nature transition plans should be expected to clearly carve out how water-related risks and impacts are assessed and managed, and the associated transitions plans. Robust disclosure requirements are not only essential for economic and financial market functioning, but also for data availability.

MACROPRUDENTIAL POLICY

Assess the exposure of the financial system to water-related risks (financial materiality), integrating water-relevant scenarios in macroprudential assessments (including most adverse scenarios) that factor in multiple stressors besides those of 'only' climate change (e.g. overexploitation, pollution, invasive species, freshwater/terrestrial ecosystem conversion). These water systems scenarios should be designed to be context-relevant and forward-looking, should consider both localized and supply chain effects, and should ideally be developed collectively with water experts. On critical issues such as pollution, CBFRs should particularly support the development of data systems and modelling tools to integrate water quality scenarios into macroeconomic and financial stability assessments. Crucially, incorporate processes in materiality assessments for qualitative and expert judgment and interpretation, particularly to address gaps due to incomplete or low-quality data.

Linked to the financial materiality assessment, also assess the effect of the financial system on water insecurity to account for sources of endogenous risk. Map financial flows linked to supporting economic activities that are likely to be contributing to water systems degradation, particularly in fragile ecosystems.[15]

Publish results from macroprudential risk assessments and stress-testing exercises. Outline implications for policy actions based on the findings.

Where material risk to the broader system is identified, integrate water-related risks in capital risk buffer adjustments – particularly, if applicable, considering the financial sectors' role in fuelling endogenous risk. For example, integrate water-related risk in systemic risk buffer, that could vary based on the level of financing provided that is supportive of water security.

MONETARY POLICY

Lead by example by integrating water-related risk and impact concerns in foreign exchange investment decisions by phasing out environmentally harmful activities, especially in key freshwater landscapes (which include World Heritage Sites, Ramsar wetlands and water-stressed catchments[16]). If already present, amend the active ownership approach to vote on water-related concerns across the spectrum (quantity, quality, ecosystem, infrastructure and governance), and set sector-specific policies which consider the ability of investees to transition with credible escalation and exit strategies. Existing frameworks and guidance documents developed for financial institutions can be used as a starting point[17].

Adjust collateral frameworks by starting with accounting for water transition risk, inspired by the recent ECB collateral framework climate factor (European Central Bank, 2024), to recalibrate eligibility and haircut valuation of assets, issuers and sectors responsible for overexploitation, pollution and freshwater ecosystem conversion. For instance, require issuer-level disclosure of water-related risks, impacts and transition plans as a prerequisite for eligibility.

INTERNATIONAL STANDARD-SETTERS

International financial standard setters like the Financial Stability Board (FSB), Basel Committee on Banking Supervision (BCBS), International Association of Insurance Supervisors (IAIS) and the International Organization of Securities Commissions (IOSCO), should integrate water-related issues into regulatory frameworks. Particular attention should go in the governance of Global and Domestic Systemically Important Banks (G-SIBs and D-SIBs) and to strengthen major banks' and insurers' resilience to nature-related shocks (including water). Through the G20 Finance Track on strategic macroeconomic issues, central banks and financial regulators should urge the FSB to expand its work on water-related risks, potentially building on and connecting with existing initiatives such as the G7 Water Coalition.

14 See safeguards in biodiversity financing mechanisms by CBD (2018).
15 See sensitive locations definition and application by TNFD (2024).
16 See sensitive locations definition and application by TNFD (2024).
17 For example, see Ceres (2026).

TACKLING THE INSURANCE PROTECTION GAP IS CRUCIAL FOR ECONOMIC AND FINANCIAL STABILITY

Public authorities in Europe and the US have already started taking action (to different degrees) to contain the protection gap, but the gap and related challenges are still increasing.

Therefore, WWF urges public actors – including local and national governments, central banks and financial market authorities – to tackle the insurance protection gap strategically, with a disaster risk reduction and resilience strategy, addressing the root causes of increasing water-related risks and using the capabilities of the insurance sector.

To complement current policy and regulatory efforts, WWF recommends, that governments and financial authorities address residual risks with a strategic approach based on the disaster risk reduction lifecycle (see Figure 20). As a foundation for political support, a holistic understanding of the risks and losses including the indirect effects of extreme weather events is fundamental – although such assessments should not delay the implementation of no-regret actions.

Building on that, reducing greenhouse gas emissions from fossil fuels, deforestation and ecosystem conversion – as well as restoring nature to preserve its capacity to store those emissions – is indispensable for preventing risk from spiralling out of control and maintaining insurability. However, climate risk will increase for some time, even under the most optimistic scenarios. Investment in climate change adaptation and building resilience is therefore another key ingredient in addressing the protection gap. Nature needs to be mainstreamed into each element of such strategies, to increase the physical resilience of affected communities and landscapes. This includes protecting and preserving nature, restoring nature to help people (e.g. through nature-based solutions), and helping nature itself adapt to climate change.

Furthermore, any residual risk needs to be managed through insurance or similar mechanisms to transfer, share and decrease the financial vulnerability of affected people, households, businesses and governments, and to ensure the swift recovery of affected communities and the restoration of vital ecosystems. It is crucial that the incentives such mechanisms create contribute to risk reduction efforts. Such incentives need to catalyse resilience investments by homeowners, companies and public entities. Moreover, participation for insurance companies in publicly backed or mandated insurance schemes should be conditional on them not fuelling the insured risks by investing in and underwriting activities incompatible with global climate and nature goals.

The earlier that governments and financial market authorities take decisive action the more likely it is that risks and losses can be reduced, and government budgets and people's livelihoods protected.

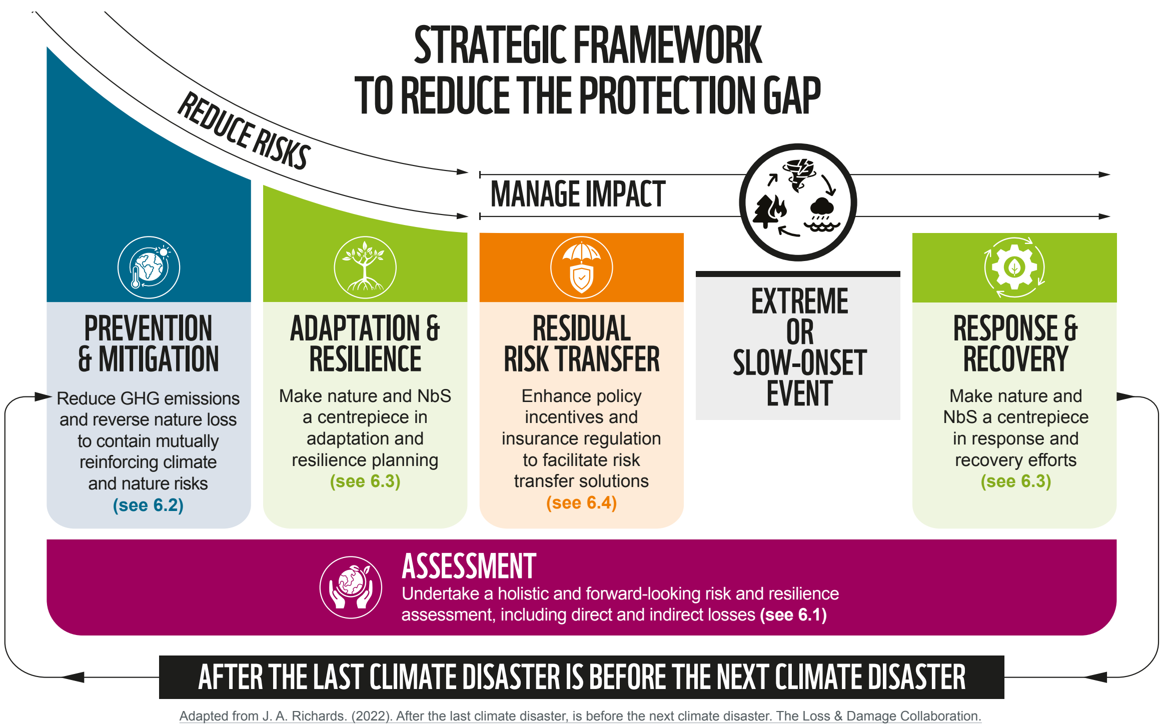

***Figure 20:** Strategic framework to reduce the protection gap*

MEDIUM-TERM ACTIONS

LEADERSHIP

Collaborate with governments, multilateral development banks, development finance institutions, NGOs and other partners to gather resources and expertise. Bring together financial institutions to boost NbS initiatives and create platforms for exchanging insights on NbS-related financing products. Facilitate forums where stakeholders can develop financial instruments or vehicles that help channel funding toward NbS and solutions focused on water security.

MICROPRUDENTIAL POLICY

Account for water-related risks in prudential requirements including capital requirements and credit guidance. Financial institutions should be expected to hold more capital or have limited credit exposures to companies or assets operating in areas of extreme water stress or contributing to intensifying water stress that do not have robust transition plans, water-resilience measures and associated policies in place.

Establish mandatory water-related due diligence and target-setting for financial institutions. Financial institutions should be expected to adopt targets (matched by science-based and timebound transition plans) showcasing their commitments towards ensuring that they are not jeopardizing efforts towards a water-secure future and adopt due diligence policies accordingly. CBFRs should engage at an international level to ensure a level playing field to minimize potential leakage effects. Provide guidance on mainstreaming NbS in investment strategies, transition plans and disclosures, giving clearer incentives for action.

Expect public disclosure of financial institutions' exposures to high-water-risk sectors and to water-sensitive locations. These expectations should particularly cover neglected matters such as pollution, encouraging enhanced reporting by financial institutions on portfolio exposures to clients with an inadequate wastewater management, and align with internationally recognized standards and the Global Framework on Chemicals.

Set up dedicated teams or departments to monitor and supervise sustainability disclosures and transition plans by financial institutions. To ensure effective oversight, central banks and regulators should create specialized units with the expertise to evaluate banks' and insurers' sustainability disclosures and transition plans, including those related to freshwater impacts. These teams can help improve data quality, identify greenwashing, and guide institutions through the transition to nature-positive business models.

MACROPRUDENTIAL POLICY

Develop a risk monitoring dashboard that spans climate and nature-related risks, and include relevant facets of water-related risks on water quantity and quality, water infrastructure, and freshwater ecosystems.

Conduct regular stress-testing exercise for both insurance and banking sectors; particularly consider spillover effects and interactions in the context of water-related risks. If such assessments already exist for considering climate-related risks, integrate broader water-related metrics that go beyond droughts and floods to capture compounding and feedback effects between water-nature-climate interactions.

MONETARY POLICY

Develop preferential reserve tiering, lending facilities and refinancing lines linked to water security and resilience. For example, developing water resilience-focused refinancing lines can incentivize commercial banks to reduce water-related risk exposure and broaden viable investment or lending opportunities aimed at enhancing water security.

ENABLING ENVIRONMENT

Support sustainable financing through the development of interoperable water security related activities taxonomies. Central banks and financial regulators can play a key role in promoting credible blue/water finance by supporting the development and harmonization of taxonomies for water security. These frameworks help define what qualifies as sustainable water investment, enabling consistency across markets and reducing the risk of mislabelling or greenwashing.

Issue or support innovative financial products aimed at growing the market for water security and resilience investments, such as green/blue bonds earmarked for NbS projects.

ANNEX

GLOSSARY OF TERMS

TERM	DEFINITION
Blue water	Water in surface water and groundwater
Green water	Water moisture stored in soil and vegetation – for the purpose of this report also including freshwater biodiversity and ecosystems.
Grey water	Referring to wastewater and related infrastructure (Global Commission on the Economics of Water, 2024; Hoekstra et al., 2011)
Nature-related risks/ water-related risks	"potential threats (effects of uncertainty) posed to an organization that arise from its and wider society's dependencies and impacts on nature. Such risks can be physical risks, transition risks or systemic risks" (TNFD, 2023).
Nature-related financial risks / water-related financial risks	"Nature-related financial risks refer to the risks of negative effects on economies, individual financial institutions and financial system that result from: i) the degradation of nature, including its biodiversity, and the loss of ecosystem services that flow from it (i.e., physical risks); or ii) the misalignment of economic actors with actions aimed at protecting, restoring, and/or reducing negative impacts on nature (i.e., transition risks)" (NGFS, 2024b). The equivalent is transferable to water.
Water stress	"Water stress" refers to the ability, or lack thereof, to meet human and ecological demand for fresh water. Compared to scarcity, "water stress" is a more inclusive and broader concept. It considers several physical aspects related to water resources, including water availability, water quality and the accessibility of water (i.e. whether people are able to make use of physically-available water supplies), which is often a function of the sufficiency of infrastructure and the affordability of water, among other things. Both water consumption and water withdrawals provide useful information that offers insight into relative water stress. There are a variety of physical pressures related to water, such as flooding, that are not included in the notion of water stress. Water stress has subjective elements and is assessed differently depending on societal values. For example, societies may have different thresholds for what constitutes sufficiently clean drinking water or the appropriate level of environmental water requirements to be afforded to freshwater ecosystems, and thus assess stress differently (CEO Water Mandate, 2017).
Drought	Drought is defined as a deficiency of precipitation over an extended period of time (usually a season or more), resulting in a water shortage (National Drought Mitigation Center, 2026).
Water scarcity	Water scarcity" refers to the volumetric abundance, or lack thereof, of freshwater resources. "Scarcity" is human-driven; it is a function of the volume of human water consumption relative to the volume of water resources in a given area. As such, an arid region with very little water, but no human water consumption would not be considered "scarce," but rather "arid." Water scarcity is a physical, objective reality that can be measured consistently across regions and over time. Water scarcity reflects the physical abundance of freshwater rather than its quality. For instance, a region may have abundant water resources (and thus not be considered water scarce), but have such severe pollution that those supplies are unsuitable for human or ecological uses (CEO Water Mandate, 2017).
Water security	"Availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems, and production, coupled with an acceptable level of water-related risks to people, environments, and economies" (Grey & Sadoff, 2007).

FRESHWATER SYSTEMS IN A NUTSHELL

Table 11: *Freshwater in a nutshell: exemplary/non-exhaustive benefits and drivers of degradation*

BLUE WATER: GROUNDWATER AND ITS BENEFITS	DRIVERS OF GROUNDWATER DEPLETION AND CONTAMINATION
Groundwater is stored within aquifers (layers of saturated sand, gravel or porous rock) underground. More than 80% of groundwater that is within 1 km of the earth surface is fossil water – that is, water that dates back more than 12,000 years to Pre-Holocene times. These aquifers are so deep that they do not get replenished by percolation (Richter & Ho, 2022). **Human settlements and drinking water:** Urban and rural areas are highly dependent on groundwater resources. Around half of global drinking water comes from the supply of groundwater resources (The Nature Conservancy, 2022). Countries with high reliance on groundwater for their populations' drinking water include Bangladesh, Central African Republic, Chad, Malawi, Nigeria, Afghanistan and India (Danert, 2019). **Irrigation for agriculture:** Around 70% of groundwater withdrawals are used for agricultural irrigation. This rate is higher in arid and semi-arid regions (UNESCO, 2022). **Industry water:** Industry is responsible for 19% of global freshwater use that also includes groundwater. However, the rate varies between regions, ranging from 5% in Africa to 57% in Europe. For some industries, such as water-bottling, groundwater makes up the product's raw material. In certain industries, groundwater is not a primary resource but rather becomes a recipient for pollution (UNESCO, 2022). **Hazard buffers:** Groundwater systems provide buffers against climate-change-induced water availability fluctuations by acting as a water storage mechanism (UNESCO, 2022). **Ecosystem regulation via baseflow:** Groundwater flow is a significant contributor to the streamflow of surface water bodies, including rivers and streams (UNESCO, 2022; Winter et al., 1998).	Globally, groundwater resources have been being depleted at an accelerating rate since 2000, driven by over-abstraction (mostly for irrigation) (Jasechko et al., 2024), and groundwater quality is increasingly becoming a challenge with urban, industrial and agricultural run-off and groundwater infiltration (UNESCO, 2022). In particular, abstraction of fossil water leads to irreversible depletion. India, Pakistan, the United States, Iran, China, Mexico and Saudi Arabia are the countries with the highest rates of fossil water extraction (Richter & Ho, 2022). **Climate change and soil degradation:** Shifts in precipitation and extended dry spells can reduce groundwater recharge by lowering soil absorption, limiting percolation even when it rains. **Pollution:** Run-off from agricultural and industrial activities – including nitrates, pesticides and various other chemical and organic pollutants – can infiltrate groundwater aquifers. Contamination of these water sources is often irreversible; once an aquifer is polluted, the entire zone may remain affected (UNESCO, 2022). **Overexploitation:** The extraction of groundwater beyond its natural replenishment rate can lead to local water stress and has been associated with increased salinization of groundwater, higher concentrations of pollutants and land subsidence. Land subsidence may increase the impacts of rising sea levels and saltwater intrusion (Davydzenka et al., 2024; NASA Earth Observatory, 2024). This is becoming a significant issue in urban areas that depend on groundwater and have an infrastructure which is vulnerable to land subsidence (UNESCO, 2022). A recent global study found that approximately 73% of mapped subsidence is in cropland and urban areas, indicating the necessity for effective groundwater management practices in these regions (Hasan et al., 2023)

BLUE WATER: SURFACE WATER AND ITS BENEFITS	DRIVERS OF SURFACE WATER DEGRADATION AND DEPLETION
Surface water is freshwater above ground which includes lakes, rivers, streams and ponds. It is both lentic (still/slow-moving) and lotic (flowing). **Sediment supply:** Rivers transport sediments critical to the health of downstream ecosystems (e.g. coastal mangroves, coastal dunes, deltas) which in turn provide key flood risk reduction services (Opperman et al., 2018). **Flood mitigation:** Naturally meandering free-flowing rivers can help slow the speed of water flow under extreme precipitation regimes and reduce fluvial flood risk (Opperman et al., 2018). **Food security:** Rivers are key for food production not only as sources of irrigation but also as hosts for fish, supporting protein demands. Even marine-based activities rely on the nutrient and sediment cycling enabled by rivers. In fact, it is estimated that 40% of global fish consumption depends on rivers, which amounts to 4% of the global protein supply. Currently, half of the fish consumed globally comes from aquaculture. Two-thirds of farmed fish depends on river systems (WWF, 2021). **Supporting economic activities:** Generally, rivers provide important sources of livelihoods. For example, it has been estimated that the Cuando River catchment in Angola, Namibia, Botswana and Zambia provides jobs to local communities responsible for generating more than two-thirds (71%) of the region's GDP (Chivava et al., 2021). **Cultural values:** For many communities, Indigenous Peoples and religious groups, rivers represent holy sites and are part of their spiritual practice (see IUCN (2021)). Lakes and rivers are also important recreational areas serving local communities and tourists.	Only about 37% of rivers longer than 1,000 km remain free-flowing along their entire length, while only 23% run uninterrupted to the ocean (Grill et al., 2019). Meanwhile, surface water quality is declining or becoming costlier to maintain with increasing urban, industrial and agricultural pollutants leaching into lakes and rivers. **Climate change:** Less rainfall and summer snowmelt lower lake and river levels. Warmer surface water and less circulation can increase pollution and allow invasive species to thrive in higher temperatures. **Pollution:** Nutrient-rich agricultural and industrial runoff can promote algal growth in lentic ecosystems, which may decrease oxygen levels and impact aquatic organisms, potentially leading to the development of dead zones if not addressed. Additionally, industries that use surface water for cooling, such as data centres and nuclear power plants, can cause temperature changes in water bodies; when combined with rising average water temperatures, this may also affect aquatic life. **River barriers and disruptions:** Dam infrastructure or other river diversions degrade free-flowing river characteristics. Construction and conversion of riverbanks amplify exposure and vulnerability towards extreme weather events. **Overexploitation:** Riverbed mining, which is increasing to meet construction and infrastructure development, is degrading river health by increasing turbidity with cascading effects on dissolved oxygen levels and the aquatic environment (Damseth et al., 2024). **Invasive species:** Recreational fishing and ballast water from trade ships facilitate the spread of invasive species that is disrupting lakes' and rivers' health (see Vander Zanden et al. (2024) for north temperate lakes; Golebie et al. (2021)).

GREEN WATER AND INFRASTRUCTURE: SOIL, VEGETATION MOISTURE AND WETLANDS/FRESHWATER ECOSYSTEMS AND BIODIVERSITY	DRIVERS OF WATER MOISTURE DEGRADATION, FRESHWATER ECOSYSTEM HEALTH AND FRESHWATER BIODIVERSITY DECLINE
Atmospheric rivers: Evapotranspiration from surfaces produces water vapour that contributes to downwind precipitation patterns. This process plays a role in rainfed activities, including agriculture and groundwater recharge. The Amazon rainforest demonstrates this effect for the surrounding region. For instance, in Brazil only about 6% of cropland is watered via irrigation, the rest being heavily dependent on rainfall (Meineke, 2024). **Carbon sequestration:** Wetlands are a key carbon sink despite taking up a relatively small amount of global landscapes (Ida, 2023). Particularly, peatlands make up about 3% of our planet's land yet store approximately 30% of all land-based carbon (Convention on Wetlands, n.d.-c). **Water purification:** Wetlands play a crucial role in water purification and pollutant removal (Ferreira et al., 2023) saving billions of dollars annually on water that otherwise would have to be treated. For example, in 1997, New York City determined that, instead of investing US$3–8 billion in new wastewater treatment plants with an estimated US$700 million in annual operating costs, it could allocate approximately US$1.5 billion toward land acquisition and conservation management to protect wetlands in the catchment. These wetlands would serve to purify the public water supply (Convention on Wetlands, n.d.-a). **Climate resilience:** Wetlands provide a key benefit in buffering against hydrological extreme weather events, such as pluvial and fluvial floods or any similar storm water. **Habitat and biodiversity hotspots:** Wetlands provide an important habitat for a myriad of species. Around 40% of global plant and animal species, including 30% of all known fish species, rely on wetlands. Over 100,000 freshwater species live in these habitats, with 200 new ones identified each year (Convention on Wetlands, n.d.-b). Freshwaters support over 10% of all known species, including approximately one-third of vertebrates and one-half of fishes (Sayer et al., 2025). **Freshwater-related ecosystem engineers:** Different species provide disproportionately important functions to the maintenance of a specific ecosystem. For example, so-called soil engineers, such as the dung beetle, create tunnels for soil aeration to enable hydration. Another water-related ecosystem engineer is the beaver, that creates changing sediment flow dynamics via its small-scale dam building (Timmins et al., 2024)	Overall water moisture in vegetation is declining, our freshwater ecosystem health is degrading, and freshwater biodiversity is sharply dropping. One-quarter of freshwater animal life is at risk of extinction (Sayer et al., 2025). Freshwater species populations are hit the hardest, according to the Living Planet Report. Since 1970 the average population size of freshwater species has declined by 85%, while the overall average decline of monitored wildlife populations has been 73% (WWF, 2024b). **Land conversion/deforestation:** Tropical deforestation is disrupting patterns of evapotranspiration and consequently altering flying river systems (C. Smith et al., 2023). These changes contribute to reduced precipitation, increased incidence of drought, decreased evapotranspiration rates and a heightened risk of wildfires. Such developments may initiate self-reinforcing feedback loops that could result in irreversible ecosystem tipping points and collapse. **Freshwater land conversion:** Since the 1700s, 87% of global wetlands have disappeared – 35% have been lost since the 1970s. Today, wetlands are vanishing three times faster than forests. Key drivers of wetland loss are drainage and infilling for agriculture (Convention on Wetlands, n.d.-b). **Pollution:** Microplastics, fertilizers and pesticides are disrupting wetlands and freshwater habitats by altering oxygen levels and food webs, as well as causing reproductive issues through micropollutants. **Climate change:** A study using satellite data found that climate change may be causing an overall loss of soil moisture (Seo et al., 2025). Additionally, increasing temperatures are affecting aquatic health with species negatively impacted by warming water temperatures. Extreme weather events exacerbate pollution risk, impacting freshwater biodiversity.

GLACIERS, ICE SHEET, GROUND ICE, SNOW COVER AND PERMAFROST BENEFITS

Up to 60% of the world's freshwater originates in mountains. Glaciers and snow cover in mountains function as natural water towers, managing the balanced flow of water seasonally and interannually. While all mountains play a role in their downstream freshwater systems in some shape or form, each region depends in different ways on its mountainous freshwater sources (UNESCO, 2025).

Freshwater supply: Glaciers and snow cover can be important freshwater sources for downstream communities, cities, towns, and agricultural land and industry, especially during summer low-flow periods (UNESCO, 2025).

Run-off regulation: Stable and predictable glacial melt can compensate for water scarcity during warmer seasons (UNESCO, 2025).

Seasonal tourism: Snow-packed seasons enable tourism such as mountaineering and skiing (UNESCO, 2025).

DRIVERS OF WHITE-WATER DEPLETION

A mismatch between the timing of mountain runoff and downstream water demand can present challenges for water users.

Climate change: Rising global and mountain temperatures are causing glaciers to melt more rapidly, permafrost to thaw, and more precipitation to fall as rain instead of snow. This leads to reduced snow cover and retreating glaciers, with peak water flow typically in spring and lower meltwater rates in summer and autumn (UNESCO, 2025). It is thought that there is now more water melting from ground ice than there is from large glacial ice sheets (Chandanpurkar et al., 2026).

Pollution: Dust from wildfires, black carbon or other pollutants may infiltrate glaciers and snow cover. This may accelerate melting until the next snowfall, due to reduced albedo (UNESCO, 2025).

GREY WATER AND INFRASTRUCTURE

Wastewater treatment and sanitation infrastructure are essential for public health, environmental sustainability and the effective operation of society. They are fundamental to upholding human dignity and play a vital role in supporting a productive economy.

Water treatment infrastructure and health: Water treatment infrastructure is associated with improvements in public health through the reduction of exposure to waterborne pathogens and contaminants linked to diseases, including bacterial infections and heavy metal poisoning. Research indicates that investments in such infrastructure can lower disease mortality, regardless of income levels, by preventing conditions such as diarrhea, respiratory illnesses and vector-borne diseases, which may also reduce healthcare costs, hospitalizations and mortality rates among populations including children (OECD, 2011).

Water infrastructure and economic growth: Access to critical water infrastructure is a key cornerstone to economic growth. Among low-income countries, those with enhanced access to water and sanitation services demonstrate higher rates of economic growth. Countries in this category that have improved access to clean water and sanitation report an average annual growth rate of 3.7%, whereas comparable low-income countries lacking such improvements experience an average annual per capita GDP growth of just 0.1% (SIWI, 2005).

DRIVERS OF DECLINING GREY INFRASTRUCTURE

Between 2015 and 2024, about 2.1 billion people, representing 26% of the global population, did not have access to safely managed drinking water (WHO & UNICEF, 2025). Eighty percent of individuals residing in rural regions lacked basic drinking water services. In terms of sanitation, approximately 3.5 billion people globally were without access to safely managed facilities that year. Coverage rates for these services were around 50% in Latin America, the Caribbean, Central and Southern Asia, and 24% in Sub-Saharan Africa (UNESCO, 2025). Each day, more than 1,000 children under the age of five died as a result of diseases associated with WASH-related issues (UNICEF, 2023). Outdated infrastructure that is increasingly affected by climate change, as well as governance models that may lack sustainability, also present ongoing challenges in high-income countries.

Outdated infrastructure: As infrastructure ages, its vulnerability to climate extremes becomes increasingly apparent. Leaks, under-capacity and declining efficiency are persistent issues that erode the reliability of water systems. This mismatch between infrastructure resilience and evolving environmental pressures creates significant challenges for both urban and rural communities. Moreover, maintenance and upgrades are often delayed due to budget constraints or competing priorities, leaving critical systems exposed. The cumulative effect is a growing risk of service disruptions, water loss and public health concerns – consequences that ripple through societies already grappling with climate-induced hazards.

Climate change: Outdated infrastructure combined with increasing extreme weather events are leaving critical water infrastructure vulnerable and with management choices that may have adverse consequences for society and the environment (e.g. de-burdening sewage overflow by dumping untreated water in rivers).

COMPANY-SPECIFIC INSIGHTS ON WATER-RELATED RISKS

Table 12: *Water-related risks and resilience – company-specific insights*

COMPANY	COMPANY SECTOR	DESCRIPTION	ECONOMIC/FINANCIAL KPIS IMPACTED
K+S Mining	Mining	K+S Mining faced severe operational and financial losses in 2018 after drought-triggered legal wastewater limits forced a 64-day production shutdown	• The company largely suspended production at its Werra plant for 64 days, incurring a €1.5 million daily loss. • Net debt/EBITDA rose from 0.5 (2011) to 7.3 (2018). • Its share price fell to €15.77 (lowest in >10 years). • Credit rating: S&P went from stable to negative; Moody's went from Ba1 to Ba2. • It had a CapEx of €180 million for a new salt-processing plant designed to reduce wastewater plant and needed new storage facilities for water resilience.
Adani	Coal	Coal mine and related infrastructure in Australia strained by aquifer depletion, regulatory hurdles, community opposition and water-related litigation (2022)	• US$1.25 billion at risk (before looking at potential losses from connected projects, amounting to around US$7 billion). • Initial production capacity plans down from 60MMT to 10MMT, due to scaling-down of operations. • Proforma drop in total assets by 14% and equity by nearly 50% from US$2.6 billion to US$1.3 billion. • Stranded assets write-off adjustment (SAWOA) totalling US$1.25 billion (non-cash, exceptional). • Difficulties accessing banking and insurance; potential refinancing challenges.
Exelon Corporation	Electric utilities	Oyster Creek nuclear power station in the USA retired early due to regulatory changes involving water use and thermal pollution (2022)	• US$0.9 billion at risk. • Early decommissioning costs and liabilities nearing US$1 billion • Minimal balance sheet impact due to asset's small share of total portfolio. • Overall P&L impact approx. US$270 million over several years (insignificant proportion of total earnings). • Little to no debt impact around decommissioning period. • Share price performance shows no clear link to asset-stranding event.
Barrick Gold Corporation	Metals and mining	Pascua-Lama gold mining project stranding in Chile/ Argentina due to water pollution, community opposition, and water-related litigation (2022)	• US$7.5 billion cumulative write-downs impacting company valuation. • Balance sheet assets related to project dropped from US$6.3 billion to a fair value less cost to dispose (FVLCD) of US$398 million by 2019. • Significant impairment charges including US$6 billion in 2013 and further charges in subsequent years. • Share price declined by more than 50% between 2011 and 2013 coinciding with impairments and commodity price drops • Ongoing tail of liabilities linked to class actions, fines and environmental remediation. • Shareholder class action in US and Canada linked to action/ performance .
TC Energy (formerly TransCanada Corporation)	Oil and gas	Keystone XL pipeline extension project stranded due to permit withdrawals; community opposition related to water pollution risks (2022)	• C$5 billion cumulative write-downs related to project impairment. • Significant year-on-year decline in equity and increased leverage ratios after 2015 write-down. • Net losses of C$1.2 billion and impact on reported earnings. • Continued debt refinancing support despite project challenges. • Share price showed limited but noticeable declines amid permit denial and project cancellations.

SECTOR-SPECIFIC INSIGHTS ON WATER-RELATED RISKS

***Table 13:** Water-related risks and resilience – sector-specific insights*

SECTOR	METHODOLOGY	SCOPE	ECONOMIC/FINANCIAL KPIS IMPACTED
Pharma-ceuticals	WWF's Water Risk Filter: synthesizing data from both the EMA EuraGMDP and FDA Drug Establishment databases (Dobson, 2022).	An assessment covering over 5,272 global pharmaceutical manufacturing sites with major clusters in Europe, India, the US and China	• **High water quality risk:** 88% of pharma sites face very high or high water quality risks, impacting operations and local relationships. • **Concentration risk and supply chain vulnerability:** 60% of sites cluster in 27 basins with flooding and water risks, risking broad disruptions. • **Rising future risk:** Sites exposed to extreme and very high water quality risks may increase from 55% to 75% by 2050 due to climate change. • **Reporting gaps:** While 80% of the top 30 global pharmaceutical companies publicly disclose quantity-related water targets, only 30% address water quality risks. Upstream coverage is particularly limited, with just 3% reporting water-related activities or risk assessments linked to raw materials. • **Regulatory threats:** 25% of sites exposed to high or very high water scarcity; future enforcement weakness raises legal and financial risks.
Mining	Combined WWF Water Risk Filter and S&P Global Market Intelligence data using a spatial join/ GIS operation (Morgan & Dobson, 2020).	Global scope covering 3,174 active mines, 73% in top 10 countries with active and operating mine sites, analysing major basins and top publicly-listed mining companies	• **Flood and reputational risks highest:** Coal and chromite face average basin water risk scores above 3 (with 5 being the highest). Floods and water scarcity can disrupt mining operations, leading to billion-dollar losses for companies and shareholders. • **Concentration risk:** 50% of chromite mines and 55% of platinum mines are clustered in single basins, risking systemic supply shocks. • **High exposure to basin water risk** in India, China and South Africa worsens potential credit and market risks for investors.
Power generation	Solar radiation models, gasification and biodigestion calculations and demographic projections to estimate renewable energy potentials in Mato Grosso and Mato Grosso do Sul states (Voivodic et al., 2020).	Upper Paraguay Basin in Brazil, focusing on Mato Grosso and Mato Grosso do Sul states, analysing solar, biomass, waste and wastewater energy projects	• **Ecosystem service decline and flood risks:** Hydropower projects threaten ecosystem services; flooding up to 1,625km² could disrupt fisheries, tourism and local livelihoods. New dams risk altering water quality and hydrology, compromising economic activities and raising compliance costs for investors. • **Other renewable energy sources enable risk diversification:** Relying solely on hydropower risks systemic economic losses during drought years or environmental incidents. • **Opportunities:** Job creation potential from renewables (people employed by these industries would be around 29,000 jobs by 2030) offsets macroeconomic shocks, supporting regional income and reducing unemployment volatility.

	Using the WWF Water Risk Filter to Screen Existing and Projected Hydropower Projects for Climate and Biodiversity Risks (J. J. Opperman et al., 2022).	Global existing and projected dams (n= 6,188 dams)	• **Water scarcity risk:** Ca. 26% of existing hydropower dams and 23% of projected dams are located within river basins facing medium to very high water scarcity risk. • **Climate-driven risk amplification:** Climate change is increasing the risk of 32% and 20% of the existing and projected dams by 2050. • **Flood risk:** 75% of existing dams and 83% of projected dams are located within river basins with medium to very high flood risk. • **Risk skewing:** The proportion of hydropower dams in basins with the highest levels of flood risk is projected to increase by a factor of nearly 20 (i.e. from 2% to 36% of dams). • **Negative freshwater ecosystem impacts:** 76% of existing dams and 93% of projected hydropower dams are located in river basins with high or very high freshwater biodiversity importance.
Textile	Textile Traceability data, supplier engagement, basin risk assessments, stakeholder input to set science-based water and land targets (SBTN, 2024a).	Central India and Eastern Cape, involving H&M Group in the global textile supply chain	• **Data gaps:** Traceability gaps and limited local data hinder precise water risk assessments and target-setting in textile supply chains. • **Blindspots:** Current methods miss key textile pollutants like pesticides and manufacturing wastewater, limiting full freshwater impact coverage.
	The water risks and opportunities facing apparel and textiles clusters (WWF, 2022).	Identification of 82 clusters (over 75,000 sites) with highest spatial density of apparel and textiles sites using WWF Water Risk Filter and key data set from Open Supply Hub	• **Cluster risk:** Textile and apparel sites are clustered in relatively few basins; the most notable clusters are in China, Bangladesh, Turkey and India. • **Persistent and increasing water scarcity risk:** Major clusters are already exposed to high physical water risk and will increasingly be so by 2050. Various clusters are projected to shift from high risk to extreme risk by 2050, including Chennai (India), Casablanca (Morocco), Bangalore (India), Tanger (Morocco), Los Angeles (USA), Karachi, (Pakistan), Shijiazhuang (China), Jaipur (India) and Beijing (China). • **Persistent and increasing water quality risk:** In 2020 56 clusters across 49,896 sites representing 50% of all assessed locations were exposed to above medium water quality risk. A total of 44 clusters are expected to be exposed to extreme water quality risk by 2050. • **Compounding risks:** Clusters across different geographies may be facing similar compounding challenges, like being highly exposed to the effects of water scarcity, water quality and flooding. For such clusters nature-based solutions, such as wetland protection, would be an efficient and effective measure to tackle all three issues. • **Intersectoral opportunities:** High-density clusters, that are shared with other industries, offer important opportunities for collective approaches to mitigating water-related risks and improving freshwater system health.

Food (fisheries)	**Combined biodiversity assessments, population declines, threat analysis, and ecosystem recovery plans using global freshwater fish data and expert input (Hughes, 2021).**	Global assessment, including major river basins (Amazon, Mekong, Congo etc.), lakes and wetlands across multiple continents led by a collaboration of 16 leading conservation, scientific and environmental organizations advancing freshwater fish conservation and biodiversity	• **Food security:** Freshwater fisheries provide livelihoods for 60 million people, representing 2.5–6% of the global agricultural workforce. • **Economic value:** Wild freshwater fisheries generate more than US$38 billion annually, supporting many local and national economies. • **Concentration risk:** 90% of the global freshwater fish catch comes from river basins facing above-average environmental stress levels. Declines in freshwater fish populations risk disrupting food security and local economies, especially in vulnerable communities.
Agriculture (conventional)	**DPSIR framework combining global data, remote sensing, modelling and socioeconomic analysis to evaluate land and freshwater resource status and trends (FAO, 2021).**	Global land and water systems by involvement primarily of governments, NGOs, research institutions, and multiple sectors	• **Loss of crop productivity:** Degraded cropland and water scarcity reduce crop and livestock productivity, threatening commodity supply stability and farmer incomes (estimated US$ 3.8 trillion worth crops and livestock production has been lost over the last 30 years due to disasters, with flooding being a primary driver (FAO, 2023). • **Water use:** Agriculture consumes 70% of global freshwater, escalating water stress and risking disruptions in commodity production and market access. • **Increasing treatment costs:** Groundwater depletion and pollution increase irrigation costs, affecting long-term viability and cost structures of crop and livestock commodities. Agricultural runoff pollution from fertilizers, pesticides, and animal waste raises water treatment costs and degrades ecosystem services critical to commodity systems. • **Resilience investing:** Increasing water scarcity and drought frequency elevate production risks for commodities, prompting a need for investment in resilient water management and adaptive farm practices.

NON-EXHAUSTIVE OVERVIEW LIST OF INITIATIVES ADDRESSING FRESHWATER CHALLENGES

Table 14: *Water-related risks and resilience – sector-specific insights*

			PARTICULARLY ADDRESSING CHALLENGES OF				
INITIATIVE	EXAMPLE	DESCRIPTION	TOO MUCH	TOO LITTLE	TOO DIRTY	BROKEN GREEN & GREY INFRASTRUCTURE	BROKEN GOVERNANCE
(Inter)governmental initiatives, conventions, coalitions and global frameworks	Kunming-Montreal Global Biodiversity Framework	The Kunming-Montreal Global Biodiversity Framework, adopted in December 2022, sets four goals and targets for 2050 and 23 targets for 2030 with the broad aim of humans living in harmony with nature. Key targets also include freshwater elements such as: • Target 2: Restore 30% of all degraded ecosystems (including inland water) • Target 3: Conserve 30% of land, waters and sea • Target 14: Integrate biodiversity in decision-making at every level • Target 15: Businesses assess, disclose, and reduce biodiversity-related risks and negative impacts In parallel, Parties to the Convention on Biological Diversity are encouraged to develop national Biodiversity Finance Plans to identify funding needs and mobilise resources for implementation. As of 2025, over 130 countries are developing or implementing such plans, providing a practical reference point for aligning financial policies and assessing whether key issues, including freshwater, are adequately addressed.				✓	
	Ramsar Wetlands Convention	The Ramsar Wetland Convention, established in 1971, is an international treaty aimed at the conservation and sustainable use of wetlands. It recognizes the ecological importance of wetlands and promotes their protection to maintain biodiversity and support human well-being. The contracting parties generally commit to: • Sustainable use of wetlands • Designation of suitable wetlands to the list of Wetlands of International Importance, the so-called "Ramsar List", and to effectively manage these • Cooperate on transboundary wetlands and species at international level Currently there are 172 contracting parties to the Convention.				✓	
	Sustainable Development Goals (SDGs)	The SDGs are a set of 17 global goals established by the United Nations in 2015 to promote peace, prosperity and sustainability worldwide. They cover various areas such as poverty, education, gender equality, climate action, and more. Freshwater challenges play a prominent role in SDG 6 (Clean Water and Sanitation), SDG 13 (Climate Action) and SDG 15 (Life on Land).	✓	✓	✓	✓	✓

INITIATIVE	EXAMPLE	DESCRIPTION	TOO MUCH	TOO LITTLE	TOO DIRTY	BROKEN GREEN & GREY INFRASTRUCTURE	BROKEN GOVERNANCE
(Inter)governmental initiatives, conventions, coalitions and global frameworks	UN Water Conference	The UN Water Conference is a high-level global platform to accelerate action on water and sanitation. It brings together governments and stakeholders to mobilise commitments, coordinate efforts, and advance solutions for global water challenges, including water scarcity, flooding, pollution, and infrastructure and governance gaps. A key outcome is the Water Action Agenda, which captures voluntary commitments toward SDG 6.	✓	✓	✓	✓	✓
	UN Water Convention	The UN Water Convention, formally known as the Convention on the Protection and Use of Transboundary Watercourses and International Lakes, is an international treaty that promotes cooperation and sustainable management of shared water resources. It aims to prevent conflicts and ensure the equitable use of transboundary waters. The convention was signed in 1992 and came into force in 1996. Signatory countries are primarily European.				✓	✓
	UN Convention to Combat Desertification	The UN Convention to Combat Desertification (UNCCD), established in 1994, is the only legally binding international agreement aimed at addressing desertification and mitigating the effects of drought. It promotes sustainable land management and encourages international cooperation to restore degraded land and improve the livelihoods of affected populations. There are 197 parties to the convention. Under the auspices of the UNCCD a multi-stakeholder coalition called the International Drought Resilience Alliance (IDRA) was established in November 2022 at UNFCCC COP27: it is a collaboration platform for more than 60 countries and actors such as multilateral development banks, financial institutions, NGOs, civil society and the private sector. A key initiative of the IDRA has been the International Drought Resilience Observatory, launched at UNCCD COP16 in October 2024, that provides actionable information on environmental and social drought resilience.		✓			
	Sendai Framework for Disaster Risk Reduction	The Sendai Framework for Disaster Risk Reduction 2015–2030 is a global blueprint aimed at substantially reducing disaster risk and losses in lives, livelihoods and health. It outlines four priorities for action: understanding disaster risk, strengthening disaster risk governance, investing in disaster reduction for resilience, and enhancing disaster preparedness for effective response.	✓	✓			✓
	COP29 Declaration on Water for Climate Action	The COP29 Declaration on Water for Climate Action is a non-binding political commitment aimed at strengthening the integration of water into global climate and environmental agendas. The Declaration can be supported by national governments as well as other stakeholders, such as international organizations, financial institutions, private sector entities, academia and civil society organizations, and is endorsed by more than 70 countries and a range of non-state actors. As part of the Declaration, the Baku Dialogue on Water for Climate Action was launched as a COP-to-COP collaboration platform to promote coherence and continuity in work related to the integration of water in climate change, biodiversity loss, pollution and desertification. The Declaration also highlights the need to mainstream water-related concerns in the design of national adaptation plans (NAPs), nationally determined contributions (NDCs), and national biodiversity strategies and action plans (NBSAPs).	✓	✓	✓	✓	

INITIATIVE	EXAMPLE	DESCRIPTION	TOO MUCH	TOO LITTLE	TOO DIRTY	BROKEN GREEN & GREY INFRASTRUCTURE	BROKEN GOVERNANCE
Multistakeholder initiatives	G7 Water Coalition	In a meeting between G7 Ministers of Climate, Energy and the Environment in April 2024, political leaders decided to launch a Water Coalition. The G7 Water Coalition seeks to identify common goals and strategies, catalyse shared ambitions and priorities to address the global water crisis, and integrate water's cross-sectoral relevance into existing forums and processes. This includes raising the political focus on water at the global level, enhancing the impact of the G7, and complementing other global initiatives.	✓	✓	✓	✓	✓
	Commission on the Economics of Water	The Global Commission on the Economics of Water, established in 2022, aims to redefine how we value and govern water by recognizing the hydrological cycle as a global common good. It focuses on driving radical changes in water management, promoting sustainability, social equity and economic efficiency through concerted action and collaboration across sectors and scales.		✓		✓	✓
	Flood Action Coalition	The FloodAction Coalition, convened by The Conduit, is a multi-stakeholder initiative that brings together insurers, investors, landowners and environmental organisations to address increasing flood risk. It focuses on scaling nature-based solutions as investable approaches to improve flood resilience, supported by a steering group of public and private sector actors.	✓			✓	✓
	Water and Climate Coalition	The Water and Climate Coalition was established in 2020 by ten UN entities (WMO, FAO, IFADD, UNDP, UNECE, UNEP, UNICEF, UNU, UNESCO, WHO) to tackle gaps that were identified in the UN SDG6 Global Acceleration Framework. The Coalition consists of leaders and members. The former are responsible for providing high-level guidance to the members of the coalition and mainstreaming the integrated water and climate agenda in the political debate. Members are diverse organizations who work together on a set of activities, such as improving data collection and access, to tackle climate and water challenges.	✓	✓		✓	
	Valuing Water Initiative	Supported by the Dutch government, the Valuing Water Initiative, inspired by the UN Valuing Water Principles, aims to prioritize water in decision-making processes by recognizing its multiple values. It promotes sustainable, equitable and efficient water management through collaboration across sectors and regions, ensuring water's essential role in all aspects of life is acknowledged and protected.		✓	✓	✓	✓
	Valuing Water Finance initiative	The Valuing Water Finance Initiative is an international investor-led effort aimed at encouraging companies with significant water usage to recognize and manage water as a financial risk, promoting substantial changes to protect water systems. This initiative is supported by the Valuing Water Initiative. As part of this initiative Ceres developed the Valuing Water Finance Initiative Benchmark where water stewardship among four key sectors – high-tech, food, beverage and apparel – are analysed against key corporate expectations.		✓	✓	✓	✓
	Global Water Challenge	The Global Water challenge is an industry-led cross-sector initiative to accelerate financial contributions and programmes aimed at improving WASH and climate resilience.				✓	

INITIATIVE	EXAMPLE	DESCRIPTION	TOO MUCH	TOO LITTLE	TOO DIRTY	BROKEN GREEN & GREY INFRASTRUCTURE	BROKEN GOVERNANCE
Multistakeholder initiatives	Water Futures Community (Global Water Initiative)	The Water Futures Community is a multistakeholder platform for the next generation of solutions and finance that addresses emerging systemic water challenges. It fosters public–private collaboration and advances the global water agenda through multistakeholder dialogue, thought leadership, and partnerships.	✓	✓	✓	✓	✓
	2030 Water Resource Group (WRG)	This initiative, supported by the World Bank, focuses on mobilizing investments for solutions that enhance water security. Collaborating with governments, corporations and civil society, the group addresses water-related risks impacting food systems, urban areas and ecosystems. Through strategic analysis, stakeholder engagement and facilitating financing, the WRG supports the scale-up of solutions that generate sustainable results. The WRG is funded through partner contributions and operates as a multi-donor trust fund administered by the World Bank's Global Department for Water.	✓	✓	✓	✓	✓
	50L Home	50L Home serves as a global platform for cities prioritizing water as a key component of urban resiliency; companies advancing low-carbon, water-efficient lifestyles; innovators redefining residential water use; and civil society organizations along with consumer networks. The coalition is co-coordinated by the World Business Council for Sustainable Development (WBCSD) and the World Economic Forum (WEF).		✓		✓	
	Global Framework on Chemicals	The Global Framework on Chemicals, a multistakeholder agreement that includes governments and intergovernmental organzations, the private sector, NGOs, academia and youth, was adopted in September 2023 at the fifth International Conference on Chemicals Management (ICCM5). The framework aims to protect both the planet and human health by advocating for strong governance mechanisms and enforcing international standards. The Framework encompasses five strategic objectives and 28 targets to guide countries and stakeholders in addressing chemicals across their life cycle, including products and waste.			✓		
	Freshwater Challenge	The Freshwater Challenge (FWC), launched at the UN Water Conference in March 2023 by six governments (Colombia, DR Congo, Ecuador, Gabon, Mexico and Zambia), is a flagship initiative under the UN Decade on Ecosystem Restoration and the Water Action Agenda. Its goal is to restore 300,000 km of rivers and 350 million hectares of wetlands by 2030, as well as protecting key freshwater ecosystems. National governments are members; non-state actors and private sector entities may offer support.				✓	✓
	Climate Resilience Alliance	The Alliance, led by the Z Zurich Foundation, brings together partners from humanitarian, NGO, research, and private sectors to boost climate resilience in rural and urban areas.	✓	✓			

INITIATIVE	EXAMPLE	DESCRIPTION	TOO MUCH	TOO LITTLE	TOO DIRTY	BROKEN GREEN & GREY INFRASTRUCTURE	BROKEN GOVERNANCE
Business initiatives	CEO Water Mandate	The CEO Water Mandate, established in 2007 by the UN Secretary General and the UN Global Compact, is a "commitment platform for businesses" and a global initiative that encourages corporate water stewardship. It aims to mobilize business leaders to address global water challenges through sustainable practices in six key areas: direct operations, supply chain management, collective action, public policy, community engagement, and transparency. Under the auspices of the CEO Water Mandate, the CEO Water Resilience Coalition was launched aiming to achieve positive water impact (covering quantity, quality and access) across 100 water-stressed catchments. Additionally, WASH4WORK was established as a multistakeholder initiative to accelerate business action on water, sanitation and hygiene (WASH) in the workplace and across supply chains.		✓	✓	✓	✓
Financial sector initiatives	Finance Leadership Group on Plastics	Established in early 2023, the Finance Leadership Group on Plastics is a core group of banks and insurers with total assets of US$9.8 trillion convened by UNEP FI and supported by the Minderoo Foundation. The group's objective is to address plastic pollution by aiding the creation of an international legally binding instrument and preparing the global finance sector for its implementation.			✓		
	Principles for Responsible Banking Pollution Working Group	A group of banks is developing a guide for the signatories of the Principles for Responsible Banking. This guide aims to enhance pollutant risk and impact assessment in the group's portfolios and identify alternative solutions to prevent and mitigate pollution in various high-impact sectors.			✓		
	Financing Agro-chemical Reduction and Man-agement (FARM) Programme	Through the Global Environment Facility's Financing Agrochemical Reduction and Management (FARM) Programme, UNEP FI, in collaboration with UNEP, the Green Growth Knowledge Platform (GGKP) and other partners, is developing a framework for sustainable financing in the agriculture sector. This project aims to address the impacts on the environment and human health of fertilizer run-off, pesticide contamination, and poor management of agricultural plastics.			✓	✓	
Sectoral certifications and standards	Alliance for Water Stewardship (AWS) Standard	AWS International Water Stewardship Standard (AWS Standard) is a globally applicable framework for major water users to understand their water use and impacts, and to work collaboratively and transparently for sustainable water management within a catchment context. The Standard is intended to drive social, environmental and economic benefits at the scale of a catchment. It achieves this by engaging water-using sites in understanding and addressing shared catchment water challenges as well as site water risks and opportunities. The standard is site-specific.		✓	✓	✓	✓

INITIATIVE	EXAMPLE	DESCRIPTION	TOO MUCH	TOO LITTLE	TOO DIRTY	BROKEN GREEN & GREY INFRASTRUCTURE	BROKEN GOVERNANCE
Regulatory frameworks	EU Water Framework Directive	Since 2000, the WFD has regulated water protection in Europe for inland, transitional and coastal surface waters and groundwaters. It takes an integrated, ecosystem-based approach by setting pollutant standards and using river catchment districts to encourage cross-border cooperation in shared water management.		✓	✓	✓	✓
	EU Urban Waste Water Treatment Directive	The revised Urban Wastewater Treatment Directive, effective from 1 January 2025, sets out requirements for the collection and treatment of urban wastewater in EU countries. Its purpose is to address the impacts of untreated urban wastewater on human health and the environment, ensuring cost-effective management by towns and cities. The directive is founded on the "polluter pays" principle, mandating that companies deemed to be significant contributors to micropollutant discharge are primarily responsible for bearing the supplemental costs associated with advanced micropollutant treatment.			✓		
	EU Nature Restoration Law	This regulation establishes a comprehensive restoration objective aimed at achieving the long-term recovery of nature across both terrestrial and marine environments within the EU. It sets binding targets for the restoration of specific habitats and species, requiring that at least 20% of the EU's land and sea areas be addressed by 2030, with the ultimate goal of restoring all ecosystems identified as needing restoration by 2050. The regulation contains specific targets covering freshwater elements, such as restoring drained peatlands and locating and removing barriers impeding surface water connectivity to achieve 25,000 km of free-flowing rivers by 2030.				✓	
	Mandatory insurance for business in Italy against natural disasters	In several jurisdictions, regulatory frameworks require, incentivise or support insurance coverage for natural disasters, including floods. These include mandatory or state-backed schemes (e.g. France and Spain), as well as voluntary public-private partnerships such as Flood Re in the UK, which aim to improve the affordability and availability of flood insurance. More recently, Italy introduced a requirement under its 2024 Budget Law for companies to insure fixed assets against natural disasters, including floods, earthquakes and landslides, with implementation from 2025.	✓				
	PFAS ban in France, New York and California in specific consumer products	France, California and New York have recently enacted bans on PFAS in consumer products due to environmental and health concerns. France: Law No. 2025-188 bans PFAS in cosmetics, most textiles, and ski waxes from January 2026, with all textiles included by 2030 except certain protective gear. The law also imposes a tax on PFAS polluters and requires stricter monitoring and public reporting of PFAS levels in drinking water. California and New York: Both US states banned PFAS in textiles and apparel as of January 2025, with California adding phased restrictions and disclosure requirements.			✓		
Target setting initiatives	Science Based Targets Network (SBTN)	The Science Based Targets Network (SBTN) is an initiative that helps companies and cities set science-based targets to address their environmental impacts. Their work spans various realms of nature, including freshwater. The SBTN has provided guidance on setting catchment-specific freshwater targets for water quantity (withdrawal) and water quality (nutrient load). A collaborative paper showcases the interoperability between the AWS Standard and SBTs for freshwater.		✓	✓	✓	

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