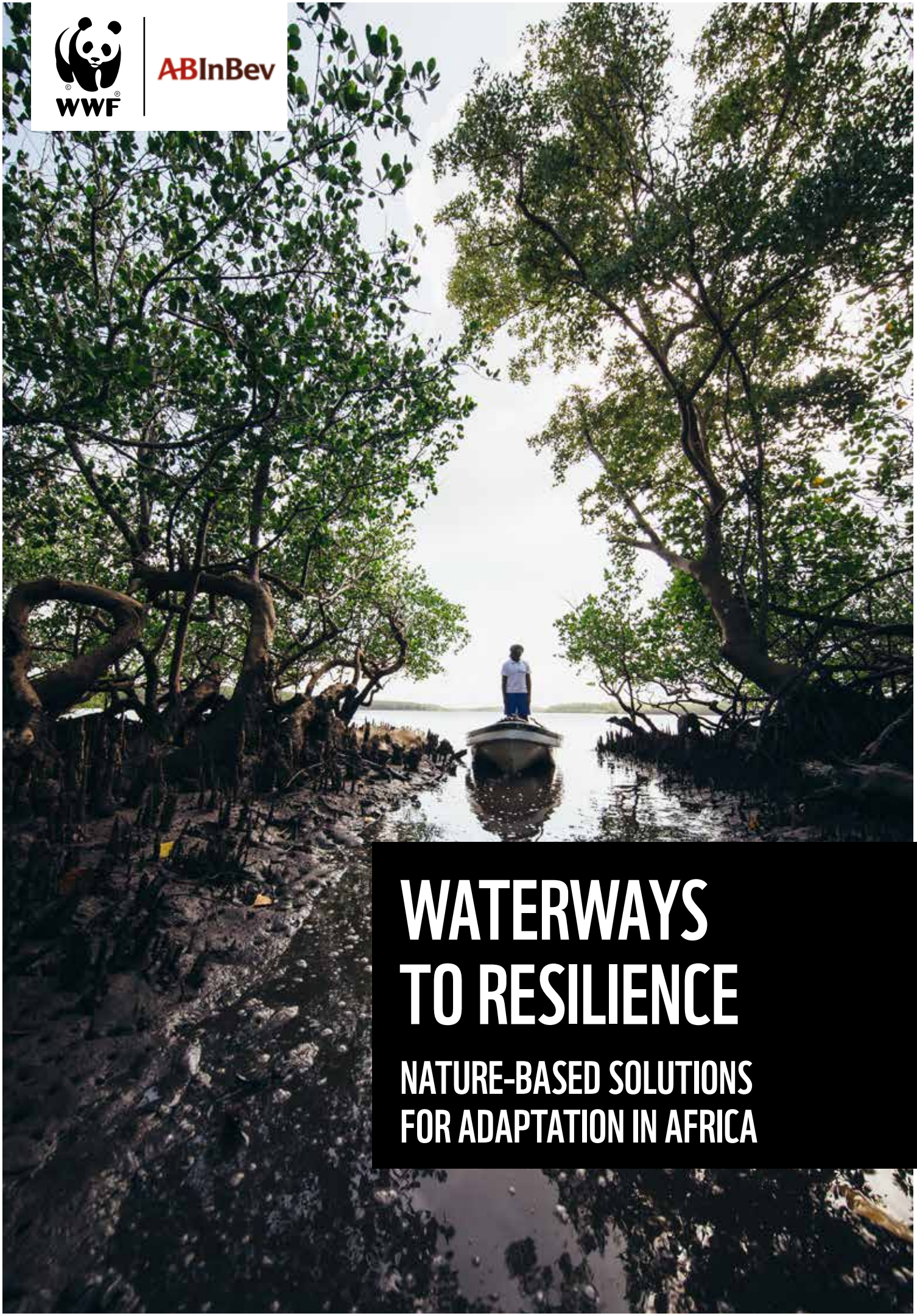


# WATERWAYS TO RESILIENCE

## NATURE-BASED SOLUTIONS FOR ADAPTATION IN AFRICA

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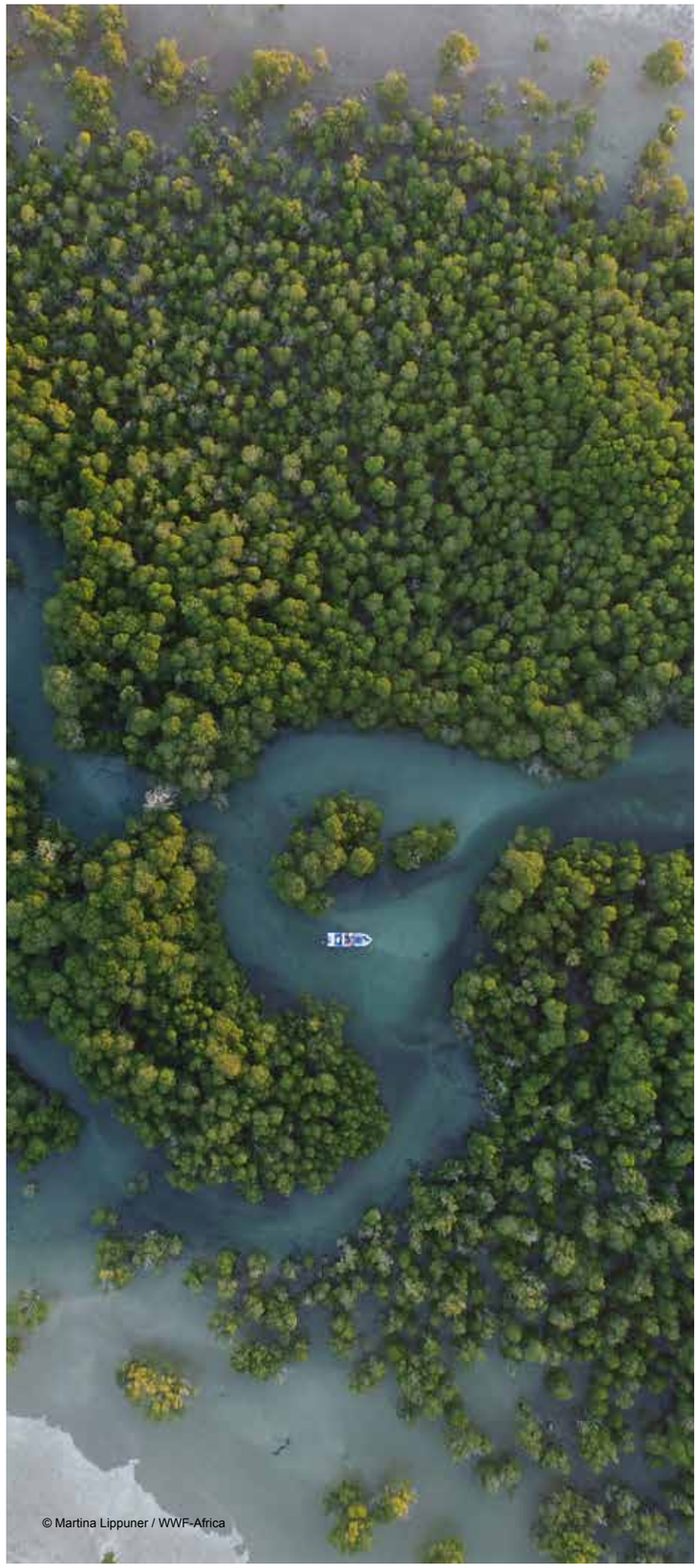
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# FOREWORD



ALICE RUHWEZA
AFRICA REGION DIRECTOR, WWF

This is Africa's watershed moment. Climate change is intensifying, harming societies and economies across the continent - mostly through water. The news is full of reports of historic floods, devastating droughts, record rainfall and coastal communities at risk from rising seas. Right now, Madagascar is on the brink of the world's first climate change famine. And the recent Intergovernmental Panel on Climate Change (IPCC) report made it clear that things are only going to get worse as global temperatures keep rising.

Today one-third of Africa's population face water scarcity, while in sub-Saharan Africa nearly two-thirds of urban dwellers struggle to access basic water services. Droughts and floods cause some 70 per cent of all disaster-related economic losses and 80 per cent of deaths. With Africa's population forecast to increase by a billion in coming decades, the effects of climate change across the continent will exacerbate these challenges, threatening even more communities with disaster, disrupting businesses and vital economic supply chains, and undermining efforts to achieve sustainable development goals.

Indeed, climate change could wipe out 15 percent of Africa's gross domestic product by 2030, while the Global Center on Adaptation's most recent report concluded that climate change will push up to 43 million people in sub-Saharan Africa into extreme poverty by 2030 if nothing is done to mitigate its effects.

Urgent action is needed to tackle these worsening risks to societies and economies: it's clear that rapid and massive investment in adaptation is required.

As this report from WWF and AB InBev shows, Nature-based Solutions (NbS) must play a central role in accelerating adaptation. The beauty of NbS is that these initiatives use ecosystems to address societal challenges, delivering benefits to people and biodiversity alike. They offer a win-win solution. Indeed, NbS represent a vital hope for Africa's future, particularly large-scale projects that will help build resilience at a landscape level.

Africa depends on its freshwater resources. By protecting and restoring watersheds and floodplains, we can increase resilience to droughts and floods while nurturing agricultural land and sustaining freshwater fisheries that feed tens of millions of our most vulnerable people. Conserving healthy mangrove forests will defend against storm surges and erosion, which would otherwise devastate coastal cities and communities. Creating and restoring urban wetlands will make our cities healthier, happier places.

Along with enhancing water and food security and reducing the risk of disasters, NbS can also reduce greenhouse gases, create local employment and protect nature,

**"FOR AFRICA, CLIMATE CHANGE IS NOT A REMOTE PROSPECT, IT IS A CRISIS NOW."**

António Guterres,
UN Secretary-General

helping countries to achieve their goals under the Paris Climate Agreement, the Sustainable Development Goals and the new global framework for nature to be agreed under the Convention on Biological Diversity in 2022.

What's more, with the right governance regime in place they make sound financial sense. The Global Commission on Adaptation calculated that an investment of US$1.8 trillion between 2020 and 2030 in five key areas – including managing water resources and protecting mangroves – would generate more than US$7 trillion in benefits. And the benefits are clear at lower levels too: a dollar invested in resilient water and sanitation not only saves lives, it creates between US$2-$12 in benefits. African countries that invest a dollar in climate-smart crops can see between $US2-$14 in benefits. Adaptation makes economic sense.

But adaptation has not received the attention – let alone the funding – it deserves. Of course, the world needs to focus on drastically cutting emissions to achieve a Net Zero world by 2050, but we must also start prioritizing adaptation because climate change is impacting all of us right now. Yet only a fraction of global climate financing is currently directed towards adaptation.

In Africa, in particular, investment in adaptation in general, let alone in NbS, is far short of what is required to keep communities safe and resilient in a warming world.

Africa has been short-changed by climate change: there is an urgent need to ensure it is not also short-changed by climate finance. The African Development Bank (AfDB) is leading the way, committing over 50 per cent of its climate financing to adaptation. Other financial institutions should now step up and follow suit. Meanwhile, AB InBev is championing corporate water stewardship and innovative ways to fund NbS. And WWF is not only implementing NbS across the continent, but helping to develop a pipeline of ambitious, large-scale NbS with governments and partners.

And partnership is the key. Africa can only build resilience if governments, companies, investors and communities work together. That is why it is so important that the AfDB and the Global Center on Adaptation recently launched the African Acceleration Adaptation Fund. It is also why we have produced this major report now as part of WWF and AfDB's joint African Ecological Futures initiative – to demonstrate how critical NbS are for our future, and to call for partners from all sectors and all countries to join us to help scale up adaptation efforts across the continent.

By scaling up investment now in healthier rivers, lakes, wetlands and watersheds, we can build more resilient communities, economies and countries, and drive long-term sustainable development.

# EXECUTIVE SUMMARY

## NATURE-BASED SOLUTIONS FOR ADAPTATION IN AFRICA

## INTRODUCTION

The people and economies of Africa confront a range of water-management challenges, including risks from degraded water quality, water scarcity and drought, flooding from both rivers and from stormwater within cities, and coastal erosion and flooding. For much of the continent, these challenges are projected to increase due to climate change over the next several decades – a period in which the continent's population is forecast to increase by approximately one billion people.

Addressing these challenges will require diverse solutions, implemented from the scale of small communities to wide regions, with interventions that range from local investments in specific infrastructure projects to broad policy reforms. There is growing evidence that Nature-based Solutions (NbS) should be included among these solutions and interventions.

NbS have received increasing attention and enthusiasm for their potential to address societal challenges. This report focuses on the evidence, both from Africa and globally, on their ability to effectively address water challenges. We also explore a set of policy reforms and financial models that can be used to scale up implementation of NbS in Africa. **Nature-based Solutions are defined as:**

> *Actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits.*[1]



© Simon Rawles / WWF



### This definition is centered around three key concepts. NbS interventions:

**1.** Address one or more societal challenges (such as flooding, drought, water quality degradation);

**2.** Use ecosystems to address that challenge (through protection, management, or restoration); and

**3.** Deliver simultaneous benefits to people (human well-being) and biodiversity (net gain).

NbS can be used to help manage a range of societal challenges, in particular water resource challenges. As simply and starkly stated by the Global Commission on Adaptation, "the effects of climate change will most immediately and acutely be expressed through water."[2] Thus, the way that most people will experience negative impacts from climate change will be through changes to water resources, ranging from a lack of access to water to suffering from too much of it in the form of damaging floods.

**"IT IS CLEAR THAT NBS HAVE CONSIDERABLE POTENTIAL TO CONTRIBUTE TO MANAGING WATER CHALLENGES IN AFRICA. FURTHER, WELL-DESIGNED PROJECTS CAN ALSO MAKE CONTRIBUTIONS TO OTHER OBJECTIVES, SUCH AS CLIMATE MITIGATION AND THE CONSERVATION OF BIODIVERSITY."**

### In terms of water challenges, this report focuses on:

**A.** WATER SCARCITY

**B.** DEGRADATION OF WATER QUALITY

**C.** FLOOD RISK

**D.** STORMWATER AND URBAN FLOODS

**E.** COASTAL EROSION AND FLOODS

Investment in sustainable management of water resources and adaptation more broadly will continue to be needed even if the world is able to follow the most optimistic pathways for reducing emissions and holding temperature rise to 1.5° C; for example, sea levels will continue to rise for a period of time after global temperature is stabilized. The adaptation challenge will increase, potentially dramatically so, if warming reaches higher levels – the number of people living in regions with water stress is projected to be 50 per cent greater under a 2° C rise compared to 1.5° C.[3] Recent reports conclude that global funding for adaptation will need to triple by 2030 and quadruple by 2050. To date, NbS have received about 13 per cent of investment from major funding programmes for adaptation (such as the Global Environment Facility and the Green Climate Fund).[4]

The African Adaptation Gap Report suggests that annual adaptation costs for Africa could reach US$35 billion and will need to increase at 7 per cent per year from today's level to meet that level of needed investment.[5]

# AFRICA'S WATER RISKS

Africa faces a number of critical water challenges, including water scarcity and quality issues, flooding, and coastal erosion. Based on an analysis using WWF's Water Risk Filter:

- Currently, about 25 per cent of Africa's population lives in areas with a water scarcity risk level of high or greater (Figure ES-1) and approximately 39 per cent of Africa's GDP is produced in areas with a water scarcity risk level of high or greater.
- Today, nearly a quarter (23%) of Africa's population lives in areas with a flooding risk level of high or greater and approximately 16 per cent of Africa's GDP is produced in areas with a flooding risk level of high or greater (Figure ES-2).
- Today, six of Africa's twenty largest cities have a flood risk level of high or greater (Figure ES-3).

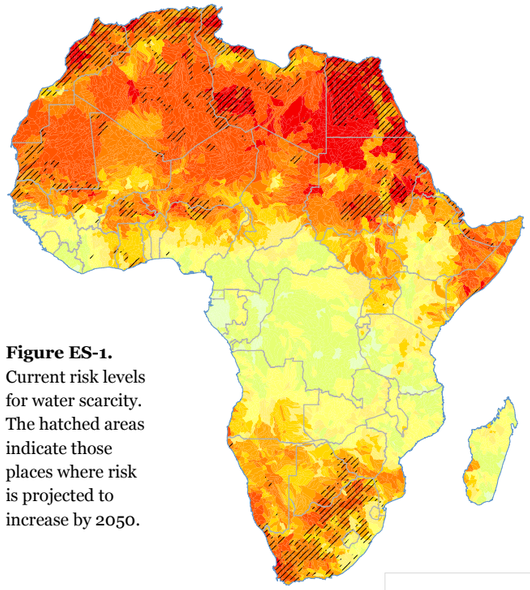



**Figure ES-1.** Current risk levels for water scarcity. The hatched areas indicate those places where risk is projected to increase by 2050.

Droughts and floods cause approximately 70 per cent of disaster-related economic losses and 80 per cent of deaths in sub-Saharan Africa (see Box ES-1)[6]. A range of socioeconomic challenges exacerbate vulnerabilities to these water-related risks, including limitations in governance and under-resourced institutions in many countries. Compounding this vulnerability, low-income communities in Africa have minimal reserves and lack formal insurance coverage[7] and many areas with high levels of poverty are also at high risk of floods or other disasters.

Both climate change and population growth are expected to exacerbate most of these water challenges, further straining limited institutions and governance. Based on an analysis using WWF's Water Risk Filter and a current trend future scenario:

- The continent's population is expected to increase by about 60 per cent by 2050, to 2.1 billion, and the percentage of Africa's population living in areas with a water scarcity risk level of high or greater will rise to 28 per cent. That translates to an additional 260 million people living in areas with high risk or greater of scarcity.
- Africa's GDP is projected to increase by more than four times by 2050, with 41 per cent of GDP expected to be produced in areas with a water scarcity risk level of high or greater.
- The proportion of Africa's population living in areas with a flooding risk level of high or greater is projected to more than double by 2050, to 54 per cent, encompassing an additional 830 million people living in areas with high risk or greater of flooding (Figure ES-2).
- In addition, the proportion of Africa's GDP produced in areas with a flooding risk level of high or greater is projected nearly triple to 46 per cent by 2050.
- Finally, it's projected that the number of Africa's twenty largest cities with a flood risk level of high or greater will increase to ten cities by 2050 (Figure ES-3).

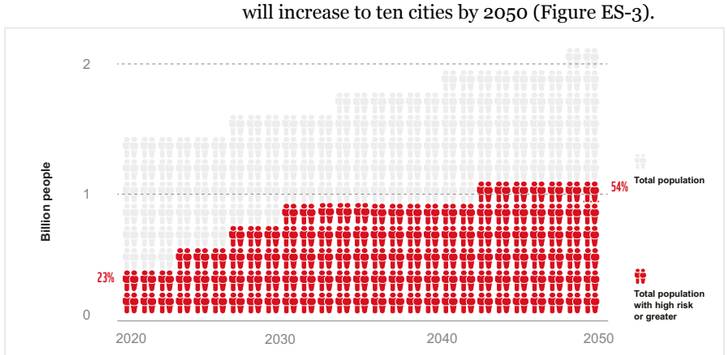



**Figure ES-2.** The number and proportion of Africa's population living in areas with a risk level for flooding of high or greater in 2020 and in 2050 under the current trend scenario.

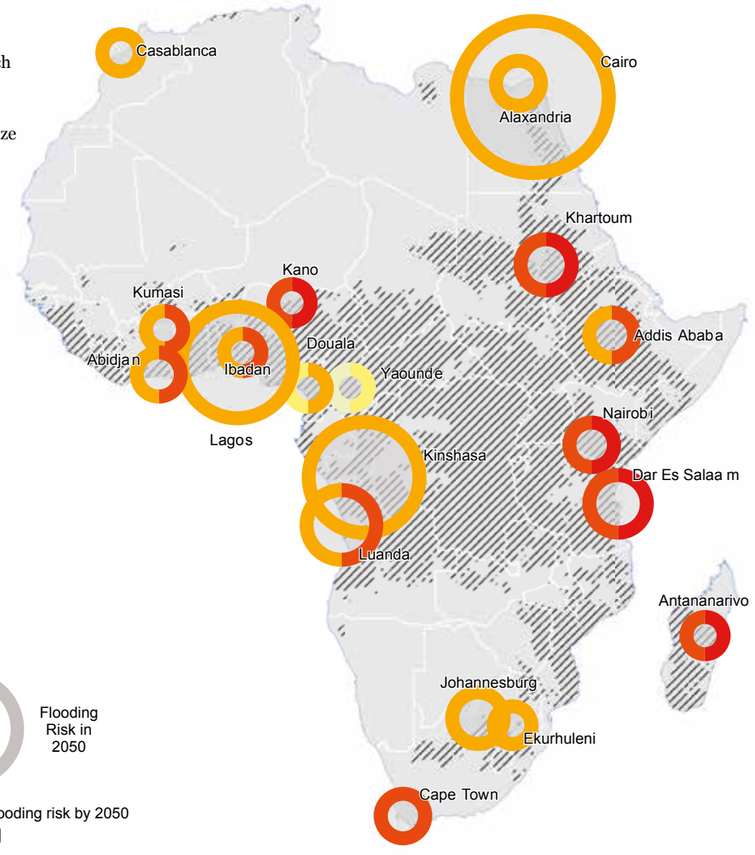
The growing challenges and risk factors described above – particularly poverty, population growth, and climate change increasing the frequency of droughts and floods – can have the added effect of triggering or worsening existing social conflicts. Low-income rural communities tend to have a higher share of their assets and wealth tied up in natural resource and environmental assets. For example, there is little irrigation in Africa (about 5 per cent of food grown) and thus most subsistence farmers rely on natural rainfall, making them highly vulnerable to even quite small changes in rainfall patterns.

Collectively, these characteristics make African countries vulnerable to the impacts of climate change – and low income, rural communities are particularly vulnerable. Thus, various disturbances from climate change – ranging from the steady deterioration of resources to sudden disasters – will likely lead to social conflicts and migration (with migration often exacerbating conflict in the places where people relocate).[8] Stabilizing or restoring water and other environmental resources can therefore be an effective strategy for defusing humanitarian crises before they emerge.

## Box ES-1: Flooding in the wrong places and flooding in the right places

Throughout this report we discuss flood risk. Indeed, floods are currently the most damaging form of disaster globally, and keeping people and property safe from flooding should be a top priority of governments. However, it is important to note that these concepts of 'flood risk' and 'flood damages' are all focused on flooding in the *wrong places* – those places where people live, have built houses or infrastructure and/or conduct economic activity that is vulnerable to flooding. In contrast, flooding in the *right places* is an important environmental process that promotes ecosystem productivity and many communities in Africa—and on rivers around the world—depend on floodplain productivity for food and livelihoods.

**Figure ES-3.** Flood risk for the 20 largest cities in Africa today (left side of each circle) and in 2050 under the current trend scenario (right side of each circle); size of circle is scaled to current population size.



# THE EVIDENCE BASE FOR NBS FOR ADDRESSING WATER CHALLENGES

To better understand the potential for NbS to help manage water risks, we examined both a global evidence base for NbS[9] and the first-ever review of evidence for the effectiveness of NbS interventions in Africa.[10] The evidence for the effectiveness and potential for NbS to help address some of the most critical water challenges facing the communities, governments and businesses of Africa—and help build climate resilience—are compelling. This evidence base, as well as case studies of NbS application across Africa, offer key findings and insights about NbS and water management:

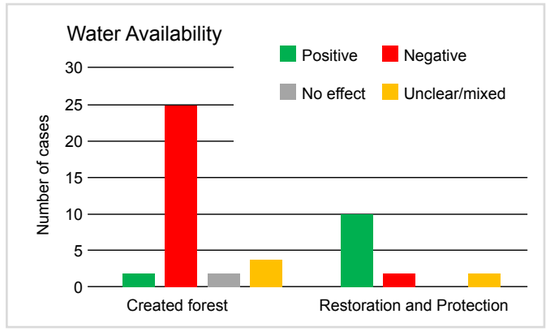



**Figure ES-4.** Impact on water quantity of planting non-native forest and protecting and restoring native forests (data from Oxford NbS evidence platform)

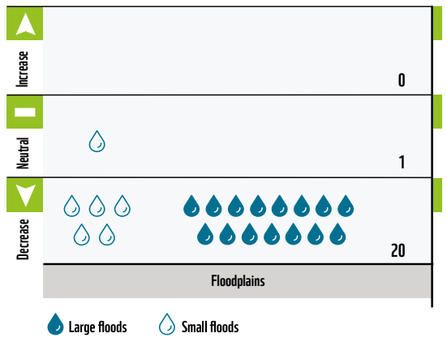



**Figure ES-5.** Impact of existing floodplains in Africa on flood levels downstream (adapted from Acreman et al. 2021).

- **Native forests can increase flows during dry seasons:** While forests can reduce total water production from a watershed due to greater evapotranspiration by trees as compared to shrubs and grasses, native forests often increase flow during the dry season, which for many ecosystems and water users can be more important than total annual production of water (Figure ES-4).
- **Planting of non-native forests can negatively impact water availability:** Restoration or protection of native forests generally had positive benefits on water quantity, while planting of non-native forests nearly always reduced water quantity from a watershed (Figure ES-4).
- **In Africa, removal of non-native trees consistently resulted in greater water production from a watershed:** In South Africa, WWF is working to remove non-native trees from watersheds that provide water for cities and agriculture. This has proven to be a cost-effective intervention for increasing water supplies.
- **Forests can improve water quality and reduce flood risk:** In both the global and African reviews, there was strong evidence that protection or restoration of forests can reduce sedimentation and improve water quality as well as reduce flood levels downstream.
- **Floodplains can reduce flood risk and regulate flows across wet and dry seasons:** In Africa, the presence of floodplains is consistently associated with reduced flood levels downstream, for both small and large floods (Figure ES-5). While floodplains often result in a net loss of water, due to evaporation and infiltration, they can act like a sponge that stores water during the wet season to release it during the dry season, increasing water availability at a time when it is most valuable for water users. For example, in Zambia the Lukanga Swamp's "sponge effect" provides a significant increase in flow of the Kafue River during the dry season providing substantial benefits to water users. WWF is working with the government of Zambia and major water users to develop long-terms plans and programs to protect and restore this water storage function of the Lukanga Swamp.
- **Wetlands can provide comprehensive improvement in water quality:** Wetlands were consistently associated with improvements in water quality; the Africa review found these improvements across a range of metrics, including biological oxygen demand, sediments, and heavy metals.
- **Mangroves and other coastal ecosystems play an important role in coastal protection:** The global review found that restoration or protection of mangroves or other coastal ecosystems consistently had positive benefits for reducing coastal erosion or flooding. On a per hectare basis, mangroves are among the most effective at storing carbon – three to five times as much tropical forests. In Kenya, the the Kenya Marine and Fisheries Research Institute, a partner of WWF-Kenya, is working with the villages of Gazi and Makongeni to implement a carbon offset project, the first of its kind in the world to successfully trade credits for the "blue carbon" from mangroves.

# INCREASING UPTAKE OF NBS ACROSS AFRICA

It is clear that that NbS have considerable potential to contribute to managing water challenges in Africa. However, funding and implementation of NbS programmes and projects lags far behind, both in Africa and globally. Although there is evidence that funding for NbS is growing, the UN Environment Programme's *Adaptation Gap Report 2020* concludes that adaptation funds are not keeping up with needed investment in adaptation:

> *Funding for NbS makes up only a tiny fraction of total adaptation and conservation finance, despite many commitments by governments, the private sector, philanthropy and finance institutions for scaling up ambition and investments in NbS.*

Overall, it appears likely that the primary global trends in the UNEP report apply to Africa:

- There is a current gap – and looming future gap – in adaptation funding;
- NbS funding remains a small part of overall adaptation funding; and
- Support for NbS is growing but the level of support and adoption lags far behind the potential for NbS projects and programmes to deliver benefits.

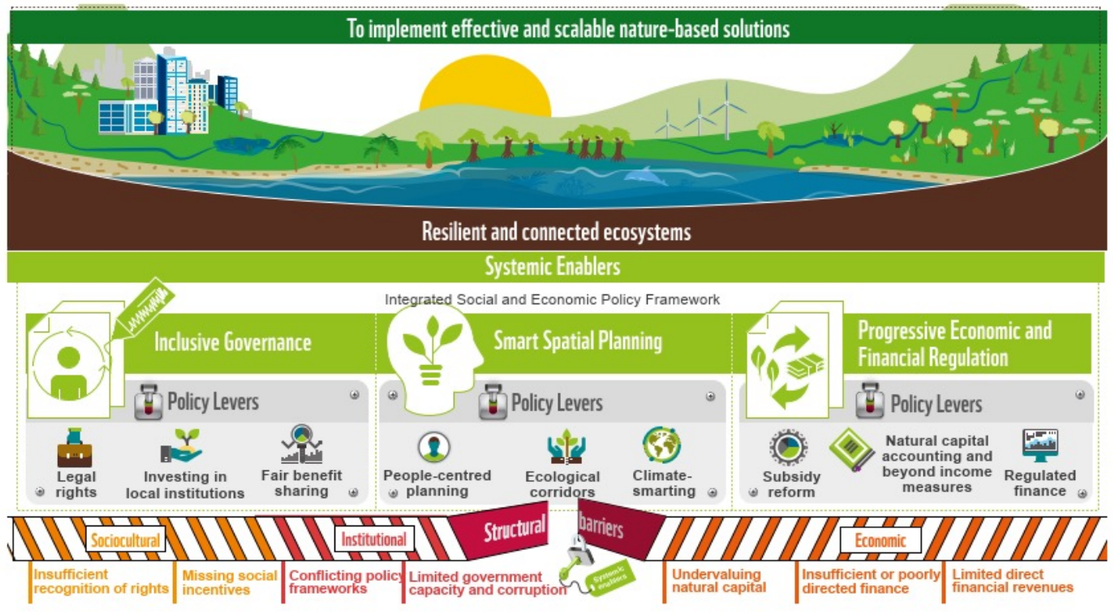
These projects and programmes are likely to deliver a high return on investment. For example, the Global Commission on Adaptation estimated that an investment of US$1.8 trillion in a range of adaptation activities, including climate-resilient infrastructure and mangrove protection, would generate US$7.1 trillion in avoided costs and environmental and social benefits.

With that potential for economic benefits, why are NbS not being implemented as large-scale projects and programmes in most countries?

Structural barriers to broad uptake of NbS can be placed into three broad categories (Figure ES-6):

- **Socio-cultural barriers** include constraints related to incentives and behaviors of key groups, such as missing social incentives that encourage short-term activities that preclude sustainable, long-term stewardship of resources.
- **Institutional barriers** include obstacles related to the policies, conventions, and rules that collectively shape governance relevant for NbS. For example, NbS may

**Figure ES-6.** An integrated set of policy levers and systemic enablers can overcome the structural barriers to NbS implementation. (From WWF 2021)



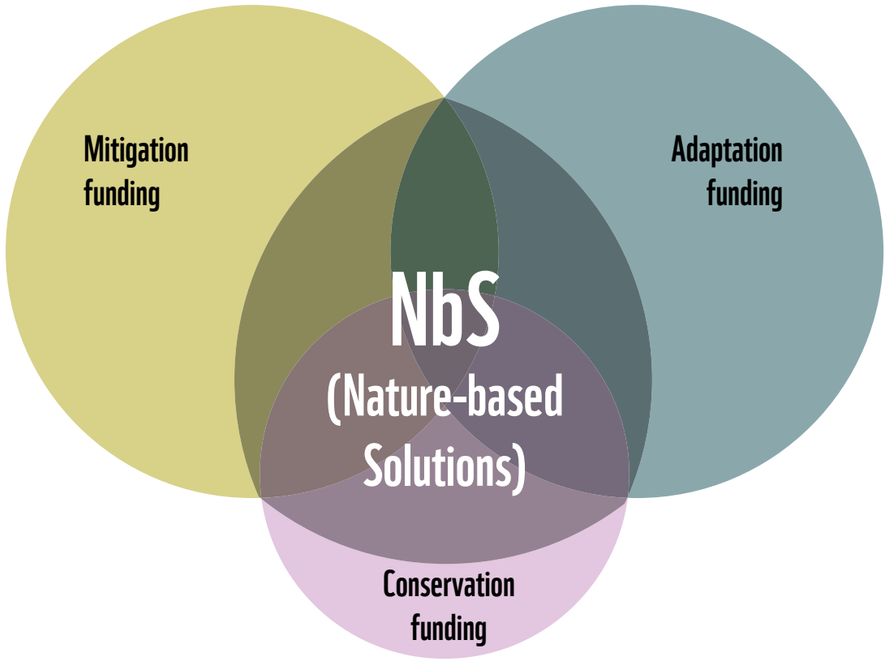



**Figure ES-7.** A conceptual figure illustrating that well-designed NbS projects can potentially draw on funding from three global sources of funding: climate mitigation, climate adaptation, and conservation. The green box shows that NbS should overlap with projects, and project funding, for all three categories.

require more cooperation from more entities – which may be governed by different, or even conflicting, policy objectives. Limited capacity for managing NbS and limited familiarity with NbS among planners and engineers can reduce the likelihood that they will be selected as options.

- **Economic barriers** include constraints related to funding and incentive structures. Many of the diverse benefits of NbS can be hard to quantify, particularly environmental and social benefits, so these may not be adequately incorporated into decision processes. Furthermore, even if these other benefits could be easily quantified, mechanisms, such as markets, may not exist to link the beneficiaries of the service with those that provide the service. Insufficient or poorly directed finance results in limited funding for NbS while, simultaneously, large amounts of public funds flow toward subsidies that are often environmentally harmful.

WWF (2021) offers a framework of systemic enablers and policy levers to overcome these barriers.[11] The overarching systemic enablers include: (1) inclusive governance; (2) smart spatial planning; and (3) progressive economic and financial regulation (Figure ES-6). Specific recommendations for overcoming constraints to scaling NbS for addressing water challenges fall into three primary categories:

*Ensure alignment of policy, funding and capacity*. Although it is generally noted that NbS programmes suffer from an investment gap, increasing funding without a conducive policy context, or sufficient capacity among decision makers and local managers, can result in in ineffective, or even detrimental, outcomes and investments that fail to yield positive impacts. So it is important that when external funders prioritize NbS and increase funding for those interventions, their investments should be made through inclusive and collaborative programmes that emphasize gaining government support and building capacity at multiple levels.

*Provide the evidence*. Clear evidence of the effectiveness of NbS interventions, and an articulation of the specific benefits that flow to different stakeholders, can help mobilize and sustain support. Therefore, NbS investments should encompass strong monitoring and evaluation programmes so that evidence can be collected and communicated. Private sector interest in NbS will increase if these benefits can be demonstrated credibly, particularly where those benefits are clearly aligned with reducing operational risks and/or achieving corporate water stewardship priorities.

*Close the funding gap by tapping into diverse public and private sources*. Funding from a range of sources will be needed to close the gap in funding for adaptation. Although precise estimates are difficult to derive, the UNEP (2021) reports that existing commitments will not close the current funding gap and needs will rise rapidly. Because NbS projects generally provide multiple benefits, these projects and programmes should be able to draw on multiple sources of funding (e.g., those for climate adaptation, climate mitigation, and biodiversity) (Figure ES-7). Although support from international donors, corporations and NGOs will be helpful for getting NbS programmes underway and providing initial demonstrations of benefits, ultimately NbS will reach their full potential when they are consistently integrated into the main budgets, and become standard operating procedure, of the ministries and agencies that manage flood risk and water supplies, rivers, coasts and other resources.




# CONCLUSIONS

Everyone involved in the climate and water worlds has a responsibility to ensure that NbS and improved water resources management are central to efforts to mitigate climate impacts. As emphasized by SDG 17 on building stronger partnerships, collective action is key to better water management (Box ES-2).

Beyond the societal challenges that NbS can address, and beyond their environmental and social benefits, NbS projects represent an important opportunity for boosting employment—particularly relevant as countries invest in pandemic-related recovery funds. The most job-intensive NbS interventions include reforestation, ecosystem or watershed rehabilitation, and management of invasive species.[12]

The news is filled with reports of prolonged droughts and extreme floods and scientists are increasingly able to find the fingerprints of climate change on these events. Communities endure losses, companies scramble due to interruptions in production and supply chains, insurance rates rise. Meanwhile, a consistent flow of scientific papers and reports develops a strong case that, without rapid action on reducing emissions, these challenges will only get worse.

Collectively, these rising risks – and drumbeat of reports and stories of disaster – make it seem as if the forces of nature are increasingly arrayed against our homes, our businesses and our economies. But the world can also harness the power of nature to help build resilience and defend us against these risks. By investing in NbS, the countries and people of Africa can get nature on their side in their efforts to manage water challenges.

## Box ES-2: Recommendations to increase uptake of NbS



### POLICY MAKERS SHOULD:

**Promote NbS alongside more sustainable and resilient 'grey' infrastructure to tackle water challenges and reduce vulnerability to climate change** as well as increase the health and resilience of the continent's rivers, lakes and wetlands;

**Invest in adaptive institutional capacity and enabling frameworks for successful and sustainable implementation and management of NbS efforts;**

**Ensure budgets include sufficient funding to implement NbS at a scale that can have meaningful, lasting impact on Africa's watersheds and water resources,** and increase financing for water resource management and climate adaptation overall; and

**Call for equal investment in mitigation and adaptation, and for a larger portion to fund NbS**.



### PRIVATE SECTOR COMPANIES SHOULD:

**Understand their water impacts and risks and engage in water stewardship efforts focused on measurable impact in watershed health.**

**Promote NbS as a critical part of the solution to shared water challenges** facing businesses, communities and economies, and incorporate NbS into their water stewardship strategies, where relevant.

**Use their influence and scale to catalyse collective action on NbS** by engaging in platforms that allow different companies and organizations from across industries and sectors to work together at basin or landscape scales to address shared water risks and have measurable impact.



### FINANCIAL INSTITUTIONS SHOULD:

**Develop a strong understanding of water risk and financial value,** including the opportunities that exist to create value. Engage with existing efforts and start to create offerings that finance NbS.

**Invest in NbS as an opportunity to both create value and mitigate risks** to assets and investments by engaging with existing efforts and mechanisms to fund NbS and creating new offerings and innovative channels for financing NbS

**Implement and support policies that lay the foundation for credible green investments** since an enabling environment is critical to support the necessary expansion in funding for NbS.

## ENDNOTES


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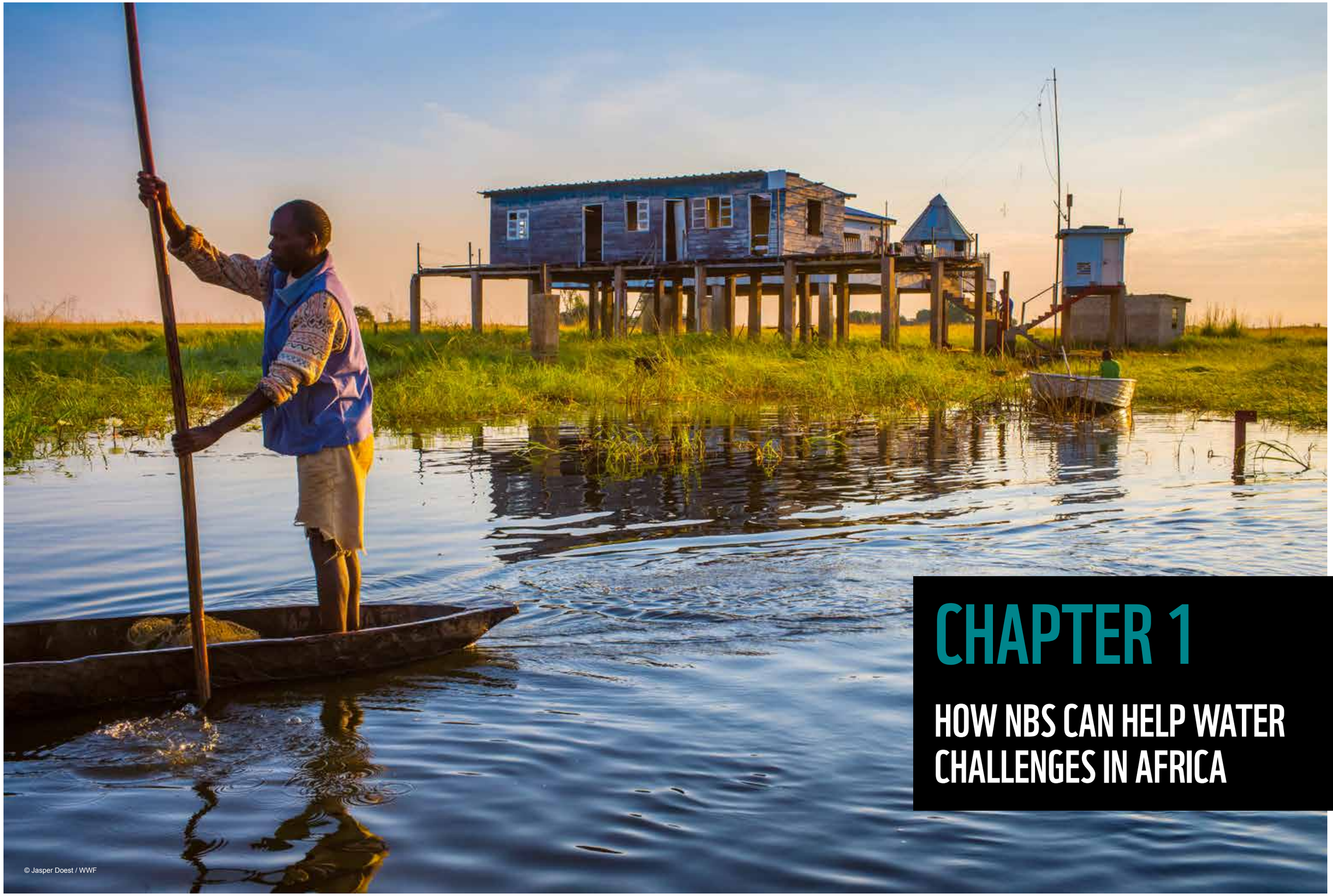
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# CHAPTER 1

## HOW NBS CAN HELP WATER CHALLENGES IN AFRICA

The people and economies of Africa confront a range of water-management challenges, including risks from degraded water quality, water scarcity and drought, flooding from both rivers and from stormwater within cities, and coastal erosion and flooding. For much of the continent, these challenges are projected to increase due to climate change over the next several decades – a period in which the continent's population is forecast to increase by approximately one billion people.

Addressing these challenges will require diverse solutions, implemented from the scale of small communities to wide regions, with interventions that range from local investments in specific infrastructure projects to broad policy reforms. There is growing evidence that Nature-based Solutions (NbS) should be included among these solutions and interventions.

NbS have received increasing attention and enthusiasm for their potential to address societal challenges (see Box 1). This report focuses on the evidence, both from Africa and globally, of their ability to effectively address water challenges. We also emphasize a set of policy reforms and financial models that can be used to scale up implementation of NbS in Africa.

Nature-based Solutions are defined as:

> *Actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits.*[1]

This definition is centred around three key concepts (Figure 1). NbS interventions:

1. Address one or more societal challenges (such as flooding, drought, water quality degradation);
2. Use ecosystems to address that challenge (through protection, management, or restoration); and
3. Deliver simultaneous benefits to people (human well-being) and biodiversity (net gain).

A common example of a NbS intervention would be the use of a restored wetland to regulate floodwaters to reduce flood risk, with the wetland managed to provide habitat and recreational opportunities. In the context of the definition and key concepts, the *societal challenge* is flood risk, the wetland is the *ecosystem* that addresses that challenge, and the habitat and recreation are the *simultaneous benefits to people and biodiversity*.

These simultaneous benefits are one of the hallmarks of NbS and an important difference compared to other types of interventions. The typical way of managing water and water risks – engineered infrastructure – can often have negative impacts on freshwater ecosystems. In fact, dams and levees (or dikes) are among the leading drivers of the loss of freshwater species, ecosystems and their services. Although water and climate are often framed as crises, which receive considerable attention, the loss of biodiversity is a concurrent crisis – with freshwater biodiversity being lost at the fastest rate. Thus, NbS interventions that are well planned and executed have the potential to make positive contributions towards all three crises.

NbS can be used to help manage a range of societal challenges. This report will focus on NbS in the context of water challenges, specifically:

- Water scarcity
- Degradation of water quality
- Flood risk (see Box 2)
- Stormwater and urban floods
- Coastal erosion and floods

Specific NbS interventions for these challenges are described in detail in Chapter 3.

## Box 1: The many names of NbS

The rapidly growing attention on NbS stems largely from their potential to address climate-related challenges, encompassing both climate mitigation (i.e., reducing greenhouse gases) and climate adaptation (managing negative impacts arising from climate change) (Figure 1). Thus, NbS for adaptation can be considered essentially equivalent to the concept of Ecosystem-based Adaptation (EBA) or, more broadly as an umbrella term encompassing EBA, green or natural infrastructure, and eco-disaster risk reduction.

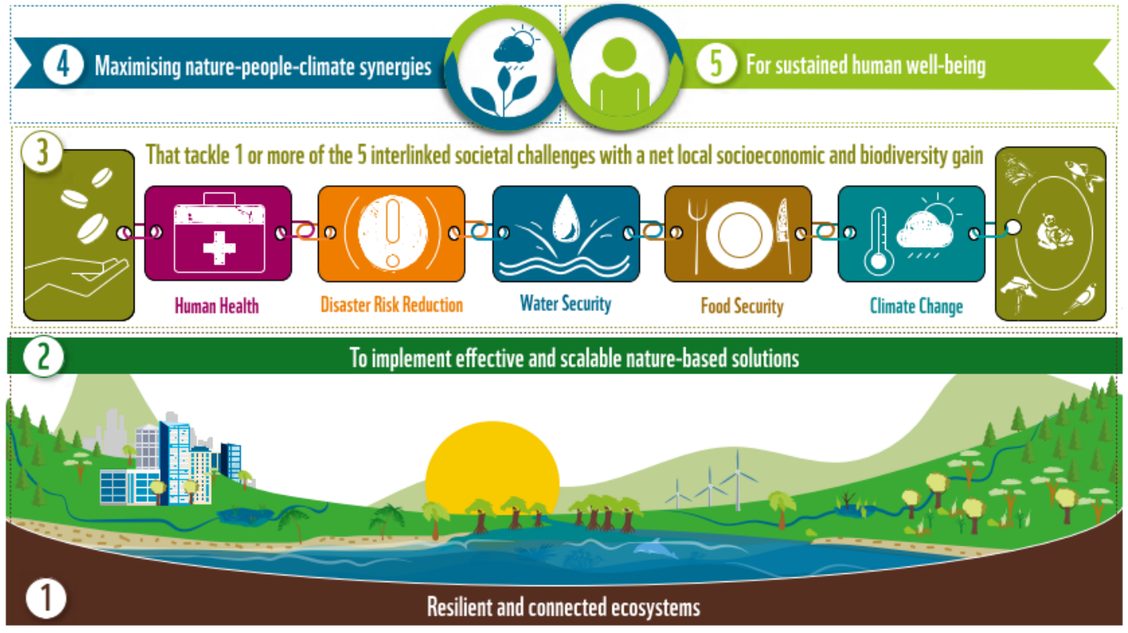



**Figure 1.** Nature-based Solutions use resilient and connected ecosystems to help manage one or more societal challenges while delivering diverse benefits for nature and people (Figure from WWF 2021).[2]

This report is intended as both a call to action on the value of using NbS to address water challenges in Africa and a guide for decision makers, funders and practitioners. We will focus on both the evidence of the effectiveness of NbS interventions, and the policy and financial enabling conditions necessary to support widespread and effective implementation of NbS at a meaningful scale.

We will start by reviewing how climate change will affect water, with consequent impacts for people and nature, along with a set of key concepts and caveats for NbS (Chapter 1). We then summarize the range of water challenges facing Africa, and how those may shift with climate change, including a detailed survey of water risks for the population and economies of Africa, both today and with climate change, using WWF's Water Risk Filter (Chapter 2). We then review NbS interventions for water management challenges, drawing on both a global evidence review of NbS[3] and the first-ever evidence review of NbS for water challenges for Africa[4] (Chapter 3 and Annex 1). We then turn to a set of case studies that put these interventions into practice on the ground (Chapter 4), followed by a discussion of the policy and financial enabling conditions needed to catalyze broader uptake of those interventions (Chapter 5) and recommendations for policy makers, the private sector and financial institutions (Chapter 6).

## Box 2: Flooding in the wrong places and flooding in the right places

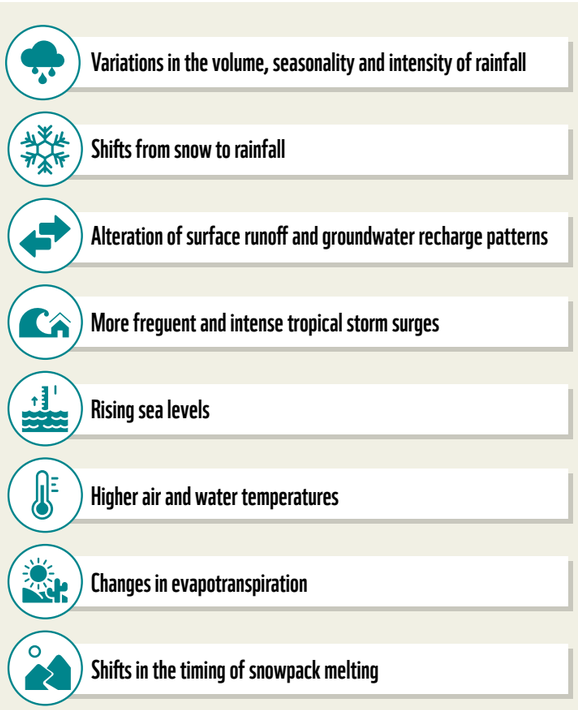
Throughout this report we discuss flood risk. Indeed, floods are currently the most damaging form of disaster globally and keeping people and property safe from flooding should be a top priority of governments. However, it is important to note that these concepts of 'flood risk' and 'flood damages' are all focused on flooding in the wrong places – those places where people live, have built houses or infrastructure and/or conduct economic activity that is vulnerable to flooding. In contrast, flooding in the right places is an important environmental process that promotes ecosystem productivity. A floodplain – the low-lying area alongside a river – is actually land that was built by the river as it deposited layers of sediment over centuries of flooding. Managing development to avoid and protect floodplains can be an effective policy that both reduces risks for people and sustains ecosystems. Floodplains are among the most productive and diverse ecosystems on the planet. In fact, many communities in Africa depend on the productivity of floodplains for food and livelihoods, including fisheries and agriculture that requires an annual flood pulse (Box 7 on page 52). Nature-based Solutions that use floodplains to reduce flood risk are a great example of promoting flooding in the right places to avoid flooding in the wrong places.

## 1.1 Climate change and water challenges

As simply and starkly stated by the Global Commission on Adaptation, "the effects of climate change will most immediately and acutely be expressed through water."[5] Thus, the way that most people will experience negative impacts from climate change will be through changes to water resources, ranging from a lack of access to water to suffering from too much of it in the form of damaging floods.

Climate change will affect the earth's water in a range of ways (Figure 2). Even without changes in precipitation patterns, warmer temperatures will affect how much water is available and when. Hotter temperatures will trigger greater rates of evaporation – from the ground, from water bodies, and through plants – resulting in less water available in streams and rivers.[6] Furthermore, warmer temperatures will shift the ratio of rain to snow, and the melting of snow and glaciers will occur more rapidly and earlier in the year, shifting seasonal patterns of runoff and flow in rivers, with major impacts on regions with rivers that typically carry snowmelt well into the dry season, such as California.[7]

**Figure 2.** Major forecasted changes to hydrological processes and water supplies due to climate change.




Beyond temperature shifts, precipitation patterns are also projected to change across much of the world. While projections of rising temperatures have a high degree of confidence, projections of how climate change will affect total annual precipitation are more variable.[8] There is some general confidence that some currently wet regions of the world will become wetter while some drier regions will become drier.[9] Warmer air can hold more moisture, leading to more intense precipitation events. This trend toward increasing intensity of rainfall is part of a broader pattern where much of the world will experience increasingly "flashy" hydrographs (higher peaks and lower low flow periods) and some areas will have increased risk of both droughts and floods.[10] Thus, climate change is predicted to increase the frequency of water-related disasters, such as floods and droughts, even as already today more than 90 per cent of disasters around the world are related to water. Chapter 2 explores these disaster risks in more detail.

In addition to water quantity, climate change can also affect water quality. The increasing intensity of rainfall can lead to higher rates of erosion, leading to greater loading of sediment and associated nutrients in downstream rivers, lakes, and estuaries. Water quality is affected by water quantity and so more severe periods of low water levels can exacerbate negative impacts from pollutants. Furthermore, warmer temperatures can exacerbate challenges that arise from poor water quality; excess nutrients in runoff can trigger harmful algal blooms in lakes and coastal waters, and warmer temperatures can increase the scale and frequency of these blooms.

These changes in global hydrological patterns will have significant impacts on both freshwater ecosystems as well as people, societies and economies[11], which we explore in detail in Chapter 2.

Investment in adaptation will continue to be needed even if the world is able to follow the most optimistic pathways for reducing emissions and hold global temperature rise to 1.5⁰ C; for example, sea levels will continue to rise for a period of time after the global temperature is stabilized. The adaptation challenge will increase, potentially dramatically so, if warming reaches higher levels – the number of people living in regions with water stress is projected to be 50 per cent greater under a 2⁰ C rise compared to 1.5⁰ C.[12] Recent reports conclude that global funding for adaptation will need to triple by 2030 and quadruple by 2050. To date, NbS have received about 13 per cent of investment from major funding programmes for adaptation (such as the Global Environment Facility and the Green Climate Fund).[13] The African Adaptation Gap Report suggests that annual adaptation costs for Africa could reach US$35 billion and will need to increase at 7 per cent per year from today's level to meet that level of needed investment.[14]

## 1.2 Key concepts and caveats about NbS

Although there are an increasing number of reports, journal articles and books about NbS, there is still considerable confusion about the concept. Below we offer some high-level concepts and caveats about NbS as a foundation for the rest of the report.

**NbS should be implemented with full participation of, and consent from, affected communities.** Recognising the rights, territories, laws and culture of Indigenous peoples and local communities is crucial to delivering inclusive and sustainable development and finding the most effective solutions to the most pressing environmental problems. Criterion 5 of a global standard for NbS from the International Union for the Conservation of Nature (IUCN) states that NbS programmes and projects should be developed and implemented through inclusive, transparent and empowering governance processes.[15] Participation needs to consider equity, diversity and inclusion.

**NbS may be doubly valuable to vulnerable communities.** Many rural communities depend directly on freshwater ecosystems for their food and livelihoods. These same communities are often among those most vulnerable to the negative impacts from climate change.[16] NbS provide an opportunity to improve the resilience of vulnerable communities to negative impacts from climate change through adaptation interventions, which are also beneficial to the ecosystem services they depend upon.

**NbS should not be confused with conservation programmes.** While NbS projects will benefit biodiversity, the definition of NbS makes it clear that their defining feature is that *they address a societal challenge*. In other words, they should provide a service that someone other than a conservation organization or agency is willing to pay for, such as entities charged with delivering clean water or reducing flood risk. Although NbS projects focus on natural systems, conservationists can ask this question as a filter to determine if a project qualifies as NbS: "Does this project solve *someone else's* problem (e.g. disaster risk reduction) to the extent they would be willing to pay for it?"

**But conservation objectives can benefit because NbS interventions can tap into different, and larger, sources of funding.** Well-planned NbS projects will contribute to objectives for both development and conservation. For development, NbS can address challenges, reduce risk, and provide multiple development benefits in ways that are cost effective while also resilient to climate change. For conservation, NbS can mobilize broader sources of funding than are typically available for conservation and contribute to conservation objectives at large scales. This provides a compelling reason for linking biodiversity, development, and social goals through NbS. From the perspective of conservation organizations, if NbS solves someone else's problem, then other sources of funding beyond conservation funds can be used to support the project. If the project is well-designed, that means those other, and generally larger, sources of funding, can be used to also accomplish conservation objectives. For example, if all water management agencies globally invested in reforestation activities within their source watersheds (to maintain or restore water quality), regional extinction risk could be reduced for over 5,000 species – with 40 per cent of those conservation gains occurring in Africa.[17] This illustrates the potential biodiversity benefits from one type of NbS intervention.

**NbS should not be viewed as a substitute for needed investments in infrastructure.** Rather, NbS can often complement traditional infrastructure and increase the effectiveness of those investments, potentially reducing some long-term costs.[18] For example, while NbS can help maintain the flow of clean water from watersheds, it is not a substitute for investments in safe, reliable municipal water supply systems to deliver water to homes and businesses. For water supply, investments in NbS are complementary to traditional infrastructure – with potential to reduce the need for some additional capital investments (such as the case of watershed protection allowing reduced investment in engineered infrastructure for New York City's water supply).[19] Similarly, while levees or floodwalls may still be necessary to reduce flood risk for urban areas, projects to reconnect

"THE EFFECTS OF CLIMATE CHANGE WILL MOST IMMEDIATELY AND ACUTELY BE EXPRESSED THROUGH WATER."

Global Commission on Adaptation

floodplains can reduce the pressure on those engineered structures, further lowering risks for people and potentially reducing damage to structures and thus lowering long-term maintenance costs.[20] Africa has a major investment gap in infrastructure (e.g., water supply and wastewater treatment), and calls for increased investment in NbS are in no way a suggestion that they can substitute for those needed investments. Rather, a key point of this report is that *a diversified portfolio approach of NbS, effectively integrated with engineered infrastructure, will improve the resilience and performance of water-management systems and reduce a range of risks.*[21]

**Many NbS interventions offer both climate mitigation and adaptation opportunities.** For instance, NbS can play a role in carbon capture and storage and offer opportunities to mitigate the effects of climate change and disaster risks. Many wetland systems, including mangroves and peatlands, offer some of the highest rates of carbon sequestration per-unit area among ecosystem types. Seddon et al. (2020) recommends increasing attention on NbS projects that can provide both mitigation and adaptation benefits[22]. Well-planned projects can contribute to both objectives – and potentially also to objectives for biodiversity conservation and restoration. Thus, well-planned NbS have the potential to achieve a "triple win" toward a set of major global objectives: the Paris Accord (mitigation), Sustainable Development Goals (adaptation) and biodiversity goals in the new global framework for nature to be agreed under the Convention of Biological Diversity in 2022.

**NbS must themselves be climate smart.** Climate change is already impacting every major biome on Earth and ecosystems are shifting in terms of species composition, rates of key processes, and the frequency and intensity of disturbances. Because NbS projects rely on ecosystems and biophysical processes, they themselves must therefore be planned and managed to be resilient to changing conditions. Key considerations include the mix of plant species used and site selection for interventions. General tools like scenario planning can be used to inform these efforts.[23]

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## 1.3 Getting nature on our side

The news is filled with reports of prolonged droughts and extreme floods and scientists are increasingly able to find the fingerprints of climate change on these events. Meanwhile, a consistent flow of scientific papers and reports develops a strong case that, without rapid action on reducing emissions, these challenges will only get worse.

These challenges and risks will be felt by communities, companies and countries. Communities will face increasing risks from extreme floods, including loss of life and property, and disruptions to water and food supplies. Companies will confront these same local risks, along with disruptions to their supply chains, as well as reputational and regulatory risks as communities and countries respond to changing conditions. All of these translate into risks for financial institutions and insurance companies. Finally, national governments will need to address these diverse risks to their people, infrastructure, and economic systems to ensure that their countries remain strong and resilient in the face of climate change.

Collectively, these rising risks – and drumbeat of reports and stories of disaster – make it seem as if the forces of nature are increasingly arrayed against our homes, businesses and economies. But the world can also harness the power of nature to help build resilience and defend us against these risks by investing in NbS. In the rest of this report, we focus on how – through widespread implementation of NbS – the countries and people of Africa can get nature on their side in their efforts to manage water challenges.

Africa faces many water challenges

# CHAPTER 2

## WHAT ARE AFRICA'S WATER CHALLENGES AND THE NEED FOR NBS?

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and risks that are compounded by climate change. Droughts and floods cause approximately 70 per cent of disaster-related economic losses and 80 per cent of deaths in sub-Saharan Africa.[24] A range of socioeconomic challenges exacerbate vulnerabilities to these water-related risks, including limitations in governance and under-resourced institutions in many countries, resulting in a safety net that is limited or absent in many places. Compounding this vulnerability, low-income communities in Africa generally have minimal reserves and lack formal insurance coverage[25] and many areas with high levels of poverty are also at high risk of floods or other disasters.

Population growth risks further straining limited institutions and governance. Africa's population is expected to increase by approximately one billion people in the next three decades.[26] The World Bank estimates that, by 2030, approximately 118 million extremely poor people (income less than US$1.25 a day) in Africa will be at risk from floods, droughts, and cyclones.[27]

In addition to population growth, climate change will very likely exacerbate most water challenges. Box 3 includes some key forecasts for Africa, and we go into greater detail throughout this chapter.

A significant deficit in infrastructure compounds these physical challenges and risks. The AfDB estimates that just meeting the water management objectives of Sustainable Development Goal 6 will require an annual investment of US$35 billion in sub-Saharan Africa and another US$4 billion for North Africa. This is considerably more than past or current rates of investment resulting in a finance gap of about 40 per cent for urban water systems and 80 per cent for rural water supplies.[28]

As described above, NbS should not be viewed as substitutes for this needed infrastructure. However, in many contexts, NbS (i.e., natural infrastructure) can be part of the overall system of infrastructure investments, complementing, improving the effectiveness of, or reducing risks and costs to, engineered infrastructure. Furthermore, poorly planned infrastructure expansion can degrade the ecosystems and services that many communities rely upon, including wetlands, lakes, free-flowing rivers, estuaries, and water source areas. Infrastructure expansion that incorporates NbS is much more likely to avoid such impacts and instead contribute to the protection or restoration of natural infrastructure during the process of expanding engineered infrastructure.

Furthermore, the continent is rapidly urbanizing and, by 2050, will encompass 11 of the world's megacities (those with populations greater than 10 million), with much of the population growth in areas at risk from riverine or coastal flooding – not to mention increasing the strain on urban stormwater management systems.

The rise in population will increase the need for water – for drinking and hygiene but also for food and energy. Rural agricultural economies are particularly dependent on access to consistent water supplies. Agriculture is the largest user of water in Africa and improved water management will be required to support the development of agricultural and rural economies, as well as feeding the increasing African population to achieve SDG2 (Zero Hunger).[29]

Thus, demands on water systems will be growing at the same time as the population at risk of water-related disasters is growing. Beyond the major investments in infrastructure and improvements in governance needed to ensure that African countries can manage these changes and build strong, resilient societies, NbS can contribute toward managing risks, while making positive contributions to the freshwater ecosystems that underpin Africa's economies.

The following sub-sections review five water-related challenges in Africa: water scarcity, water quality degradation, flood risk from rivers and stormwater in cities, and coastal erosion and flooding. For the first three categories, we provide an analysis of risks using WWF's Water Risk Filter (WRF).[30] Although the WRF considers three types of risk – physical, regulatory, and reputational – here we focus on physical risk, with individual risk factors for water scarcity, water quality degradation and flood risk. These categories are based on global datasets drawn primarily from the latest peer-reviewed literature. Current risk is categorized into five levels: very low, low, medium, high, and very high. The WRF also provides three future scenario pathways that are different combinations of climate and socio-economic projections. Here we use the current trend scenario, which corresponds to a warming of approximately 2°C by the end of this century. Due to climate change, some portions of the world that are already in the highest risk category are projected to have increased risk and thus future scenarios have a sixth risk level: extreme risk. Details on the methods can be found in the footnote.[31]

## Box 3: Climate change and Africa's water challenges

There are many uncertainties associated with projecting the impact of climate change in Africa. However, an IPCC report offers these projections:

**The drier subtropical regions will warm more than the moister tropics.**

**Northern and southern Africa will become hotter and drier, with precipitation falling by 15% or more.**

**In eastern Africa, including the Horn of Africa, and parts of central Africa average rainfall is likely to increase.**

**Vector-borne diseases such as malaria and dengue may spread and become more severe.**

**Sea levels will rise, perhaps by half a metre, in the next fifty years, with serious consequences in the Nile Delta and certain parts of West Africa.**

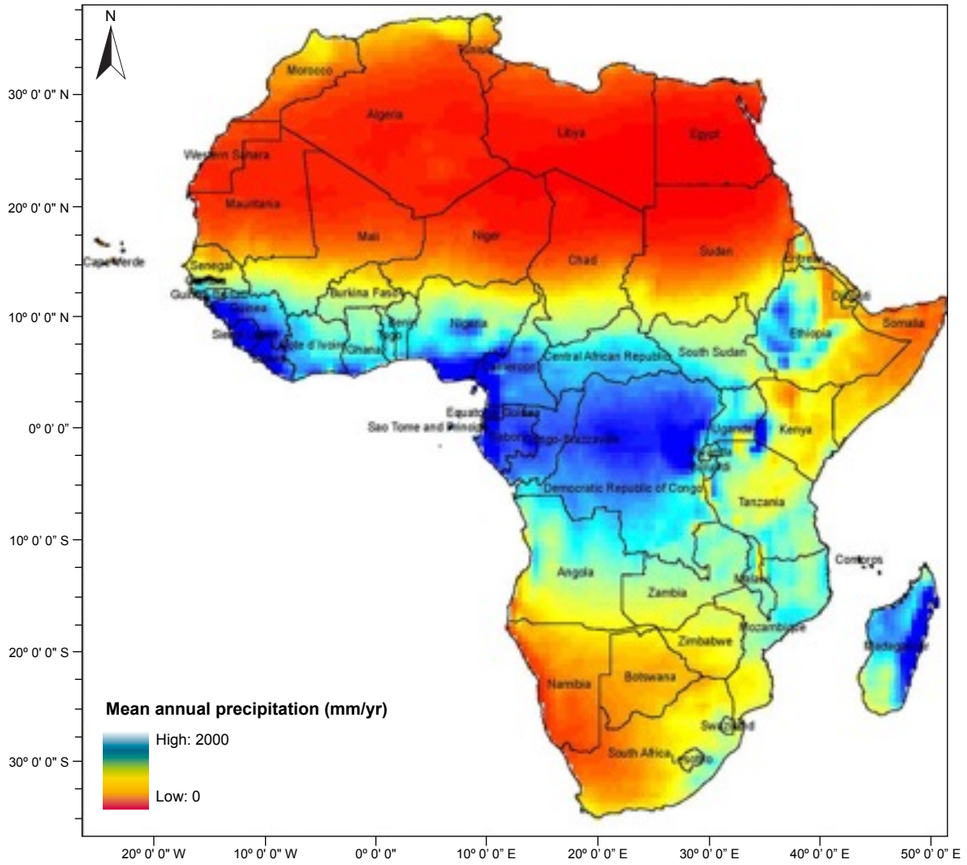



**Figure 3.** Mean annual precipitation in Africa.[34] From Masih et al. (2014).

## 2.1 Water scarcity

The amount of precipitation and water available varies widely across Africa (Figure 3). Not only are water resources spread variably, but Africa has extremely low runoff in relation to precipitation. Due to very high rates of evaporation and evapotranspiration, Africa has a 15 per cent conversion factor of precipitation to runoff – the lowest among continents.[32] One third of Africa's productive area is already classified as dryland, and climate change may bring less rainfall and a shorter growing season, extending such drylands over a larger area.[33]

Alongside climate change, a number of other drivers will affect future water scarcity, including population growth, urbanisation, agricultural growth and land-use change. For example, a study of future water shortages in North Africa projected that, by 2050, climate change will be responsible for about 20 per cent of decline while a range of socioeconomic factors will account for the remainder.[35]

Currently, about 25 per cent of Africa's population lives in areas with a water scarcity risk level of high or very high. The continent's population is expected to increase by about 60 per cent by 2050, to 2.1 billion, and that percentage will rise to 28 per cent (note that the population projections for Africa used in this WRF scenario are somewhat lower than the median UN projections cited earlier; also note that the future scenario includes a new level of "extreme" above the level of "very high"). That translates to an additional 260 million people living in areas with high risk or greater of scarcity (Figures 4 and 5). Today, approximately 39 per cent of Africa's Gross Domestic Product (GDP) is produced in areas with a water scarcity risk level of high or greater. The continent's GDP is projected to increase by more than four times by 2050, and a slightly higher proportion (41 per cent) will be in areas with a water scarcity risk level of high or greater (Figures 6 and 7 on the next page).

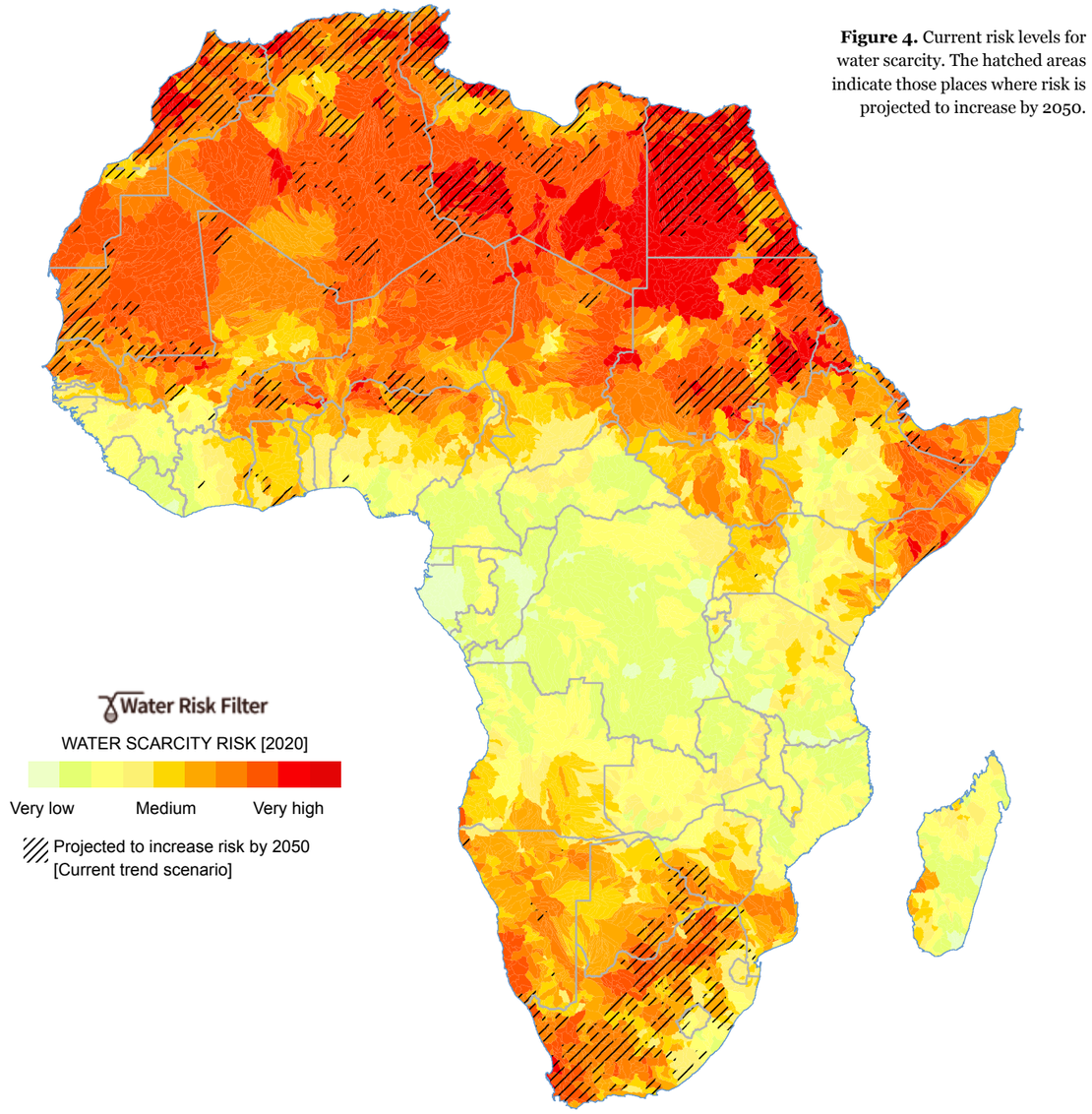



**Figure 4.** Current risk levels for water scarcity. The hatched areas indicate those places where risk is projected to increase by 2050.

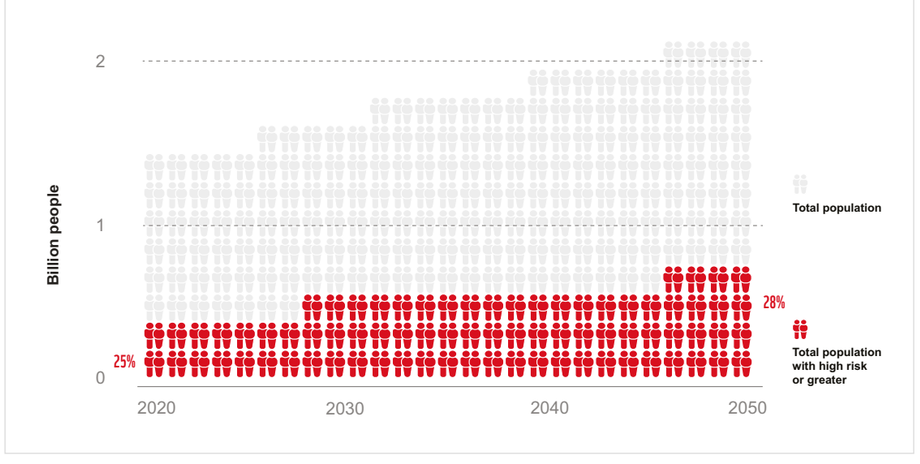



**Figure 5.** The number and proportion of Africa's population living in areas with a risk level for water scarcity of high or greater in 2020 and in 2050 under the current trend scenario.

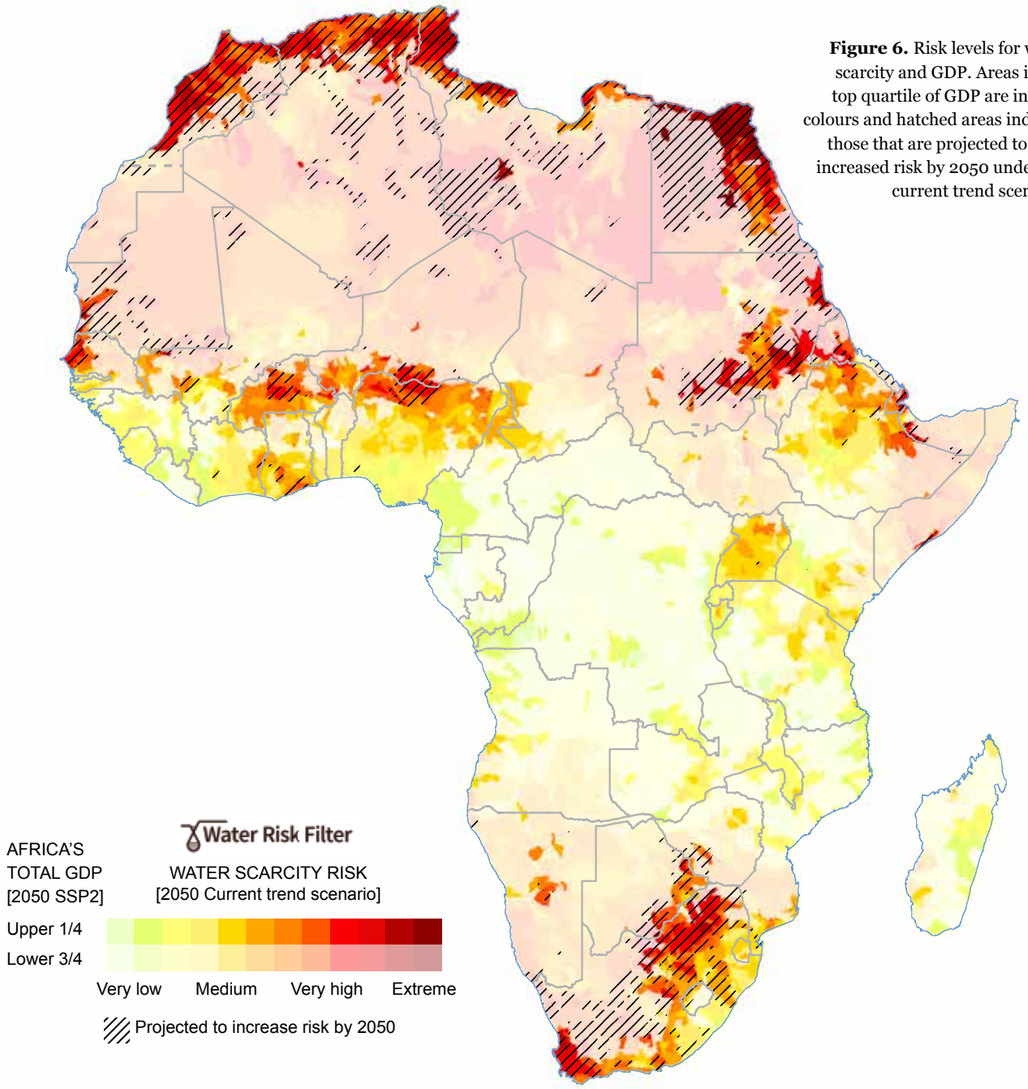



**Figure 6.** Risk levels for water scarcity and GDP. Areas in the top quartile of GDP are in dark colours and hatched areas indicate those that are projected to have increased risk by 2050 under the current trend scenario.

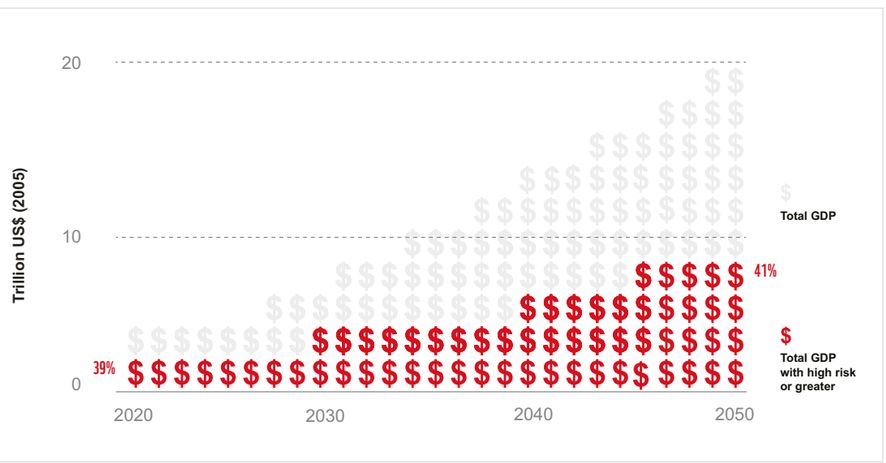



**Figure 7.** The amount and proportion of Africa's GDP that is produced in areas with a risk level for water scarcity of high or greater in 2020 and in 2050 under the "current trend" scenario.

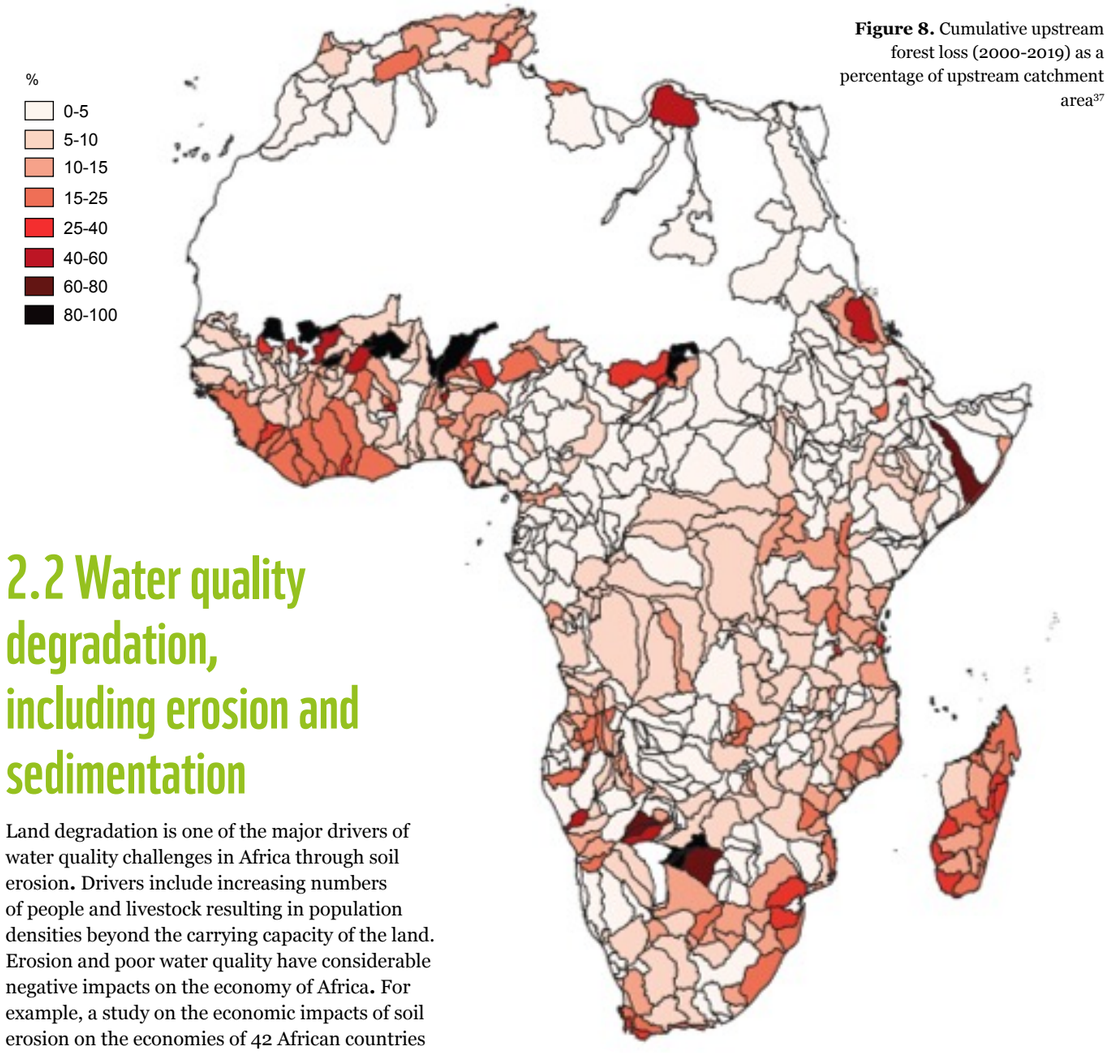



**Figure 8.** Cumulative upstream forest loss (2000-2019) as a percentage of upstream catchment area[37]

## 2.2 Water quality degradation, including erosion and sedimentation

Land degradation is one of the major drivers of water quality challenges in Africa through soil erosion. Drivers include increasing numbers of people and livestock resulting in population densities beyond the carrying capacity of the land. Erosion and poor water quality have considerable negative impacts on the economy of Africa. For example, a study on the economic impacts of soil erosion on the economies of 42 African countries found that this erosion and loss of fertility of cropland would result in an average decline of GDP in those countries of 12 per cent. The study suggested that efforts to reduce erosion and retain fertility could cost 5 per cent of GDP, but that it would be a worthwhile investment to avoid larger losses.[36] Further exacerbating erosion-related impacts to water quality, Africa has lost almost 9 per cent of its forest cover since 2000 (530,000 km² out of a total of 6.2M km² in the year 2000; Figure 8).

In addition to the economic impacts of poor water quality, the health impacts are significant too. Most cases of diarrheal disease (80%), the second leading cause of mortality for children under five, are caused by contaminated water due to a lack of hygiene and sanitation services. Increasing access to clean water and reducing water-related disease will require a comprehensive approach. Investments at the household and community level, including investment in modern piped water and sanitation systems, should be complemented by programmes that protect sources of water (e.g., watersheds that support drinking water systems) to reduce pathogen contamination.[38]

Currently, a quarter of Africa's population live in areas with a water quality degradation risk level of high or greater. That proportion is projected to increase dramatically by 2050, to 82 per cent, encompassing an additional 1.3 billion people living in areas with high risk or greater of water quality degradation (Figures 9 and 10 on the nex page). Today, approximately 45 per cent of Africa's GDP is produced in areas with a water quality degradation risk level of high or greater and this is projected to nearly double to 87 per cent of GDP by 2050 under the current trend scenario (Figures 11 and 12 on the nex page). These projections are based on the assumptions that agriculture will expand significantly in Africa and growth of agricultural pollution loading is fastest in the group of low-income developing countries.[39]

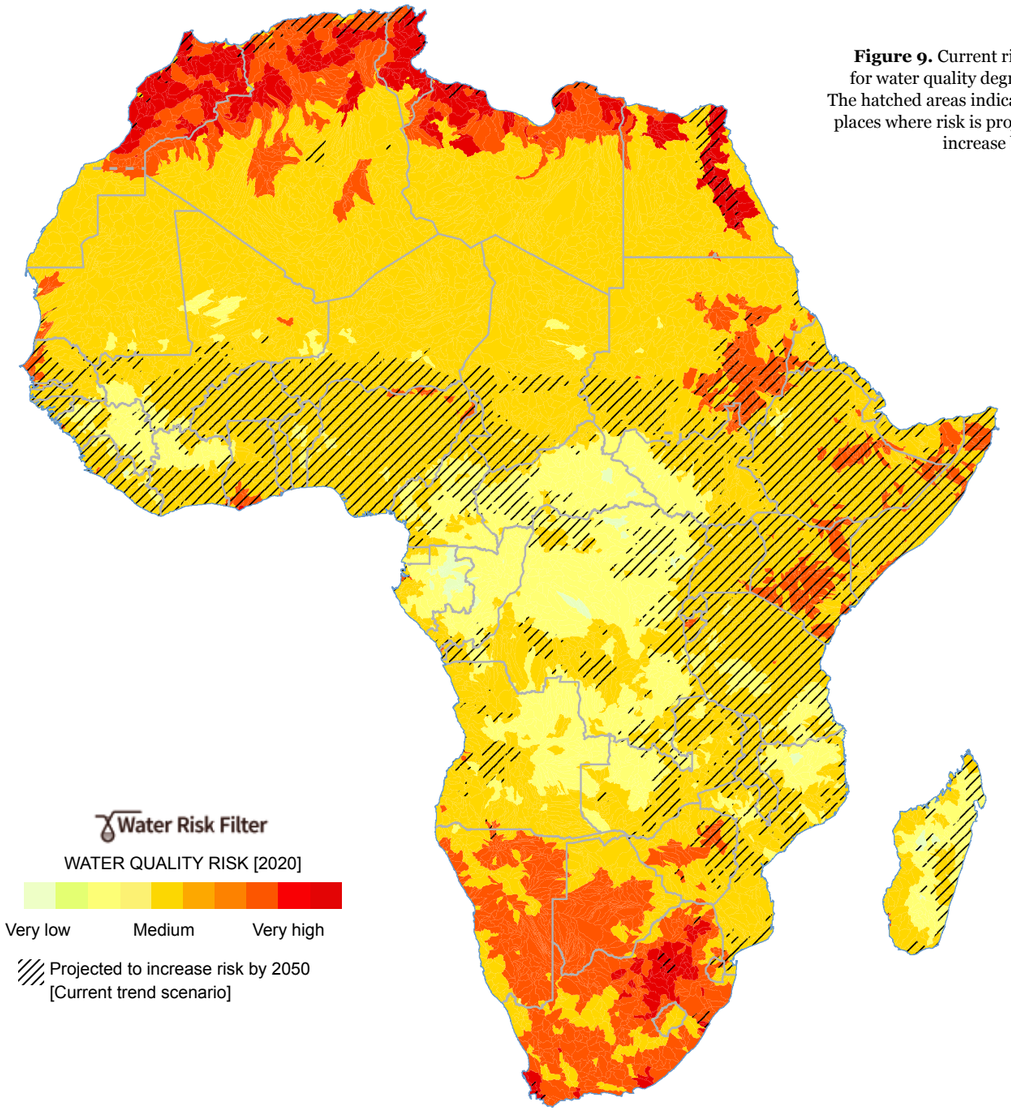



**Figure 9.** Current risk levels for water quality degradation. The hatched areas indicate those places where risk is projected to increase by 2050.

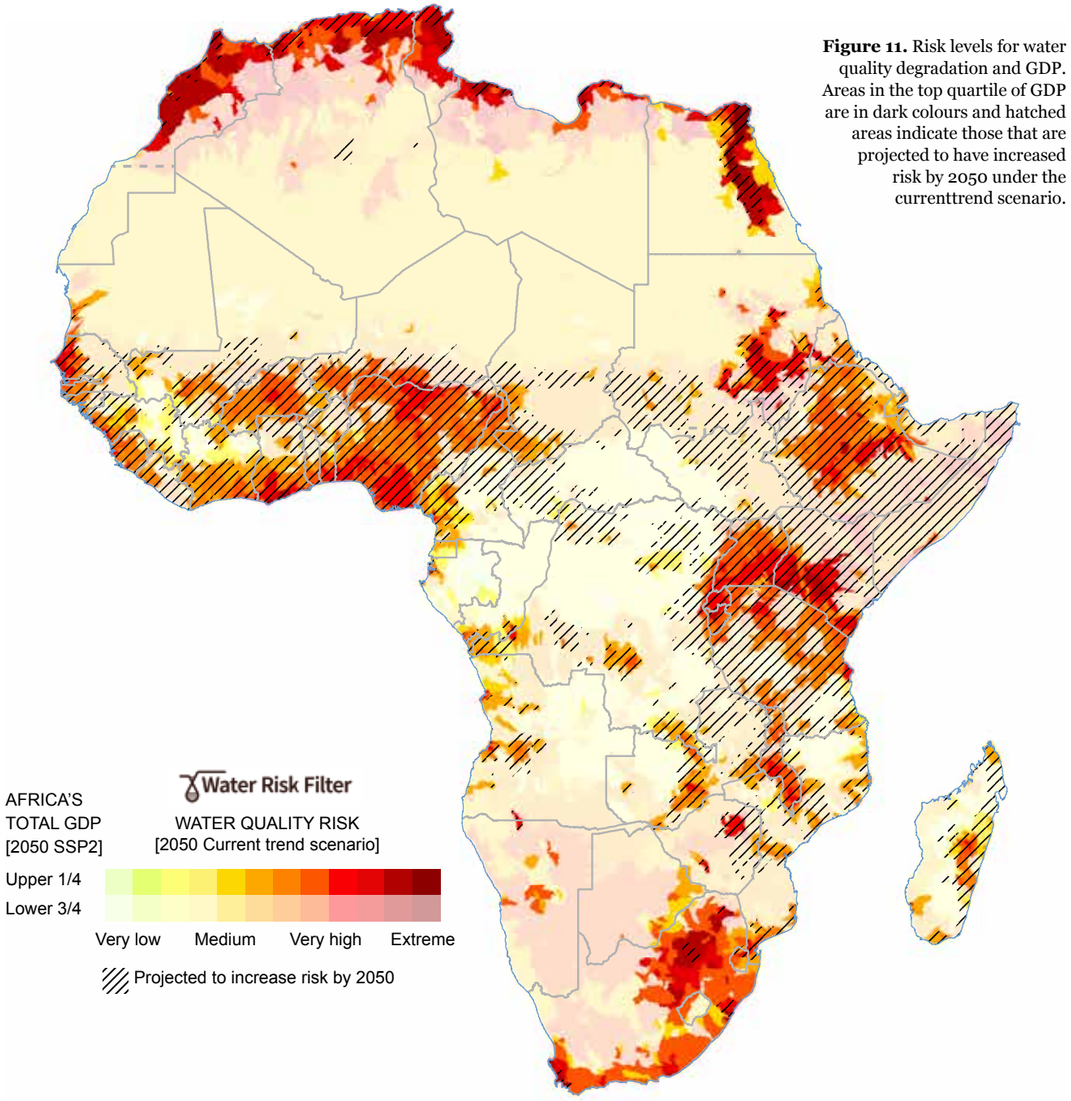



**Figure 11.** Risk levels for water quality degradation and GDP. Areas in the top quartile of GDP are in dark colours and hatched areas indicate those that are projected to have increased risk by 2050 under the currenttrend scenario.

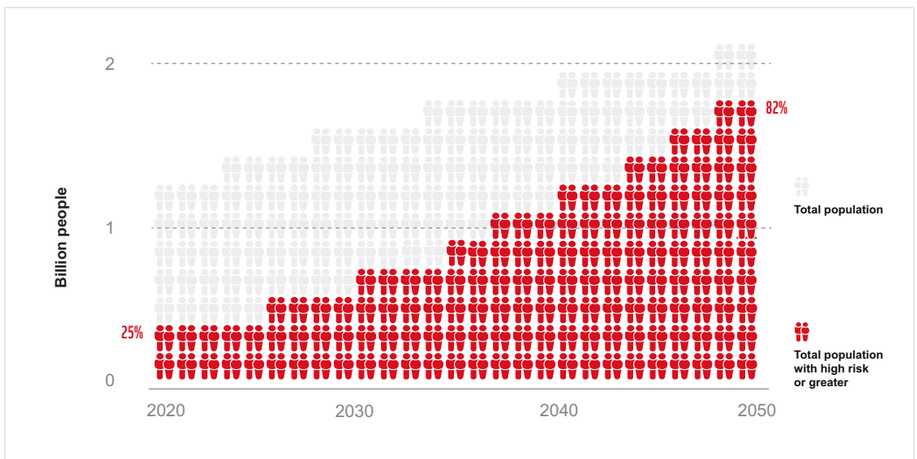



**Figure 10.** The number and proportion of Africa's population living in areas with a risk level for water quality degradation of high or greater in 2020 and in 2050 under the current trend scenario.

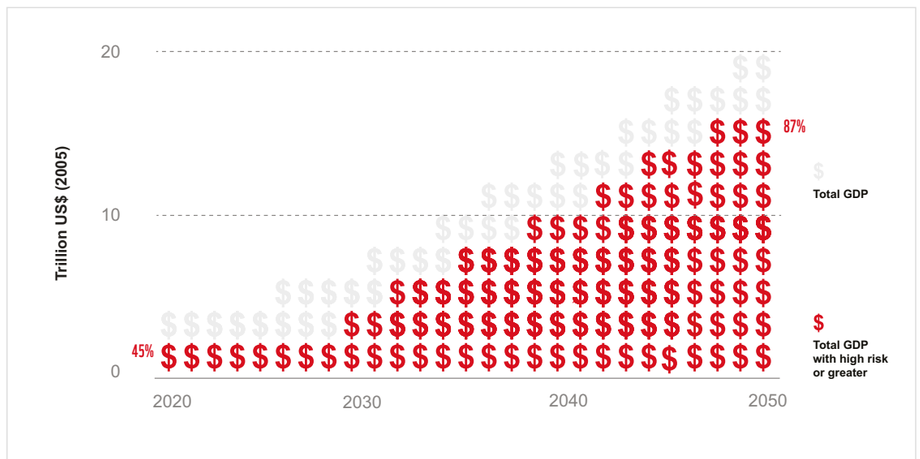



**Figure 12.** The amount and proportion of Africa's GDP that is produced in areas with a risk level for water quality degradation of high or greater in 2020 and in 2050 under the current trend scenario.

## 2.3 Flooding (rivers and urban stormwater)

Of all water-related disasters in Africa, floods are the most frequent and widespread. Due to their climates, Eastern and Western Africa are the most affected by flooding.[40] Flooding is anticipated to increase both in terms of frequency and intensity across many regions in Africa.

Low-income countries are especially at risk since their infrastructure systems to manage floods tend to be more limited, emphasizing both the need for increased investment in infrastructure in these areas along with the potential importance of those NbS interventions that are low cost and can provide benefits in the near-term before investment in infrastructure ramps up.

Continued migration into flood-prone urban areas across Africa, along with the expansion of impervious surfaces, has resulted in an increased number of people threatened by flooding. Projected rates of urbanisation are expected to result in a trebling of the population in African cities by 2050, with the urban population exceeding the rural population of Sub-Saharan Africa by about 2040[41]. African countries are experiencing some of the world's highest urbanization rates with many of Africa's evolving cities unplanned and associated with the growth of informal settlements, inadequate housing and basic services, and urban poverty. Nearly half of all urban development between today and 2030 will occur within areas with elevated risks of flooding.[42]

Based on the WRF analysis, nearly a quarter (23%) of Africa's population lives in areas with a flooding risk level of high or greater. That proportion is projected to more than double by 2050, to 54 per cent, encompassing an additional 830 million people living in areas with high risk or greater of flooding (Figures 13 and 14). Today, approximately 16 per cent of Africa's GDP is produced in areas with a flooding risk level of high or greater and is projected nearly triple to 46 per cent of GDP by 2050 under the current trend scenario (Figures 15 and 16 on the nex page).

Today, 18 out of the 20 largest cities in Africa, with a total population of 123 million, are rated as having medium or higher risk of flooding, with 6 of those cities having high risk or greater (29 million people) (Figure 17 on the nex page).

By 2050, 19 of the 20 cities, with a total population of at least 174 million, will be at least medium or higher risk. The six cities with high or greater risk in 2020 will increase to 10 cities, with a total population of 73 million. Furthermore, 10 cities, with a combined population of 70 million, will have an increase in flood risk of a full risk class (e.g., high to very high).

## 2.4 Coastal protection

More than a quarter of Africa's population lives within 100 km of the coast and more than half of Africa's total population living in low-elevation coastal zones is urban, accounting for 11.5 per cent of the total urban population of the continent. Due to sea level rise, coastal zones will become increasingly vulnerable to erosion and flooding from storm surges. By 2050 there will be six megacities in Africa located on coasts and therefore vulnerable to climate change induced sea level rise and flooding.[43] Sandy and deltaic coastlines of North Africa are already experiencing increasing erosion and saline intrusion into coastal aquifers, leading to loss of agricultural productivity and population displacement.[44] More than one-third of Africa's coastline is vulnerable to sea level rise, with deltas being the most vulnerable.[45]

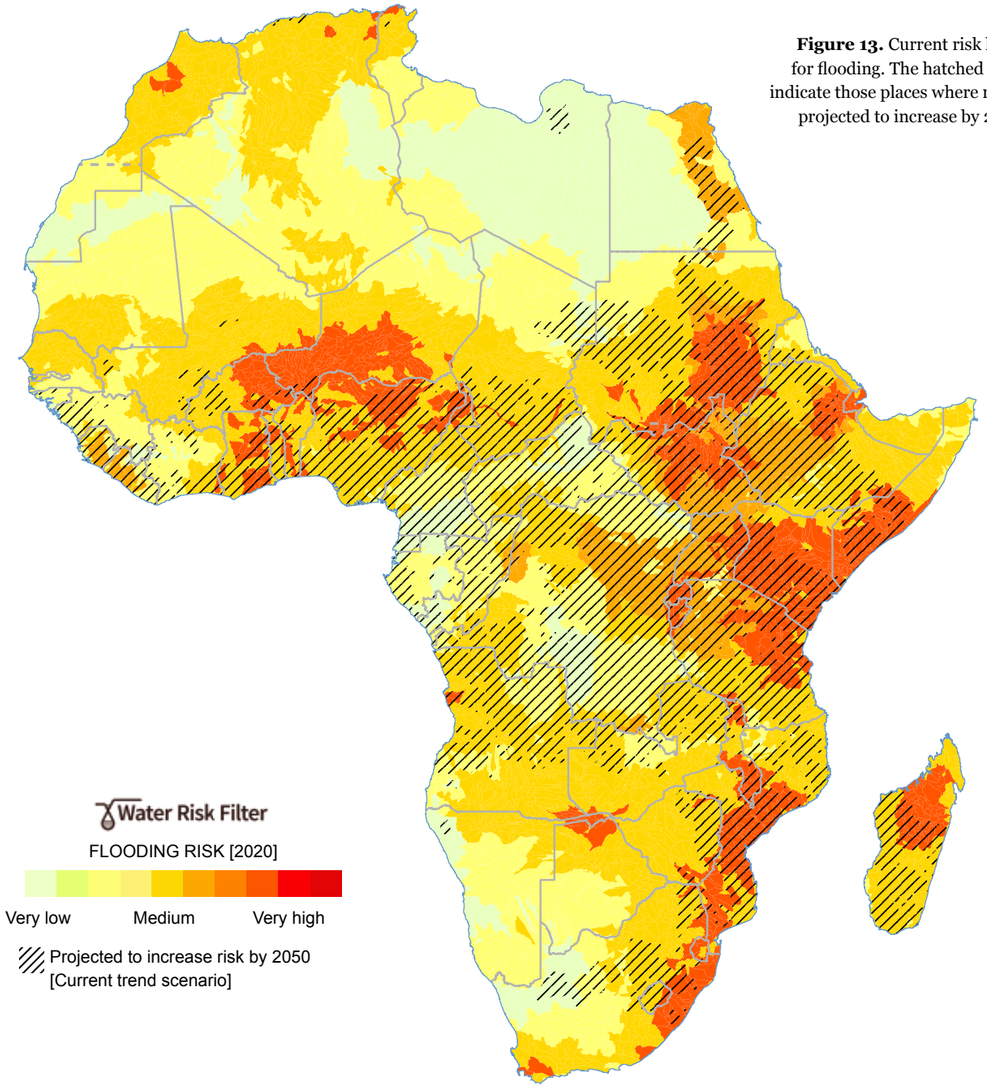



**Figure 13.** Current risk levels for flooding. The hatched areas indicate those places where risk is projected to increase by 2050.

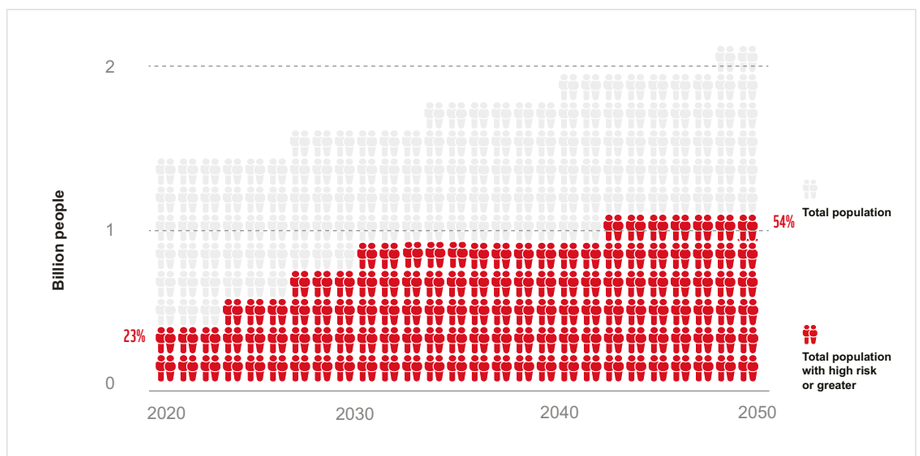



**Figure 14.** The number and proportion of Africa's population living in areas with a risk level for flooding of high or greater in 2020 and in 2050 under the current trend scenario.

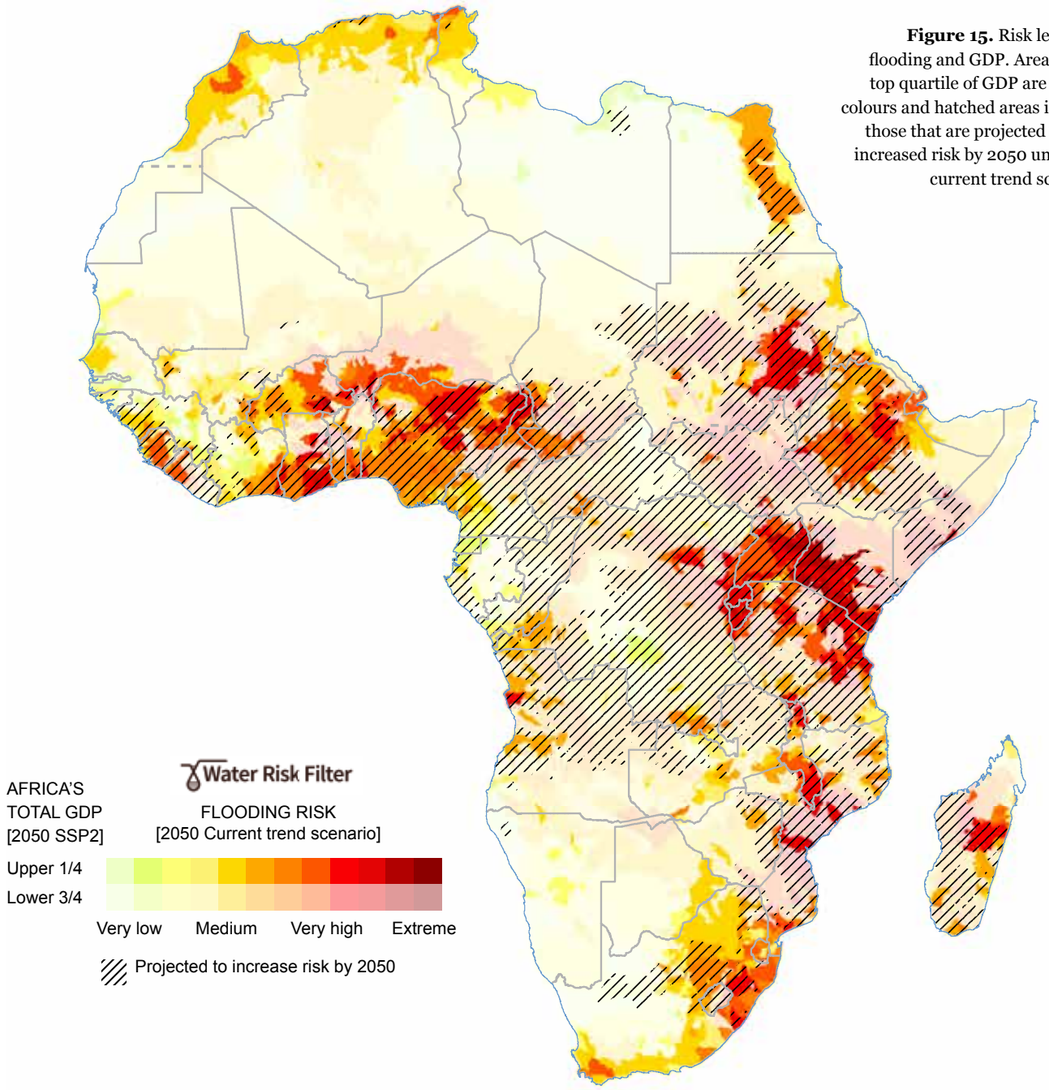



**Figure 15.** Risk levels for flooding and GDP. Areas in the top quartile of GDP are in dark colours and hatched areas indicate those that are projected to have increased risk by 2050 under the current trend scenario.

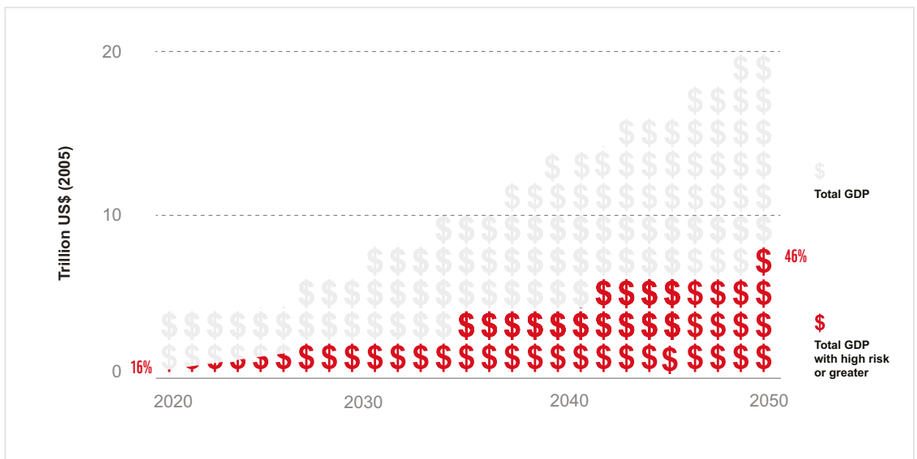
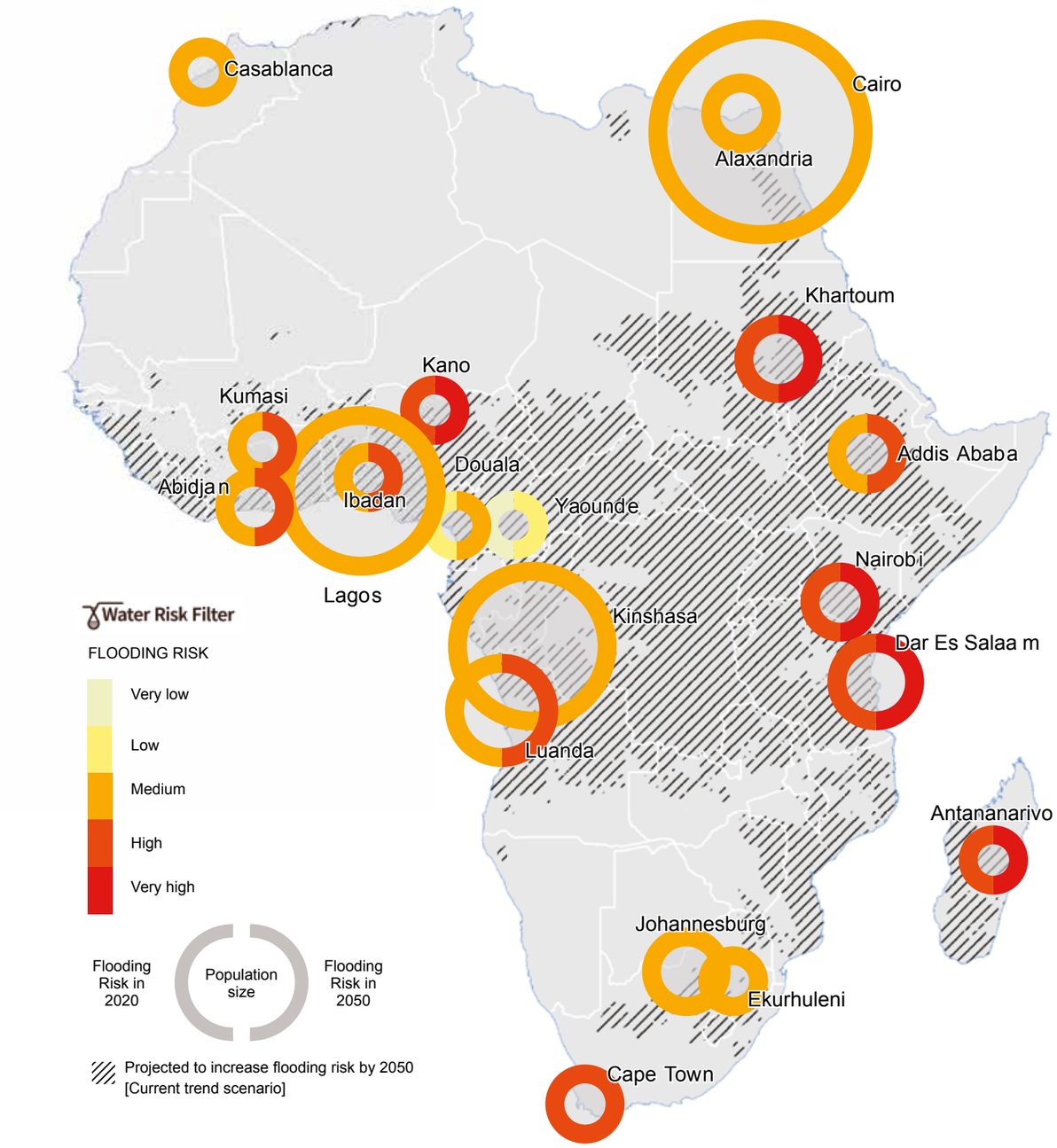



**Figure 16.** The amount and proportion of Africa's GDP that is produced in areas with a risk level for flooding of high or greater in 2020 and in 2050 under the current trend scenario.

**Figure 17.** Flood risk for the 20 largest cities in Africa today (left side of each circle) and in 2050 under the current trend scenario (right side of each circle); size of circle is scaled to current population size. Hatched areas indicate those that are projected to have increased risk by 2050 under the current trend scenario.



# 2.5 Water challenges, social conflict and migration

The growing challenges and risk factors described above – particularly poverty, population growth, and climate change increasing the frequency of droughts and floods – can trigger or worsen social conflicts. Many African countries are highly dependent on natural resources and small-scale agriculture for their food, employment base, incomes, tax revenue and exports. Furthermore, low-income rural communities tend to have a higher share of their assets and wealth tied up in natural resource and environmental assets. For example, there is little irrigation in Africa (about 5 per cent of food grown) and thus most subsistence farmers rely on natural rainfall, making them highly vulnerable to even quite small changes in rainfall patterns. Collectively, these characteristics make African countries vulnerable to the impacts of climate change – and low income, rural communities are particularly vulnerable. Thus, various disturbances from climate change – ranging from the steady deterioration of resources to sudden disasters – will likely lead to social conflicts and migration (with migration often exacerbating conflict in the places where people relocate).[46] Migration driven by climate-related impacts is already contributing to, and will be a major future driver of, Africa's rapid urbanization. Rapid migration into cities can strain urban water and sanitation systems.

Various rankings and indices underscore that many countries in Africa are at risk from climate-driven disturbances (floods, droughts, crop failures) that could impact low-income people, drive migration and destabilize countries or regions:

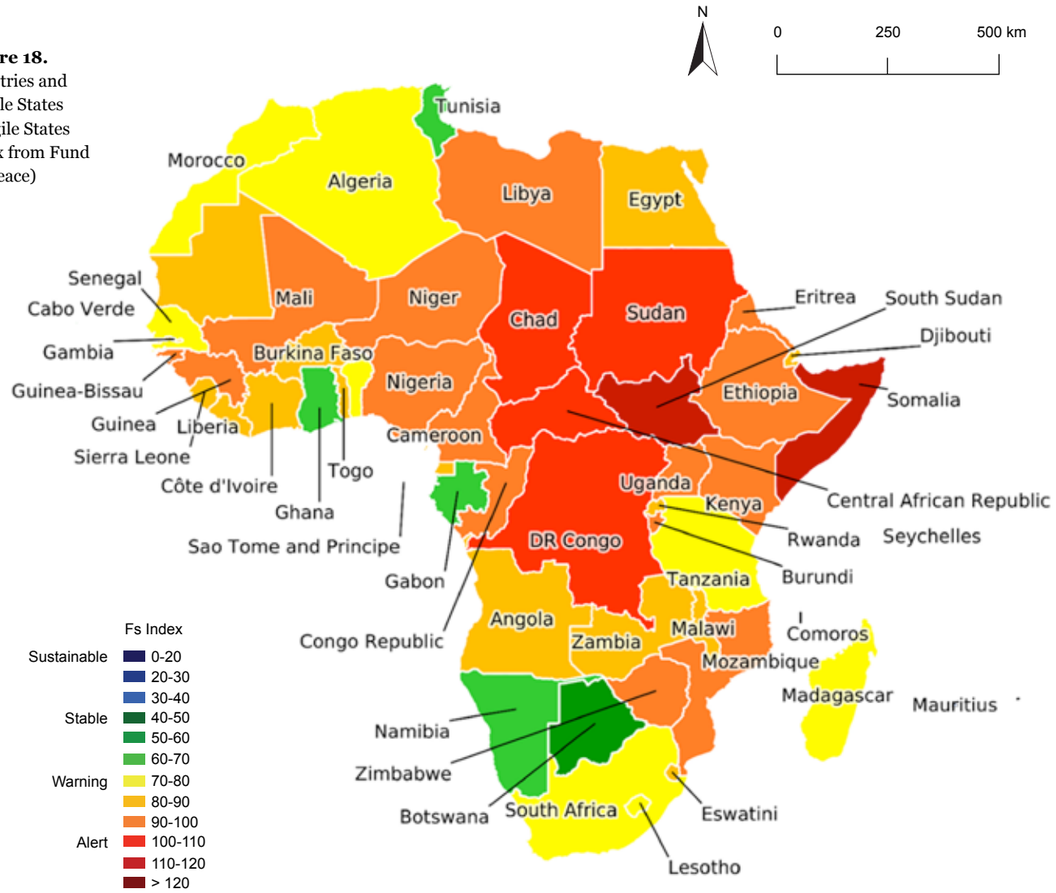



**Figure 18.** Countries and Fragile States (Fragile States Index from Fund for Peace)

- In a climate vulnerability index developed by the University of Notre Dame, the ten most vulnerable countries, and 15 of the 20 most vulnerable, are in Africa.[47]
- Similarly, six African countries are among the ten countries on the "watch list" of the International Rescue Committee, focused on countries that may be poised to descend into a humanitarian crisis due to climate change and associated conflicts.[48]
- In the Fragile States Index from the Fund for Peace, very few African countries are ranked as 'stable' or 'sustainable' and the high majority are at the levels marked 'warning' or 'alert' (Figure 18).

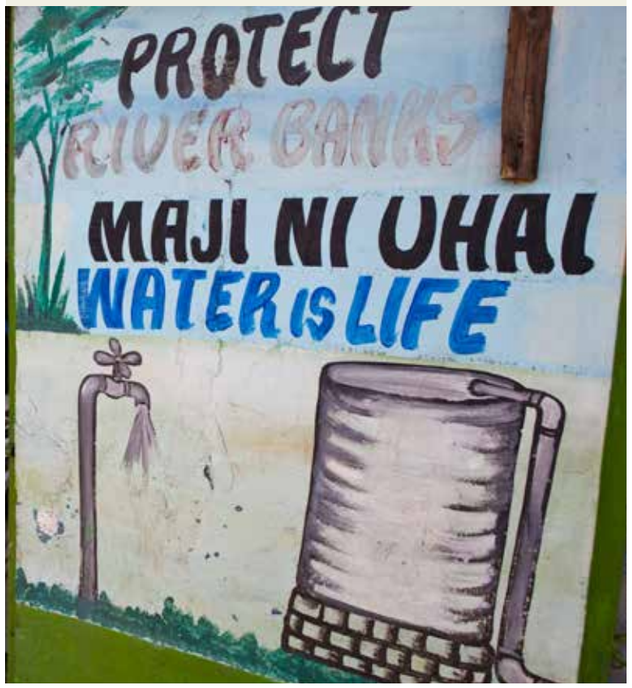
Stabilizing or restoring environmental resources can therefore be an effective strategy for defusing humanitarian crises before they emerge. In addition to direct action on the ground, promotion of sound water governance and mechanisms for dialogue and dispute resolution can also help avoid or reduce conflict. For example, in Kenya, Water Resource Users Associations have demonstrated how improved governance, dialogue, and on-the-ground interventions, including NbS for managing water resources, can avoid degradation of water resources and associated conflicts, and help resolve conflicts that do arise[49] (see Box 4).

## BOX 4: Kenya: Improved water governance and watershed management to reduce social conflict

Kenya is a water scarce country and periods of drought can lead to conflict between different groups of people. For example, during droughts, pastoralists will move their herds into new areas in search of water and forage, leading to conflict with people already using those resources. Historically, this has led to violence between groups. Through a set of legislative actions, including the Kenyan Water Act of 2016, the Kenyan government established and clarified the role of Water Resource Users Associations (WRUAs) as groups that can improve collective management of water resources – and specifically also to resolve conflicts.[50]

WWF works closely with WRUAs in Kenya's 'water towers' to solve water conflicts and implement sustainable watershed management, including NbS interventions, such as reforestation, to reduce erosion, increase infiltration and improve water quality. This is an example of a two-fold approach to reducing conflict over water. First, improve watershed conditions to promote more resilient woodlands, watersheds and water supplies. Second, promote strong WRUAs that can collectively solve challenges and conflicts over water when they do arise. Across Africa, climate change and intensified resource use are likely to increase competition over water and other resources, potentially leading to conflicts and migration. Mechanisms such as watershed management through participatory forest management programmes and local governance, such as WRUAs, can help reduce the frequency of conflicts and help defuse them when they do arise.






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# CHAPTER 3

## TYPES OF NBS FOR WATER CHALLENGES AND THE EVIDENCE FOR THEIR EFFECTIVENESS

In this section, we review NbS interventions that can be used to address five water challenges in Africa:



a. Water scarcity



b. Degradation of water quality



c. Flood risk



d. Stormwater and urban flood



e. Coastal erosion and floods

Figure 19 provides a conceptual diagram of where these interventions could be implemented across a river basin. The figure also underscores the importance of understanding the need for NbS, and then planning for implementation, at the scale of systems, such as a river basin.

In addition to reviewing key concepts and examples of these interventions, in Section 3.6 we provide a high-level summary of reviews of the evidence of the effectiveness of various NbS interventions for managing these challenges, including from a global evidence base for NbS[51] and the first review of evidence for the effectiveness of NbS interventions in Africa.[52] Annex 1 provides more comprehensive summaries of the evidence reviews.

## 3.1 Water quantity can be secured through forest management and floodplains

Globally, the demand for water has been increasing at approximately 1 per cent per year and demand will continue to grow due to shifting patterns of consumption and population growth.[53] Studies consistently forecast a shortfall between supply and demand and, in much of the world, climate change will likely exacerbate these challenges. By 2050, over half the world's population could live in regions with water stress.[54] Meanwhile, many parts of the world – including much of Africa – are predicted to face more frequent and severe droughts.

There is growing evidence that healthy and well-managed ecosystems can help manage water resources – ranging from protecting regional scale forests to maintain rainfall patterns[55] to restoring native vegetation to regulate flows and minimise impacts, such as soil erosion and wildfires, on the watersheds that provide drinking water.[56] Forests with deep soils can promote infiltration and, by reducing excess surface erosion, decrease the amount of sediment and associated nutrients that enter water supplies. A 2021 report from the Global Water Partnership and International Water Management Institute recommends a "shift in thinking around water storage," encouraging water managers to view storage as more than reservoirs, but rather as integrated systems encompassing both built infrastructure and natural sources of water storage, including soils, groundwater and wetlands.[57]

Floodplains that remain connected, or are reconnected, to river flows can promote groundwater recharge and have the potential to be managed in conjunction with water supply reservoirs. Managed aquifer recharge (MAR), or water banking, encompasses a range of methods to store water in aquifers. In California, the Department of Water Resources is pursuing "Flood-Managed Aquifer Recharge" (Flood-MAR), using floodplains as well as intentionally flooded farm fields and flood bypasses as locations where floodwaters can infiltrate into the groundwater, to be stored and managed as part of the state's overall water supply.[58]

The case study on Zambia's Lukanga Swamp, in the next chapter, illustrates how large areas




Category of NbS interventions

| Water-related societal challenge | FP. Floodplain restoration and/or protection | CM. Catchment management | W. Wetland restoration and/or protection (incl. coastal) | BZ. Riparian buffer zones | NI. Natural infrastructure in urban spaces |
|---|---|---|---|---|---|
| Water scarcity | ✓ | ✓ | ✓ | | |
| Water quality degradation | ✓ | ✓ | ✓ | ✓ | ✓ |
| Riverine flood risk | ✓ | ✓ | ✓ | | ✓ |
| Urban stormwater and flood risk | | | ✓ | ✓ | ✓ |
| Coastal erosion and flooding | | | ✓ | | |

**Figure 19.** A conceptual diagram of where NbS interventions could be implemented across a river basin, emphasizing the importance of planning for NbS implementation at the scale of a system, such as a river basin.

of floodplain can serve as a "sponge" that stores water during wet the season (and wet years) and can slowly release it, augmenting flows during the dry season (and dry years) to the benefit of downstream water users (agriculture, hydropower and water supply utilities). Note that floodplains can have high evaporation and so can reduce overall water volumes; but the shifting of volume from wet season to dry can be a major benefit to water users even if total volume is reduced.

The 2018 World Water Development Report[59], from UN Water, emphasizes that NbS should play a central role in how the world manages water supplies in the context of growing demand and climate change, including increased risk of water scarcity. The report recommends a range of NbS, including using natural features to increase water availability (e.g., recharging groundwater and retaining water in soils).

These NbS interventions that are aimed at improving the regulation of water quantity also generally improve water quality (see following section) along with providing other diverse benefits, including carbon sequestration in plants and soils, and habitat for fish and wildlife[60].

Similar to managing flood risk, managing for water scarcity and drought risk should strive for a "diversified portfolio" approach, which includes a comprehensive array of measures ranging from management practices, policies and incentives to strategic integration of engineered infrastructure and NbS. This diverse, integrated and comprehensive approach can help countries move from simply reacting to droughts to building a drought resilient society.[61]

## 3.2 Water quality can be improved through forests and wetlands

A range of NbS can help improve water quality, particularly within agricultural landscapes or drinking water systems. NbS for improving water quality for drinking water systems largely overlap with those for managing for water security and decreasing risk of water scarcity.[62] These primarily entail improving the health of soils and vegetation within the watershed that generates water for a drinking water system, discussed in the previous sub-section. The Mau Forest Complex in Kenya illustrates how forests can regulate flows of water and improve water quality. These forests supply clean water to downstream users and also filter water from streams that come from agricultural land.[63]

Globally, agriculture (both crops and livestock) is the largest contributor to diffuse water pollution as runoff from farm fields, pastures and grazing lands carries sediment, fertilizer and pesticides into streams and ultimately into aquifers, rivers, lakes, estuaries and the ocean. Increasing natural vegetation cover in permanent crops or between annual crops can reduce soil erosion. Filter strips or riparian buffers can be placed along streams to intercept runoff in the form of overland flow from farm fields. The roughness and complexity of the vegetation can filter out the sediment from the flow. Because nutrients such as phosphorous are largely absorbed into sediment particles, this filtering can reduce the amount of nutrients that enter streams as well as reducing sedimentation.

However, much of the runoff from fields does not move as overland flow that can be intercepted by a filter strip but instead flows off fields in ditches or drains. Strategically placed wetlands or small ponds can help manage this more concentrated flow to reduce the volume and rate of runoff that flows into streams and to filter nutrients and other pollution. By creating areas of water with low or no velocity, ponds and wetlands allow sediment to drop out from the waters flowing off fields – along with the phosphorous bound to the sediment.[64] Nitrogen can be removed through biological processing within wetlands as plants and bacteria convert nitrates to less harmful forms. Working in Illinois (USA), researchers found that converting six per cent of a farm's area into wetlands that intercepted the farm's drainage system could reduce runoff of nitrates by 36 to 44 per cent.[65]

Reconnecting rivers to their floodplains can also reduce nutrient pollution through deposition of sediment and phosphorous and biological processing of nitrates.[66] Thus floodplain restoration and reconnection have been recommended, or implemented, as strategies to reduce nutrient pollution to downstream water bodies such as the Great Lakes of North America[67], Chesapeake Bay[68] and the Gulf of Mexico.[69]

## 3.3 Flood risks can be reduced by floodplains, wetlands, and forests

Flooding already causes average annual losses of nearly €40 billion around the world.[70] Forecasts suggest that even relatively small increases in the global average temperature will result in an increase in the frequency of intense and damaging storms and floods, and the modeled predictions are already being confirmed with extreme flood events across the world.[71] Beyond climate change, flood risk is rising for other reasons. In regions with mature flood defense systems, the engineered structures, such as dams and dikes, are often deteriorating with insufficient budgets for repairs and maintenance. Furthermore, ongoing changes in river basins – including conversion of forests and wetlands into agriculture land and the expansion of urban areas dominated by impervious surfaces – are increasing the size and frequency of floods.

Too often, debates about investing in flood-risk management focus strictly on engineered structures, such as dams, dikes and floodwalls. However, a consensus is emerging that a much broader approach – a 'diversified portfolio' – is needed to manage current and future flood risks.[72] This portfolio should emphasize non-structural measures such as improved zoning, building codes and insurance, as well as investments in NbS such as wetlands and floodplains managed to reduce flood risk[73]. These same approaches can be referred to as natural infrastructure, natural flood management (NFM)[74], or nature-based flood defense.[75]

In addition to providing the benefit of flood-risk reduction, NbS projects can also help restore floodplain ecosystems, which are among the most productive and diverse habitats on the planet.

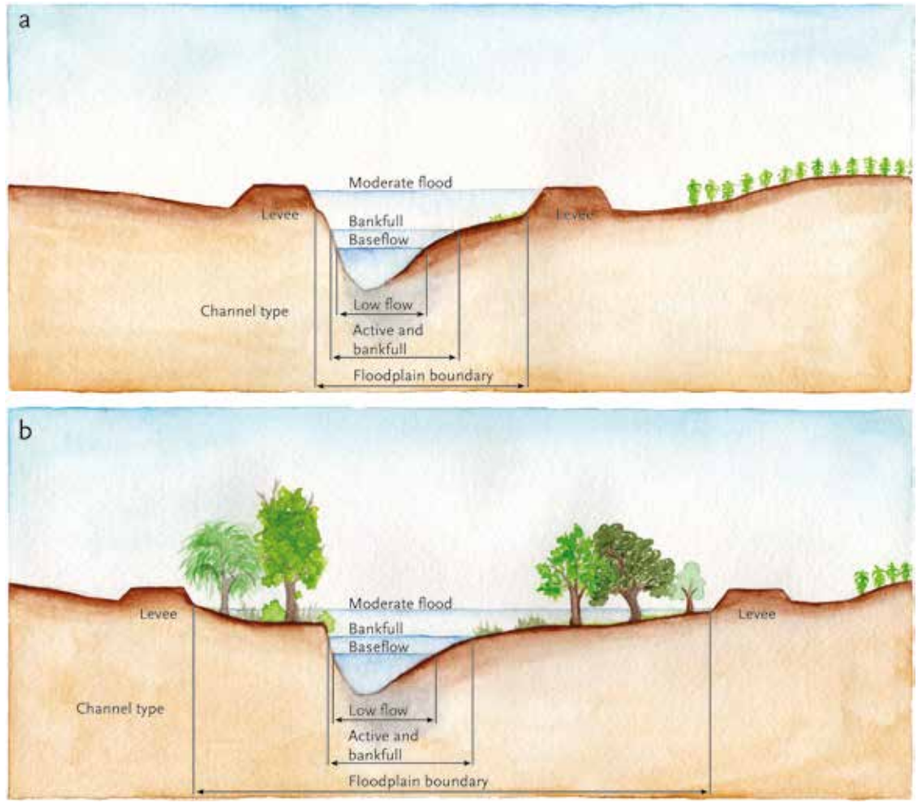



**Figure 20.** Setting dikes back away from the river can provide more area for conveyance of flood flows, reduce pressure on dikes, and provide habitat for fish and wildlife (from Opperman et al. 2017).

There are three main categories of NbS for reducing risk from river flooding:

***1. Managing land to retain and slow runoff.*** Precipitation across a watershed or river basin leads to runoff into streams and rivers; above a given rate this runoff can lead to flooding. Land – including soils, vegetation and wetlands – can be managed to slow down and retain runoff as much as possible, potentially reducing flooding downstream (with impact varying by size of runoff event and area of watershed). Specific interventions can include protection of natural forests, reforestation, restoring healthy wetlands, and best practices in agriculture and grazing that encourage infiltration into soils or the addition of features — such as small wetlands — that can retain runoff. Note that these interventions also reduce erosion and risk of landslides. They generally also overlap with those interventions intended to improve water quality or increase resilience to water scarcity.

*2. Large-scale preservation of floodplains along rivers* can reduce flood levels and risk in some situations, both through storage of floodwaters that reduces flood levels downstream and – because land that remains in forest, wetland, or other flood-tolerant land uses is generally not vulnerable to damage during floods – by minimizing economic damage from floods.

***3. Hybrid grey-green approaches including dike setbacks and floodways.*** Dikes can be repositioned further from the river to increase the area of floodplain available to convey floodwaters, potentially reducing flood levels elsewhere in the system (Figure 20). Floodways are large areas that are designated to be inundated during floods, greatly expanding the area available to store and convey floodwaters. Depending on the frequency with which a floodway is inundated, the land within it can be used for low intensity activities, such as certain types of agriculture or forestry and/or recreation, including ecotourism. Both floodways and the additional floodplain area connected to the river after a dike setback can provide important habitat for fish, birds and other wildlife. From a flood-management perspective, these interventions are often focused on large, potentially damaging floods. However, small and frequent floods can have great value to ecosystems. To promote these ecological benefits, NbS interventions can be planned to incorporate features that maximize the benefits of these small floods.[76]



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## 3.4 Urban wetlands and green infrastructure can help manage stormwater and reduce risk of urban flooding

Cities are dominated by impervious surfaces – including rooftops, parking lots and roads – and thus only a small proportion of rainfall infiltrates into the soil. Compared to an undeveloped watershed, an urban area will produce five times as much surface runoff for the same rainfall event.[77] Additionally, many cities have paved over lakes and wetlands and channelized their streams and rivers so that heavy rainfall can rapidly overwhelm storm drainage systems and cause severe flooding. A range of NbS interventions can be used to increase infiltration, slow down and store runoff, and reduce flood peaks.

Some NbS for urban flood risk are methods integrated directly into buildings or infrastructure – such as porous pavement, "green" (vegetated) roofs, rain gardens and rain barrels – that slow and retain runoff to replicate the hydrological functions of more natural systems. Other NbS features aim to attenuate runoff for larger areas, including grassy swales and detention basins. These can even begin to overlap with the recovery of natural ecosystems and include the restoration of – or construction of new – lakes and wetlands.

Rapid urban runoff also contributes to water pollution. Runoff on roads and parking lots picks up trash and oil residues and other pollutants and carries them directly into storm drains that then flow into creeks and rivers. The rapid and high magnitude flows discharged from storm sewers into creeks also contribute to widespread erosion of channel beds and banks, contributing to excessive sedimentation downstream. By slowing down runoff, NbS can reduce this erosion, while other NbS features, such as wetlands and detention ponds, can serve to filter out trash and pollutants from runoff before they enter natural drainage systems.

Fortuitously, most NbS methods that slow runoff also make urban spaces healthier, greener and cooler in summer, improving recreational values and aesthetics for cities. Parks, urban gardens and wetlands all increase infiltration and slow stormwater but also contribute to more vibrant urban environments contributing to the physical and mental well-being of city dwellers.[78]

## 3.5 Coastal protection is increased by mangroves and other features supported by riverine sediments

Coastal storms, floods, and erosion are already a major cause of damage to countries, with US$300 billion in insured losses globally in the past decade and potentially three times more in uninsured losses.[79] Rising sea levels will increase these losses. Without significant investments to reduce risk, global flood damage to coastal cities will increase by an order of magnitude or more by 2050, according to a 2013 study led by a World Bank economist.[80]

Similar to management of river flooding, investments to reduce coastal flood risk have traditionally focused on hard engineering solutions such as flood walls and dikes. These will continue to be needed in some situations, but they require continued maintenance and rehabilitation and contribute to the loss of coastal wetlands and other ecosystems – and the world has already lost an estimated 87 per cent of its wetlands.

A range of NbS interventions can reduce risks of coastal erosion and flooding, while also helping to reduce the loss of coastal habitat and providing other diverse benefits, including habitat for fish, birds and wildlife and carbon sequestration. These interventions feature the protection and/or restoration of coastal ecosystems, such as mangroves, salt marshes, and coral reefs.

These natural features provide protection in three ways:[81]

- ***Reducing wave energy.*** Plants and other natural features dissipate the energy of waves breaking on the shore, while roots help bind soil to reduce erosion from waves.
- ***Attenuate storm surges.*** Major storms send a large volume of water inland, raising water levels. Natural features break up the energy of the surge and, if the features are sufficiently broad, they can reduce the height of the surge experienced further inland.
- ***Maintain shoreline elevation.*** Vegetation and other complex physical structures found within natural ecosystems trap sediment, which helps to build new land and stabilize shorelines – a benefit that is particularly important to counteract sea level rise.

Coastal NbS can be potentially lower cost than traditional engineering interventions and, rather than causing negative impacts to coastal ecosystems, NbS interventions can support a range of other values. A report from the World Bank estimated that, for managing wave heights of up to a half metre, the restoration of coastal wetlands could be two to five times less expensive than construction of submerged breakwaters.[82] A study of the eastern US found that coastal wetlands reduced damages during a hurricane by a total of over US$600 million during that storm.[83] The Global Commission on Adaptation found that restoring mangroves is not only less expensive than conventional engineered structures that protect against sea-level rise, but their protection could also generate substantial economic benefits, such as securing food supply and livelihoods, improving water quality, reducing storm impacts, and generating incomes for the local community.[84] Another study found that, based on economic and hydrodynamic modelling, mangroves are estimated to provide flood protection benefits exceeding US$65 billion per year; their global loss would lead to 15 million more people being flooded annually across the world.[85]

Because coastal ecosystems are among the most important for sequestering carbon, protection or restoration of coastal wetlands could serve as NbS for both mitigation (sequestering carbon) and adaptation (reducing losses from rising risk)[86], with carbon credits potentially providing an additional source of funding for NbS projects (see section 4.4).

Many coastal ecosystems are strongly influenced by rivers, particularly rivers' ability to deliver sediments. Thus, the performance of some coastal NbS projects will be closely linked to river processes (see Box 5).

## BOX 5: Free-flowing rivers as a Nature-based Solution: sediment, deltas and mangroves

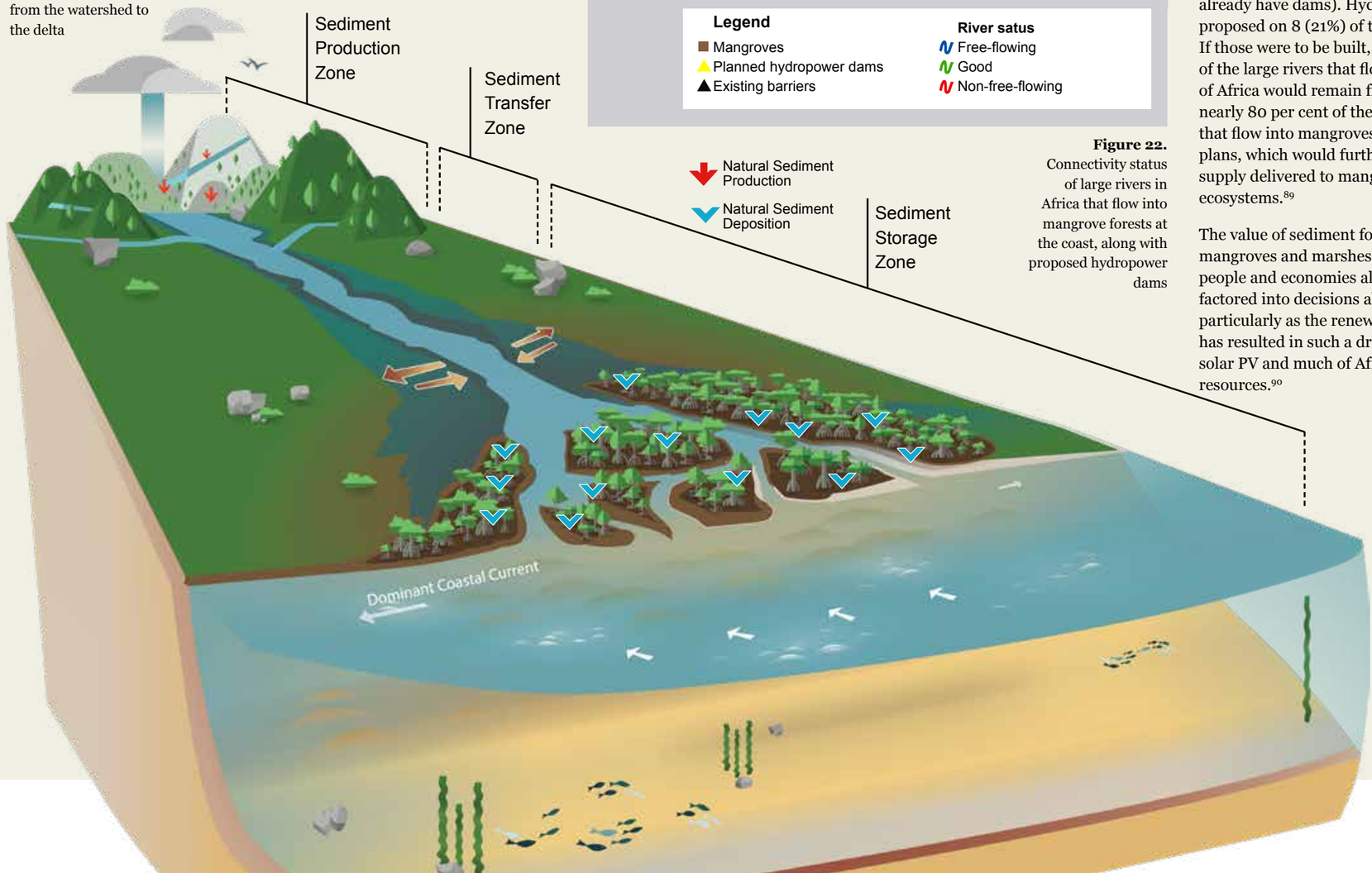
Free-flowing rivers are generally not included among lists of Nature-based Solutions. However, rivers that carry a natural sediment load are essential to the functioning of many of the more commonly listed NbS interventions, such as restoration or protection of floodplains, coastal marshes and mangroves. That is because rivers carry sediment, and a key function of many NbS interventions is their ability to turn river-borne sediment into land. For example, deltas are landforms created by the sediment deposited when rivers meet the ocean. Over time, those sediments become compacted and are eroded by waves and storms and so, to remain stable, deltas require ongoing replenishment from the sediment delivered by a river (Figure 21). When a dam is built on a river, the reservoir behind it can trap the river's sediment supply, leaving much less sediment available downstream to be carried to the delta. Globally, reservoirs capture approximately 25 per cent of the sediment that rivers carry each year and this reservoir capture is a primary reason that deltas are sinking and shrinking around the world, with rising sea levels exacerbating this problem.[87] For example, dams on the Nile trap more than 95 per cent of the river's sediment and the Nile Delta – home to nearly 40 million people and responsible for most of Egypt's agricultural production – is rapidly eroding. Widespread losses of deltas would have global implications as they are home to 500 million people and produce 4 per cent of the world's food from just 0.5 per cent of the land surface.[88]

On deltas, management agencies often invest in a range of interventions, such as sea walls and rip rap to hold back salt water and reduce erosion. Managers are beginning to recognize the value of using river borne sediment as a NbS for protecting deltas. For example, the US Army Corps of Engineers is creating openings in levees to allow sediment-rich floodwaters to flow out into marshes to build their elevation and provide additional protection from rising sea level and storm surges along Louisiana's coast. In the Netherlands, WWF began working with a range of partners in 2015 to direct water into the Haringvliet, which had formerly been an estuary before being disconnected from the sea by floodwalls. Managing flows through the floodgates will allow more natural sediment deposition, helping to rebuild elevations in the estuary, counteracting subsidence and reducing risks of flooding and erosion. Furthermore, this reconnection will allow migratory fish, such as salmon and eel, to once again enter the Maas and Rhine rivers through the Haringvliet. The restoration will be partially funded through "bankable projects" that leverage private capital (see Box 9 on Bankable Nature Solutions).

Sediment deposition from rivers is also crucial to the functioning of mangroves. In systems where mangroves grow in areas influenced by rivers, their essential NbS functions – including sediment trapping, land building, and coastal protection – all depend on the supply of sediment from rivers. Globally, about 70 per cent of mangroves grow in areas directly influenced by rivers and their sediment supply (estuaries and deltas).

Understanding the sediment dynamics of where rivers meet the ocean, in estuaries and deltas, including sediment supply and how currents and tides distribute that sediment, will be key for planning and maintaining many coastal NbS projects. Because sediment supply is crucial to coastal protection and the viability of NbS projects, anything that affects sediment supply should be viewed in that context. Thus, upstream sand mining and reservoir capture should be viewed as factors that affect the viability of coasts and NbS coastal protection projects. Planning and management of both reservoirs and sediment mining should incorporate this perspective. If a dam is planned on a free-flowing river, the value of the river's sediment for maintaining downstream deltas and mangroves should be an important decision variable. While not often framed this way, the protection of a free-flowing river, and its sediment supply, could be among the most beneficial and impactful NbS interventions that can be implemented.

**Figure 21.** Sediment processes along a river from the watershed to the delta



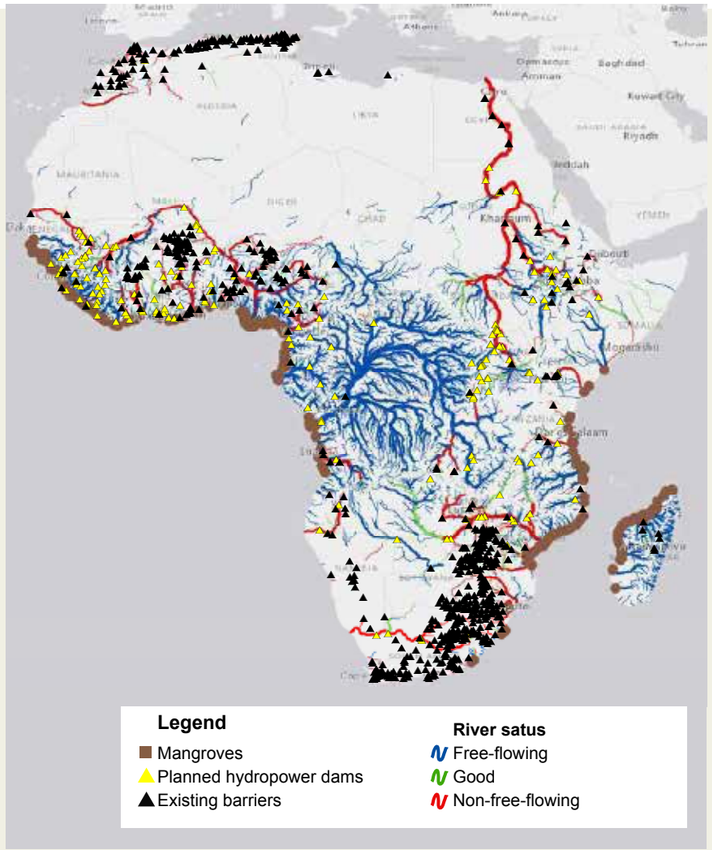




**Figure 22.** Connectivity status of large rivers in Africa that flow into mangrove forests at the coast, along with proposed hydropower dams

In Africa, there are 56 relatively large rivers (those with a discharge greater than 100 cubic meters per second at their mouth) that flow into mangrove forests along the coast (Figure 22). Of these, 39 (70%) remain free flowing (the others already have dams). Hydropower dams have been proposed on 8 (21%) of those free-flowing rivers. If those were to be built, then just over half (55%) of the large rivers that flow into mangrove forests of Africa would remain free flowing. Furthermore, nearly 80 per cent of the already dammed rivers that flow into mangroves have additional dam plans, which would further reduce the sediment supply delivered to mangroves and other coastal ecosystems.[89]

The value of sediment for downstream deltas, mangroves and marshes – and the protection of people and economies along the coast – should be factored into decisions about dam development, particularly as the renewable energy revolution has resulted in such a dramatic drop in the cost of solar PV and much of Africa has abundant solar resources.[90]




## 3.6 Key findings of the evidence reviews

As this chapter has shown, NbS can help tackle a range of societal challenges facing Africa. Our review of a global database of NbS performance[91] and the first review of evidence for NbS in Africa[92] also confirmed this potential. Both of these summaries of evidence conducted systematic reviews of the literature, focusing on studies that provided quantitative results of the impact of a NbS intervention, and reported whether the study found a positive or negative (or inconclusive) impact on the intended objective (e.g., whether a reconnected floodplain measurably reduced flood flows). Here we outline some of the key overall findings of the reviews to help guide NbS development. More comprehensive summaries are provided in Annex 1.

- Because trees have greater evapotranspiration than shrubs or grasses, forests can reduce total water production from a watershed. However, native forests often increase flow during the dry season and, for many ecosystems and water users, increased availability of water in the dry season can be more important than total annual production of water.
- In the global survey, planting of non-native forests nearly always reduced water quantity from a watershed, while restoration or protection of native forests generally had positive benefits on water quantity (Figure 23).
- In Africa, removal of non-native trees consistently resulted in greater water production from a watershed (a key NbS intervention in South Africa, see section 4.1).
- In both the global and African reviews, there was strong evidence that protection or restoration of forests can reduce sedimentation and improve water quality as well as reduce flood levels downstream.
- In Africa, the presence of floodplains is consistently associated with reduced flood levels downstream, for both small and large floods (Figure 24).
- Wetlands were consistently associated with improvements in water quality; the Africa review found these improvements across a range of metrics, including biological oxygen demand, sediments, and heavy metals.
- The global review found that restoration or protection of mangroves or other coastal ecosystems consistently had positive benefits for reducing coastal erosion or flooding.

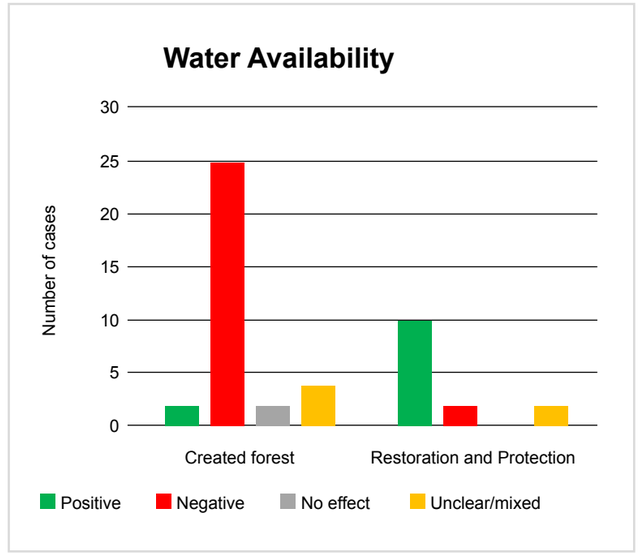



**Figure 23.** Impact on water quantity of planting non-native forest and protecting and restoring native forests.[93]

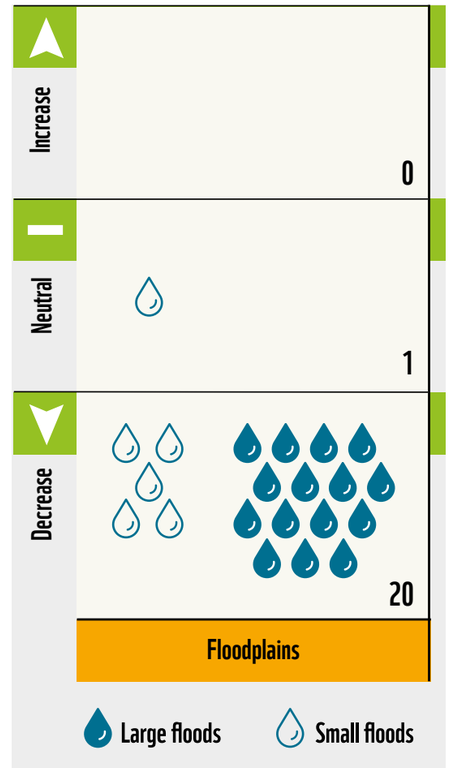



**Figure 24.** Impact of existing floodplains in Africa on flood levels downstream.[94] Adapted from Acreman et al. 2021.

# CHAPTER 4

## CASE STUDIES OF NBS APPLICATIONS IN AFRICA

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Across Africa, there are examples showing how NbS are helping to mitigate some of the water-related risks being faced by communities, cities and countries. We review four of these in this chapter.

# 4.1 South Africa: removing non-native trees to increase water availability

South Africa is a water-scarce country with rainfall distributed unevenly in space and time. Both floods and droughts negatively impact people and the economy. Urban centres, mining and industry tend to be in water scarce areas and the constrained availability of freshwater has a significant influence on economic growth, agricultural productivity and health. Many catchments are oversubscribed with 98 per cent of available water already being allocated. The country's Department of Water and Sanitation therefore predicts an overall 17 per cent shortfall in supply by 2030.[95]

In response to the limited supply of water, South Africa has intensely engineered water-supply systems, with reservoirs and transfer systems built to move water from areas of higher availability to water scarce urban and industrial centres. However, recent droughts and other challenges have underscored the dependency of the engineered part of the water system on the healthy functioning of the natural ecosystems that are the actual source of the water.

The most important of these natural systems are called Water Source Areas. These areas provide a disproportionate amount of run-off relative to their area as a result of high rainfall. Water Source Areas cover 10 per cent of the land area of South Africa, Eswatini and Lesotho, but contribute 50 per cent of the freshwater in the rivers and reservoirs (Figure 25). This water supports 50 per cent of the population, 64 per cent of the economy and 70 per cent of the country's irrigated agriculture. Water Source Areas therefore have very high strategic importance and are critical to water security. Downstream users and ecosystems are dependent on the healthy functioning of these areas to sustain good quality water supplies. Reductions in the water supply from Water Source Areas will result in serious negative impacts to the country's water security, economy and food production.

### Risks to the water source areas in South Africa

There is no legislation specifically focused on protection of Water Source Areas. Only 10 per cent of these areas are incidentally protected as a result of falling within protected areas, and even these face a number of significant threats. Non-native and invasive trees such as acacia, eucalyptus and pines out-compete native species and become dominant across landscapes. These non-native trees are larger and are therefore "thirstier" than the indigenous species they replace (i.e., they have higher rates of evapotranspiration). They are consequently the primary threat to the ability of Water Source Areas to provide water and have a particularly negative impact on surface flows and ground water availability in dry seasons and droughts. An estimated seven per cent of South Africa's available water resources are currently lost to non-native plants. This exacerbates the impact of climate change on water security. Another major risk facing the Water Source Areas is land degradation from poorly managed agriculture or livestock grazing, leading to the loss of nutrients and soil through erosion. The excess sediment and nutrients can degrade the water quality and habitat of streams, rivers and wetlands and leads to rapid siltation of reservoirs, further reducing water security.

### Nature-based Solutions can help maintain and restore South Africa's water supply

Active removal of non-native trees can increase the amount of water produced from a watershed. This catchment rehabilitation is particularly important for strategic Water Source Areas (see results from Acreman et al. (2021) summarized in Annex 1). South Africa provides a clear illustration of the potential for NbS in reltion to watershed management to increase water supply and resilience.

Cape Town provides a compelling example. The South African city suffered a historic drought, receiving global media coverage in 2018 for how close it came to running out of water. The impact of the 2018 drought was increased by the presence of invasive non-native plants in the upper catchments of the Water Source Areas, which currently use 55 billion litres of water per annum. These invasions have a disproportionately high impact on runoff in droughts. Indeed, if the catchments had been fully invaded during the 2018 drought the probability

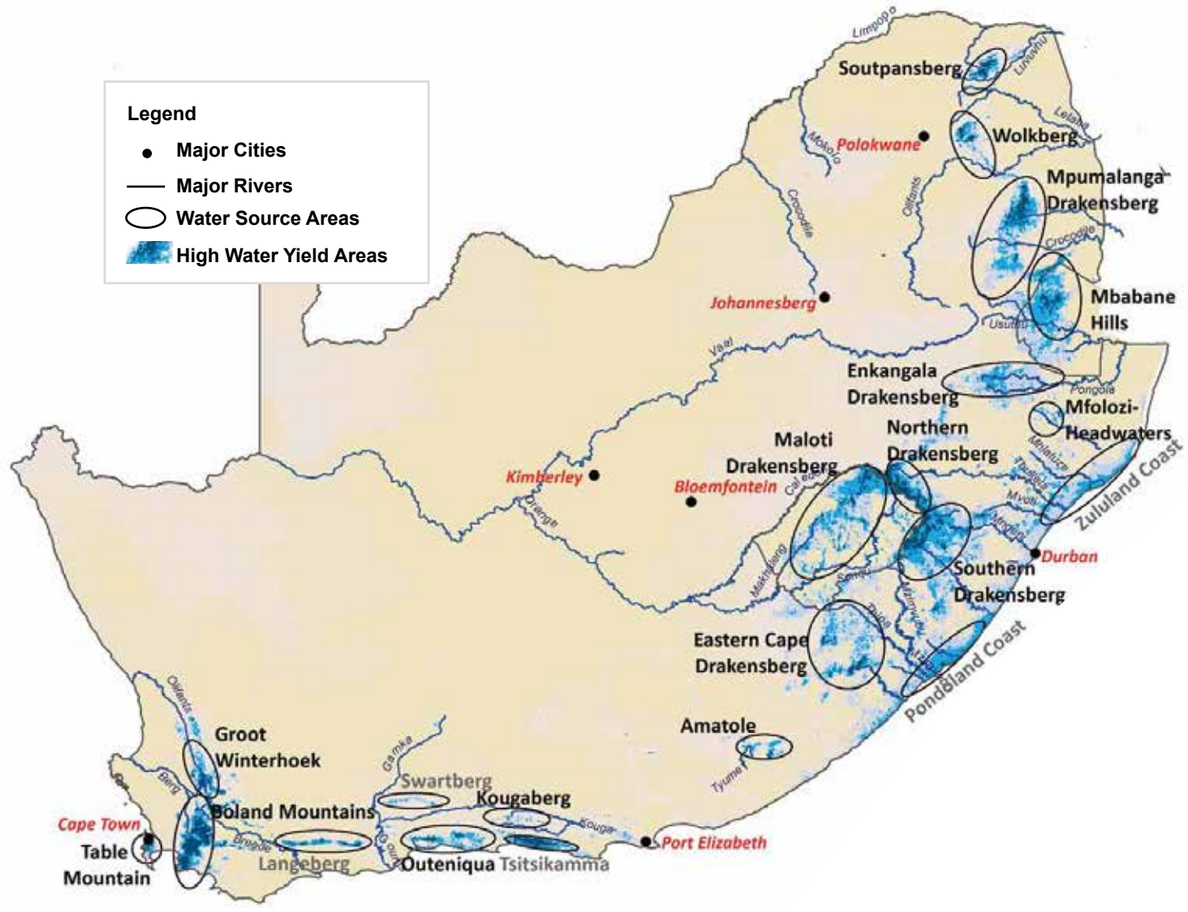



**Figure 25.** Map of the Water Source Areas in South Africa, Eswatini and Lesotho that cover 10% of the land area while providing 50% of the freshwater in the country's rivers and dams

that the city would have run out of water would have been much higher.

While investing in some forms of engineered infrastructure – from additional reservoirs to groundwater pumping and desalination – is necessary, the region can also invest in NbS to improve its water supply. For example, in the watersheds that supply Cape Town's water, restoration of native vegetation can increase available water at a cost comparable, or lower, than many other alternatives.[96] The recognition of the financial case for clearing invasive non-native plants to strengthen water security has led to the establishment of the Greater Cape Town Water Fund and the commitment of the City of Cape Town to making substantial investments of R50 million into the clearing of the catchments above its major dams – which form part of the strategic Water Source Areas. Through the Water Fund, The Nature Conservancy, WWF, local government agencies, and private sector partners are collaborating to restore the high rainfall Upper Berg River Catchment – a typical Water Source Area where one percent of the catchment provides 20 per cent of the river flow. This proactive action will significantly improve the region's resilience to climate change and this approach is being expanded to other Water Source Areas in South Africa and the continent (see Box 6).

WWF-South Africa has been working to remove non-native plants, and restore native vegetation, in the Water Source Areas that provide water to Cape Town in partnership with other members of the Greater Cape Town Water Fund. WWF-South Africa has similar programmes across the country and, collectively, they illustrate several key aspects of the potential for NbS to solve water challenges – and how organizations can pursue the partnerships and facilitate the enabling conditions to spur broader uptake.

**Governance, water stewardship and collective action can be strong enablers of NbS implementation.** Relatedly, implementation of NbS can serve as a catalyst for stakeholders to gain experience with water stewardship and to work together towards strengthening water governance. As an example, WWF-South Africa supported partner organization Environmental and Rural Solutions (ERS) to convene a Water Source Partnership (WSP) in the Eastern Cape Drakensberg Water Source Area. WWF initially focused on strengthening local water governance by supporting multi-stakeholder participation in a WSP, which included a range of different community, public and private sector partners. The partners fundraised, developed and jointly implemented a range of projects, such as clearing of non-native trees and enhanced management of grazing, which improved water security and local livelihoods.

In other projects, corporate partners have funded NbS implementation as part of their water stewardship efforts, demonstrating collective action toward improved water management at the basin scale. For example, Woolworths, a retailer, funded a coordinator for non-native tree clearing, with the position based in a local Water User Association in the Breede catchment. Funding this position proved an effective way to support local governance and implementation and led to the establishment of a further 11 placements distributed over six Water Source Areas. In the George area, a key hops growing region, SAB (a part of AB InBev) partnered with others to help support the clearing of 1,275 hectares of non-native trees, enabling an estimated 36,000 per-days of employment. The company also funded the creation of a tool to calculate the water savings produced by the non-native tree-clearing activities. Programmes like these can help catalyse additional funding for NbS for water stewardship in a region. Water funds are another example of a structure intended to catalyze collective action toward improved watershed management (Box 6).

WWF-South Africa has an ultimate goal of influencing water pricing policies so that funding for sustainable management of Water Source Areas is built into water tariffs. Thus, the implementation of NbS in South Africa demonstrates application of the water stewardship ladder (Figure 26) moving from raising awareness about the value of Water Source Areas to South Africa's people and economy to actions funded by corporations to building stakeholder collective action to influencing governance.[97]

**Market mechanisms can catalyze additional uptake of NbS.** Market mechanisms can contribute to improved enabling conditions to facilitate implementation of NbS. In the Eastern Cape Drakensberg Water Source Area project, livestock grazing was contributing to the degradation of soils and vegetation – even as non-native trees took over former pastureland, reducing the amount of land for grazing and drying up springs. To encourage participation in programmes for clearing non-natives and improved livestock management, WWF and its implementing partners have worked with the traditional leadership, the local Grazing Associations (the structures that govern the use of rangelands), and a business called Meat Naturally PTY to improve access to markets for beef raised using more sustainable practices. Farmers that are part of Grazing Associations implementing rangeland management best practices get preferential access to the auctions and pay a lower rate of commission on their cattle sales. This has proved to be a powerful incentive for farmers to join Grazing Associations and to implement more sustainable practices. Further actions included the establishment of mobile auctions, which improve market access for women and the elderly. This example provided critical cash injections into the rural economy during the economic crisis triggered by COVID-19.

The clearing of non-native trees in the Eastern Cape has been catalyzed by creating markets for the felled wood, with charcoal certified by the Forest Stewardship Council that will allow access to more lucrative markets. As part of the work restoring the Boland Groot Winterhoek Water Source Area, WWF has helped establish small, medium and micro enterprises (SMMEs) that could benefit from a "biomass economy" of selling wood-based products from the clearing of non-native trees. For example, some companies have mulched the wood and sold it to spread on farm fields to reduce water evaporating from soils, lowering irrigation needs by 30 percent, while poultry farmers are using the biomass for heating and bedding.

**NbS programs can promote livelihoods, health and biodiversity.** A hallmark of NbS are the co-benefits for people and nature. Implementation of NbS can promote job creation, both in the clearing of non-native trees and other watershed improvements. In addition, SMMEs have developed around these programmes, including better managed livestock and wood products. This livelihood component is a crucially important co-benefit of NbS programmes in a country with very high unemployment.[98] The potential of these catchment restoration projects to create meaningful jobs that benefit the economy has been recognised through grants made through the Presidential Economic Stimulus Programme, which was South Africa's response to the COVID-19 economic crisis.

NbS implementation has also been coupled with programmes focused on health. In the Eastern Cape Drakensberg Water Source Area project area, people have long drawn water from the same springs used by livestock, exposing them to water-borne pathogens such as *E. coli*. To address water quality and human health, WWF also invested in projects to protect springs from livestock impacts and to safely store and treat water. Through this, more than 1,000 people have gained access to improved water. In addition to benefitting human health, this has built support for watershed protection among communities and local authorities.

Finally, all of these activities are restoring native vegetation and habitats in areas that are rich in biodiversity. For example, the Cape region boasts more than 9,300 plant species, over 68 per cent of which are endemic, and is also rich in endemic invertebrates and vertebrates.

Since the activities benefit water supplies and health, they accomplish these conservation objectives by tapping into sources of funding that would not otherwise be available for conservation. The scope of the challenge of restoring the catchments is so substantial that it is essential to blend and align funding that supports a number of different goals – recognizing the significant co-benefits of catchment restoration, including potential for increased resilience to climate change.

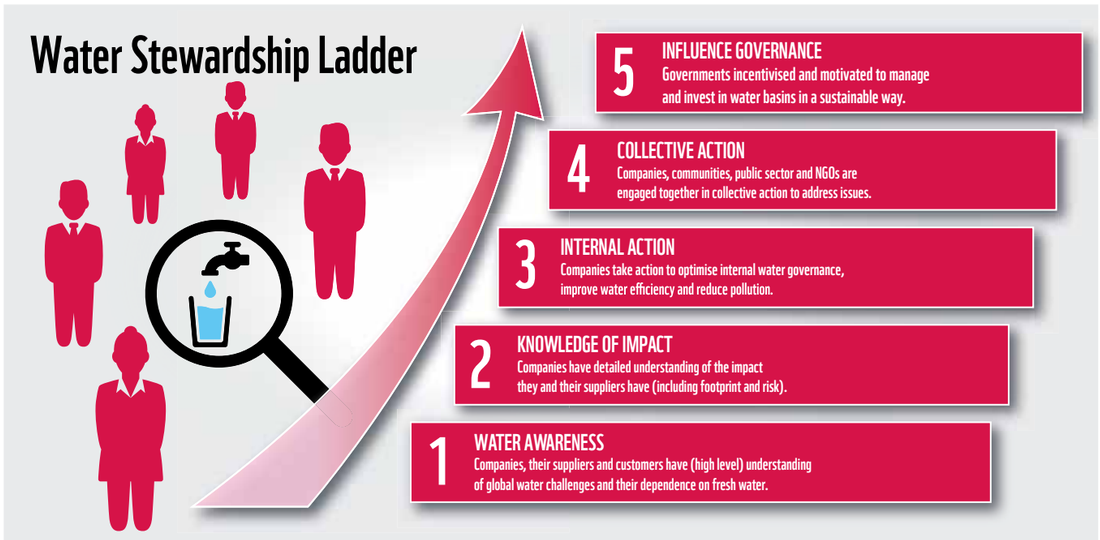



**Figure 26.** The water stewardship ladder (from Morgan 2018).

## BOX 6: Water Funds to invest in healthy watersheds: the Sebou Water Fund

Water funds are a mechanism intended to maintain or increase water quantity and quality by investing in improved watershed management through funds provided by the beneficiaries of that water. The Nature Conservancy has developed several water funds across Africa, including within the water supply systems of Cape Town, South Africa and Nairobi, Kenya.[99]

In 2018, WWF launched the Sebou Water Fund, the first water fund in North Africa, focused on the Sebou River and its basin. The Sebou River basin is a water tower for Morocco, encompassing just 6 per cent of the country's land area, but providing 30 per cent of its surface water resources and 20 per cent of its groundwater resources. The Fund will focus on projects that will maintain and restore the quantity and quality of surface waters (lakes, streams and wetlands) and recharge the aquifer. The Fund is currently providing support to 15 local civil society organizations to implement projects, ranging from construction of check dams to collect and store runoff, to improved management of springs to more sustainable agriculture practices – for example, switching to less water-intensive crops, such as lavender, to reduce groundwater pumping that has been drying up lakes and wetlands in the Middle Atlas region. Future projects will focus on the restoration of Atlas cedar forests to improve watershed soils and infiltration of rainfall.

The Fund is overseen by a steering committee (including Agence du Bassin Hydraulique du Sebou, Water and Forest Department, WWF and three Moroccan Ministries: Interior, Agriculture, and Tourism). The Fund is pursuing improved data sharing with government ministries and supporting an inventory of the best projects for improving water quantity and quality. To date, the Fund has been supported primarily through philanthropic funds but the long-term goal is to create a sustainable financing mechanism, supported by beneficiaries of water supplies, using a payment for ecosystem services model. Furthermore, WWF hopes that the Sebou Water Fund can be a model that promotes development of other water funds in Morocco and the region.

# 4.2 Zambia: Lukanga Swamp is critical for water and energy security

The Kafue River is critical to Zambia's domestic and industrial water supplies (40% of the total for Zambia) and energy (50% of total) through two hydropower projects. One-third of the Kafue's annual discharge of approximately 13,000 million cubic meters (MCM) flows through the Lukanga Swamp in the river's upper basin. Located approximately 100 km north of Zambia's capital city of Lusaka, the swamp encompasses an area of 3300 km² – but the inundated area more than doubles during the wet season (Figure 27). Beyond serving as a natural reservoir that stabilizes water and energy supplies, the swamp is also crucial for wildlife and local communities, who use it for fishing, hunting and charcoal production.

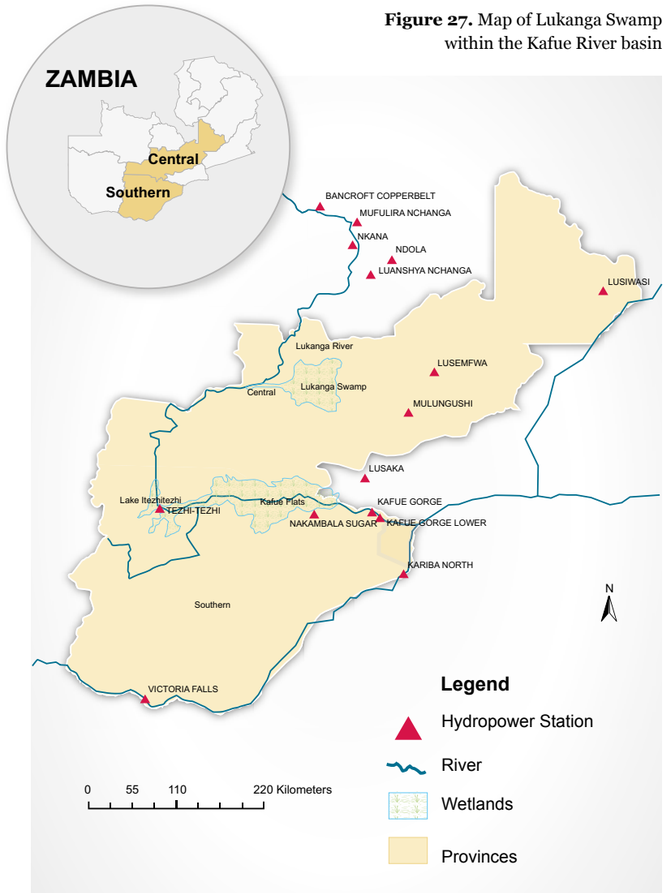



**Figure 27.** Map of Lukanga Swamp within the Kafue River basin

## The importance of the Lukanga Swamp for Zambia's water and energy

During the wet season, the Lukanga Swamp swells to encompass 8000 km² and the wetland stores the additional water and gradually releases it during the dry season (the "sponge effect" of floodplains as described in Section 3.1). This storage and release process is particularly important for supporting low flows. Note that, due to evaporation and infiltration, the swamp releases about 30 per cent less total water volume than what flows into it (though note that sub-surface flows have not been measured and some of this "lost" 30 per cent could return to the Kafue via subsurface flows, which are known to be substantial in this area). Moreover, for water users, the swamp's ability to shift volume from the wet season (when water is plentiful) to the dry season (when water is limiting) provides benefits that more than compensate for the overall loss of volume over the whole year. Thus, the Lukanga Swamp acts like a natural storage reservoir for all downstream water users, which include some of the most important energy projects and water suppliers for Zambia.[100]

Hydropower provides 85 per cent of the electricity for Zambia, including two hydropower projects on the Kafue River downstream of the Lukanga Swamp (Figure 27), providing the main source of electricity for Lusaka and its 3.3 million people. Recent drought reduced power generation by more than 30 per cent, illustrating the vulnerability of this power system to reduced flows on the Kafue. The swamp is also key for a secure water supply, particularly during the dry season, for utilities that extract water from the Kafue, including Lusaka Water and Storage and Lusaka Southern Water.

To put the natural reservoir function of the Lukanga Swamp in perspective, it can store up to 10,000 MCM of water, which is about 50 per cent larger than the combined storage volume of the hydropower reservoirs downstream (6800 MCM). This storage capacity means that the Lukanga Swamp serves as a storage buffer not just during the dry *season* but during dry *years:* the swamp is capable of storing water during wet years and releasing water during dry years.

Furthermore, the Kafue River carries runoff from the mines in Zambia's copper belt. When the Kafue River overflows into the Lukanga, the Swamp (along with other floodplains along the Kafue) can improve the river's water quality. The long retention time in the wetland facilitates the deposition of heavy metals along with sediment from upstream erosion and the deposition and processing of excess nutrients from surrounding agriculture. Collectively, these processes result in cleaner water downstream, which is important not just for water supply utilities but also other water users.

| Beneficiary | Risk of a 10% loss of Lukanga | Damage per year |
|---|---|---|
| LWSC (Lusaka Water Company) | 50% loss of revenue for three months | $1,166,317 |
| Zambia Sugar | 20% crop loss in a dry year | $2,920,291 |
| ZESCO | 18% revenue loss in a dry year | $37,596,154 |
| **Potential Loss** | | **$41,682,762** |

**Table 1.** Potential financial impact of a 10% loss in storage capacity of Lukanga Swamp to downstream beneficiaries.

## The importance of the Lukanga Swamp for nature and people

In 2005, the Lukanga Swamp was designated as Zambia's third Ramsar Wetland of International importance. As the largest permanent water body in the Kafue Basin, the Swamp provides a critical habitat for birds and wildlife, hosting a number of threatened species such as the wattled crane, the red lechwe, African python, and the sitatunga, an antelope adapted to walking and swimming in marshy environments. The area is also an important breeding ground for fish and fishing is the major economic activity in this rural region, with the site supplying fish to three provinces (Lusaka, Central and Copperbelt) with a combined population of 6.1 million. The Swamp's diverse benefits – from water regulation to fishing to biodiversity – illustrate the value of Africa's mostly intact floodplain systems (see Box 7).

## Water challenges

The Lukanga Swamp – and its ability to secure both energy and water for Zambia – faces a number of threats, including: (1) unsustainable extraction of water by large agricultural schemes; (2) increasing periods of drought due to climate change; (3) invasive species, including the Kariba weed, which now covers about half the Swamp; (4) land degradation and encroachment within the Swamp; and (5) water pollution from sediment and nutrients from agriculture and heavy metals from copper mines.

Several of these, including encroachment, degradation and siltation, are contributing to a reduction in the swamp's storage capacity, which could have negative financial impacts for downstream water users, and economic impacts for the country overall. The hydrological consulting firm Deltares analyzed the potential financial costs to water users of a 10 per cent loss of storage capacity in the Lukanga Swamp, based on recent trends and future risks.[101] They estimated that this storage reduction would result in total financial losses of nearly US$42 million per year, with the electric utility, ZESCO, bearing 90 per cent of the loss (Table 1).

## Potential interventions – and how to implement and fund them

Maintaining and increasing the storage capacity of the Lukanga Swamp will be key to ensuring that it can continue to serve as a nature-based reservoir, supporting both energy and water security and that this service is more resilient to drought and climate change. Potential key interventions include protecting riparian vegetation, preventing encroachment and draining of wetlands, removing invasive plant species, improving upstream land management to reduce erosion and sedimentation, and restoring hydrological connectivity within the swamp. Identifying and supporting sustainable livelihood opportunities will be key to implementing the interventions that require wetland protections or changes in land use. The development and expansion of "bankable projects" – e.g., linking investment capital with these sustainable economic activities – could help achieve this transition (see Box 9 on bankable projects).

Both implementation of NbS activities and improved management of land, water and natural resources (e.g. fisheries and wildlife) will benefit from the development of a conservation and management plan for the swamp (currently under development) and the establishment of a management authority.

How could these activities be funded? Capital for bankable projects could come from sources such as the Dutch Fund for Climate and Development. Other funding for the implementation of NbS interventions and improved management could come from a combination of sources, including the downstream beneficiaries of the water-storage services of the swamp. The potential losses from a continued decline in the Lukanga Swamp's storage capacity (Table 1) illustrate that downstream water users have an economic rationale for investing in improved management of the swamp. Its role in reducing water pollution from copper mines could serve as a basis for seeking support from mining companies, following a payment for ecosystem services model.

## Box 7: Floodplains: Africa's opportunity to maintain their multiple benefits

The floodplains of Africa's rivers are relatively undeveloped compared to floodplains on other continents. Since the continent retains significant areas of functioning floodplains that are still connected to rivers, African countries can make strategic decisions about land and water management to maintain floodplains and continue to get as much benefit from them as possible. In many other countries, river managers built levees along their major rivers to disconnect their floodplains, only to later realize that this approach did not reduce flood risk sufficiently. While in these countries managers are now reconnecting floodplains, Africa has the chance to get it right the first time.

**Major benefits from Africa's floodplains include:**

**Fisheries.** Floodplains are among the most important habitats for freshwater fisheries. Not only do floodplains offer large harvests themselves, they also provide critical spawning and rearing habitat for fish that are later caught in lakes and rivers. Furthermore, floodplains are among the most productive freshwater habitats and this productivity subsidizes the food webs of adjacent and downstream rivers and lakes. A 2010 report from the United Nations Environment Program (UNEP) indicated that at least 100 million people in Africa regularly consume fish harvested from lakes and rivers.[102] The Food and Agricultural Organization (FAO 2020) reported that the annual harvest of fish from Africa's inland waters (i.e., freshwater systems) was nearly 3 million tons. Note that inland fisheries are often small-scale and outside of formal markets and so official catch total are routinely underestimated; actual harvests are likely to be at least 65 per cent larger[103], suggesting that inland fish harvest for Africa could be at least 4.8 million tons. An estimated 3 million people engage in fishing, for food and livelihoods, with another 2.1 million people engaged in post-harvest processing. UNEP estimates that women represent 55 per cent of the total employment derived from inland fisheries.[104]


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**While floods are often viewed only in negative terms – as disasters – in much of Africa people depend on the productivity of floodplains for food and livelihoods. The Barotse people, who live on the floodplains of the Zambezi River in western Zambia, celebrate the annual return of the floods with a festival called the Kuomboka (the "moving out of the waters"). The benefits of floods and floodplains are celebrated in poetry and song:[109]**

***It is flood time in Bulozi. The floodplain is clothed in the water garment.***

***Everywhere there is water! There is brightness!***

***There are sparkles!***

***Waves marry with the sun's glory***

***Birds fly over the floods slowly; they are drunken with cool air.***

***They watch a scene which comes but once a year***

***Floods are beautiful.***

**Flood recession agriculture.** Based on FAO data, there are at least 3.6 million hectares of land managed as flood recession agriculture – the original form of irrigated agriculture that was practiced along the Nile and other rivers that provided the foundation for early civilizations.[105] Flood recession agriculture occurs along rivers that retain a relatively predictable flood pulse and is often particularly important along rivers in arid or semi-arid regions. People plant crops along the fringe of the receding flood, taking advantage of the recently deposited sediments and nutrients – and planting in areas that will retain a relatively high water table to maintain growing plants. These areas are also important for livestock grazing. While a relatively small proportion of overall agriculture in Africa, flood recession is extremely important in some regions and provides a method of growing crops that requires very limited capital inputs.

**Water management services.** As discussed in the Lukanga Swamp case study, large areas of floodplain can act as a sponge that stores water during wet seasons, and wet years, and releases it slowly to increase water availability in dry seasons, and dry years. This same sponge effect can also reduce downstream flood risk, with strong evidence for lowered flood levels downstream of floodplains.[106]

Our spatial analysis estimated that Africa has 1.8 million km² of "functional floodplain" defined as the area inundated by a 1-in-25 year flood event. As of 2015, development had taken place on only 23,000 km² (approximately 1% of that area). Meanwhile, there are 104 million people (about 8% of the continent's total population) living on floodplains with a relatively high risk of flooding (defined here as the floodplain inundated by the 1-in-50 year flood event). This same area of floodplain generates about US$640 billion in economic activity, approximately 12 per cent of the continent's total GDP.[107] This significant proportion of Africa's population and GDP represents the people and property that potentially benefit from the reduction in flood levels that floodplains provide.

As discussed earlier, floodplains are not the only solution to reducing flood risk, and levees, flood walls and other engineered infrastructure will be needed in places to keep people and property safe. However, the countries of Africa, with their largely undeveloped and hydrologically functioning floodplains, can learn lessons from countries in Europe and the United States that invested heavily in engineered infrastructure and then later continued to endure damaging floods – and then decided to reconnect large areas of floodplain to help reduce risk. These examples include the Sacramento Valley and the lower Mississippi in the US, and the Rhine and Elbe in the Netherlands and Germany – where engineers originally tried to fully contain rivers within levees, only to realize, in the face of repeated floods, that the river would need some room to spread out during the largest floods. In each of these regions, managers have now reconnected rivers to their floodplains in key areas.[108] African countries can avoid these mistakes and get it right first time by pursuing a diversified portfolio and taking maximum advantage of the multiple benefits of existing floodplains.

# 4.3 Kigali: NbS for urban resilience

The Rwandese capital, Kigali, experiences regular flooding during rainstorms, due to the runoff from the surrounding urbanized hills, with the stormwater concentrating at the valley bottom in former wetlands. These floods cause disruption to traffic, preventing all travel between hillside communities.[110] Urbanized land in Kigali has tripled in 25 years and with more urban growth and densification expected in the future, flooding problems are likely to intensify due to the continued expansion of impervious surfaces coupled with climate change.[111] Based on the Water Risk Filter analysis, Kigali is projected to go from a flooding risk of high to very high by 2050 with the current trend scenario (see Chapter 2). In Kigali, the valley bottom wetlands have been mostly reclaimed for small-scale agriculture, light industrial areas and road transport. Thus, many of the former wetlands have lost both their ecological value and their retention capacity (Figure 28).

The wetlands in Kigali are in a degraded state for a number of reasons. Valley bottom agricultural activities in Rwanda are generally either large intensive plantations of sugar or rice or, more commonly in Kigali itself, informal small-scale agriculture or aquaculture. These small-scale plots are typically formed by digging small channels in the wetlands to prevent water logging. Excavating square ponds for fish farming is also common. The valley bottoms can also be important transportation routes and in some cases include industrial or commercial assets. A notable example is the transportation node for the main Kigali–Uganda, Kigali–Goma and Kigali–Bukavu roads, where the main bus station is positioned at the downstream end of the Nyabugogo wetland. Most of the light industry in the wetlands is either derelict or has been moved to less flood-prone locations. A recent study identified several pollution hotspots associated with these former facilities, where the soil has become contaminated from the former industrial use. Furthermore, the drainage of these wetlands has been heavily modified to enable development for agriculture, light industry and transport (road culverts). The light industrial use focuses on facilities for processing agricultural products, cloth processing, logistics and light manufacturing (with significant pollution impacts).

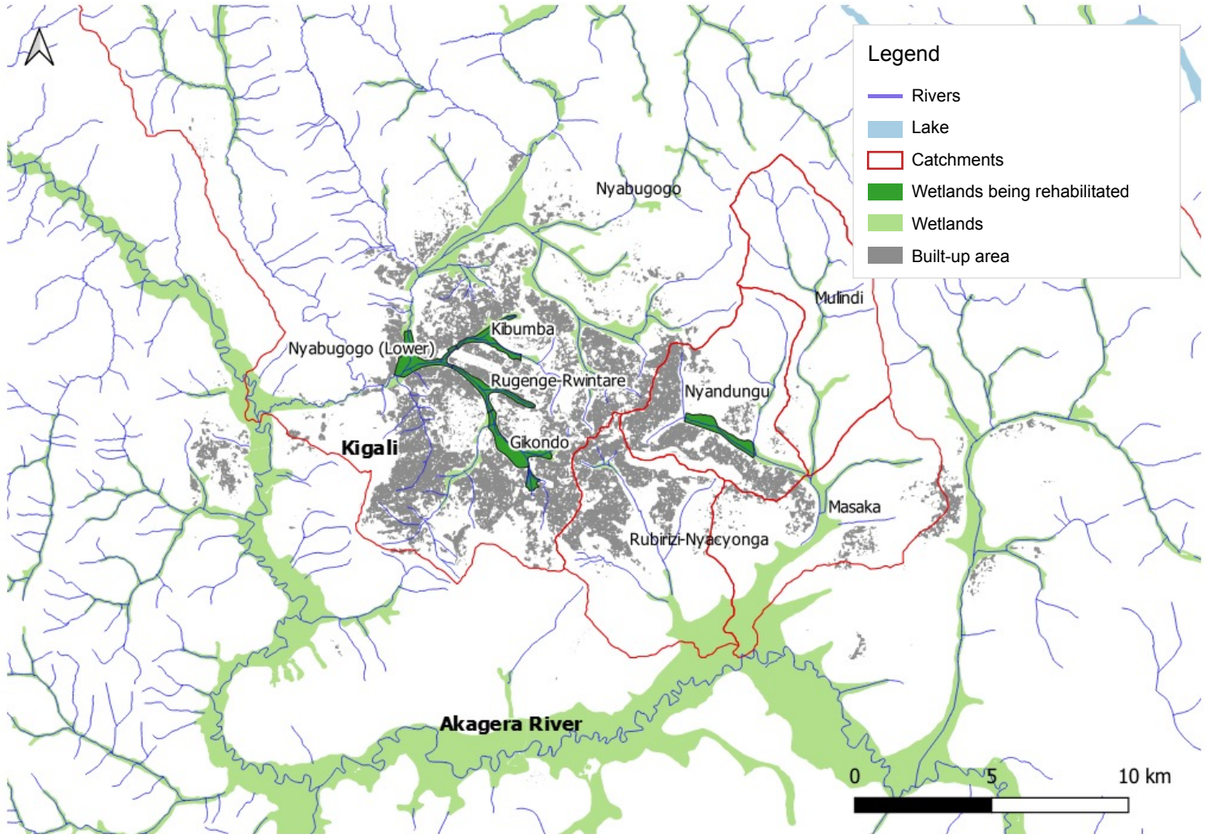



**Figure 28.** Map of the wetlands in and around Kigali

Restoration of the wetlands and their stormwater 'sponge' function can contribute to the mitigation of flooding in Kigali. The Government of Rwanda, with the support of the World Bank and other donors, is preparing urban wetland rehabilitation plans to achieve the following multiple benefits:[112]

- Restore the wetlands' 'sponge' effect to retain stormwater runoff and reduce flooding;
- Improve wetland buffering to improve water quality; and
- Restore wetland habitat as green urban space for recreation.

Therefore, there is already strong national and international commitment to invest in Kigali's wetlands as NbS.[113] Given the planned expansion of the Kigali urban area, there is interest in scaling up to other wetlands across the city. These urban NbS can constitute an important showcase for Africa as the continent will undergo dramatic urban growth during this century.

Implementation of NbS projects is already underway in Kigali as the government invests in the services associated with healthy wetlands. For instance, the government relocated an industrial area away from the flood prone Gikondo wetland to a safer location. This was carried out in 2019 and 2020. This action both reduced flood risk to property as well as restored some of the retention capacity of the wetlands (Figure 29). Further research is also underway to assess scenarios of how selected wetlands can slow stormwater drainage to reduce downstream flooding.







**Figure 29.** Clearance of light industrial area from the Gikondo wetland.

**"THE GOVERNMENT OF RWANDA, WITH THE SUPPORT OF THE WORLD BANK AND OTHER DONORS, IS PREPARING URBAN WETLAND REHABILITATION PLANS WITH THE INTENTION TO ENHANCE THE FLOOD BUFFERING CAPACITY, IMPROVE WATER QUALITY AND ENHANCE URBAN LIVING THROUGH THE PROVISION OF GREEN RECREATIONAL SPACE"**

# 4.4 Kenya: coastal protection thanks to mangroves

Currently, mangroves cover approximately 62,000 hectares along the 500km of Kenya's coastline, with the largest remaining mangrove forests being those in Lamu County and the Tana River Delta. Mangroves mitigate against a wide range of coastal risks, providing protection against flooding and erosion from storm surges and waves. They also provide a broad range of other benefits, supporting fisheries breeding grounds, aquaculture, bee farming, and eco-tourism. Local communities use mangrove forests for timber, fuel wood, medicines and shrine sites. Mangrove forests are also highly effective systems for climate change mitigation, sequestering approximately four times as much carbon per unit area compared to terrestrial forests.

The loss of mangroves negatively impacts community livelihoods and cultural values and can lead to erosion of the shoreline increasing the risk of coastal flooding. These risks are rising: an assessment of the impact of coastal flooding due to sea level rise in Kenya found that, by 2030, in the coastal city of Mombasa, the population at risk of 1-in-100-year return period extreme water levels is estimated to be between 170,000 and 266,000 inhabitants, with approximately US$1 billion of assets at risk.[114] Meanwhile, the population of Mombasa has doubled in the past decade to over 1.2 million people. Yet even as the population and economic assets at risk of flooding are increasing – due to both climate change and population growth in vulnerable areas – the region has been losing its best natural defenses as 70 per cent of local mangroves have been lost.



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The loss of mangroves is not confined to Mombasa. Between 1985 and 2009, Kenya lost 20 per cent of its mangrove forests and the remaining areas continue to face a range of threats, including overharvesting mangroves for wood and clearing for aquaculture, poorly planned developments along the coast and other economic activities. Furthermore, climate change will induce sea level rise and increase the frequency and intensity of flooding and periods of extreme drought, exacerbating the loss of mangroves. From a policy perspective, poor planning and uncontrolled infrastructure development along the coast contribute to further losses of mangrove ecosystems. All these factors result in reduction of total available suitable mangrove habitat and increase stresses on remaining mangroves.

### Potential interventions – and how to implement and fund them

Although the loss of mangroves in Kenya has been accelerating, the country still retains most of its mangroves. Thus, a primary strategy is the protection of existing mangroves – and the processes that maintain them (see Box 5 on riverine sediment and mangroves). A second strategy features restoration of mangrove forest through planting in suitable areas with the matching of species to appropriate conditions. Additionally, semi-permeable barriers made of sticks and brush can be built and these reduce wave energy and trap sediment. Sediment accretion promotes the appropriate conditions for natural regeneration, which can be more effective than restoration through planting.

This combination of protection and restoration will require a multi-faceted approach, spanning policy and practice, and requiring engagement with national and county level government agencies and local communities. To date there has been considerable mangrove restoration through pilot projects. The scaling up of the conservation and restoration of mangroves will require integrating top-down and bottom-up approaches. The top-down approach will require full integration of mangroves and reefs in coastal protection strategies and spatial planning at the national level. Bottom-up activities can range from community capacity building and awareness raising to transformation of livelihoods, including mixed mangrove aquaculture. Kenya has reached a critical pivot point: without intervention, the country will likely continue to lose mangroves and their diverse services and consequently face increasing coastal flooding and erosion. However, with the right mix of policy, local programmes and funding, there is still time and (in most places) sufficient space available to fully integrate mangrove-related NbS in the protection of Kenya's coast and the people and economies that depend on a stable coast.

At a national level the importance of conserving coastal ecosystems is acknowledged in multiple visions and actions plans, such as the national mangrove ecosystem management plan. Mangrove management in Kenya falls under the Forest Act of 2005. The legislation provides for community involvement in forest management through community forest associations. Harvesting of mangroves is also regulated through licensing. However, a lack of resources and unclear management plans have resulted in unregulated cutting of mangroves along the entire coastline.[115] The need for the wood from mangroves and land encroachment resulting in the clearing of mangroves must be reduced.

Thus, programmes for restoration and/or protection will have greater likelihood of success if they are coupled with livelihood and development programmes that catalyze activities consistent with healthy mangroves. For example, "mixed mangrove aquaculture" can locate aquaculture ponds that, rather than replacing mangroves, provide sufficient room for mangroves to persist.[116] A 2021 report from Deltares includes a review of specific areas in Kenya and recommends specific priority mangrove management and restoration projects.[117]

Because mangroves can contribute to climate mitigation goals, in addition to adaptation, carbon credits provide an additional source of potential funding for mangrove programmes. On a per hectare basis, mangroves are among the most effective at storing carbon – three to five times as much tropical forests. In response to their carbon opportunity, the Kenya Marine and Fisheries Research Institute, a partner of WWF-Kenya, is working with the villages of Gazi and Makongeni to implement a carbon offset project, the first of its kind in the world to successfully trade credits for the "blue carbon" from mangroves.[118] The project, known as Mikoko Pamoja, is generating money from the sale of carbon credits, funding a range of community benefits, such as purchasing schoolbooks. WWF is in the process of designing a mangrove blue carbon project in Lamu, leveraging lessons from the Mikoko Pamoja project and capitalizing on the extensive mangrove cover in Lamu to expand the impact of this approach.

# CHAPTER 5

## INCREASING UPTAKE OF NBS ACROSS AFRICA

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Through both the evidence review and case studies, this report has shown that NbS have considerable potential to contribute to managing water challenges in Africa. However, funding and implementation of NbS programmes and projects lags far behind, both in Africa and globally. UNEP's *Adaptation Gap Report 2020* concludes that adaptation funds are not keeping up with needed investment in adaptation — which could reach US$500 billion per year by 2050 for developing countries.[119] Furthermore, they note that, although there is evidence that funding for NbS globally is growing:

> *Funding for NbS makes up only a tiny fraction of total adaptation and conservation finance, despite many commitments by governments, the private sector, philanthropy and finance institutions for scaling up ambition and investments in NbS.*

However, the report acknowledges that it is difficult to track the flow of investments toward NbS because relevant projects are often not specifically categorized as being NbS. Furthermore, if management agencies shift budgets toward activities more consistent with NbS – e.g., a flood management agency redirects some funding toward floodplain protection or setting levees back further from rivers – these flows of funding are likely not tracked through these type of global surveys of NbS funding.

Overall, it appears likely that the primary global trends in the UNEP report apply to Africa:

- There is a current gap – and looming future gap – in adaptation funding;
- NbS funding remains a small part of overall adaptation funding; and
- Support for NbS is growing but the level of support and adoption lags far behind the potential for NbS projects and programmes to deliver benefits.

These projects and programmes are likely to deliver a high return on investment. For example, the Global Commission on Adaptation estimated that an investment of US$1.8 trillion in a range of adaptation activities, including climate-resilient infrastructure and mangrove protection, would generate US$7.1 trillion in avoided costs and environmental and social benefits.[120]

With that potential for economic benefits, why are NbS not being implemented as large-scale projects and programmes in most countries?

In this chapter, we assess common constraints to broader uptake of NbS and discuss some solutions to overcome them. We then use one of the case studies to demonstrate how a business case and financial model can be built to support funding and implementation of large-scale NbS projects. Finally, we offer a set of recommendations focused on scaling up and expanding implementation of NbS in Africa.

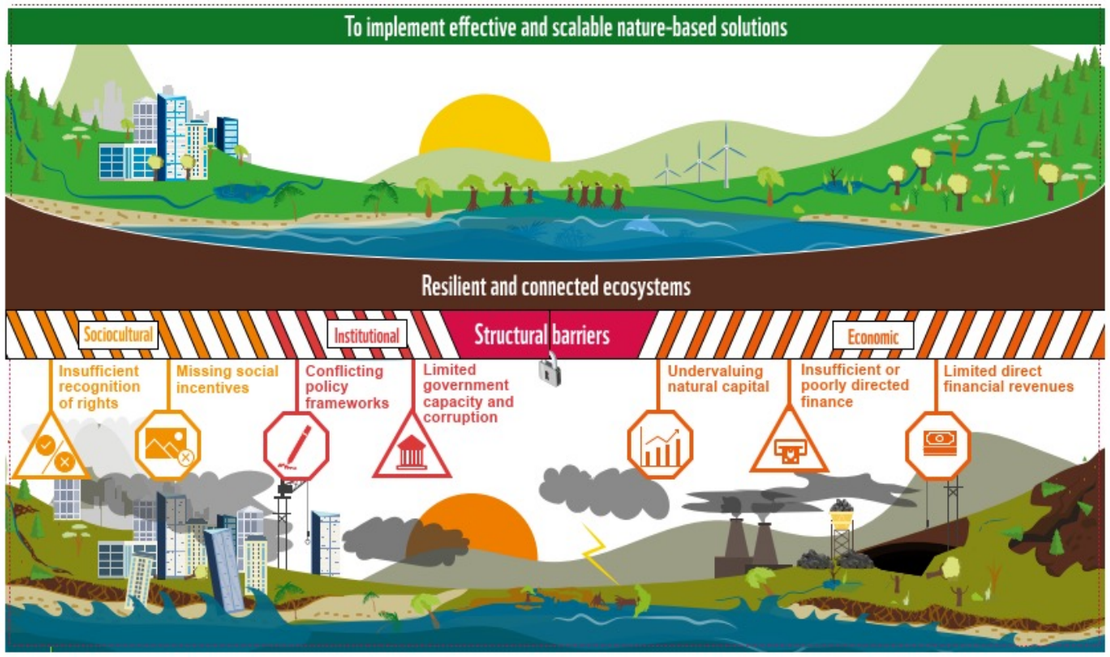



**Figure 30.** Structural barriers to NbS implementation. (From WWF 2021)

## 5.1 Constraints and enabling conditions to overcome them

In this section we review a set of constraints, or structural barriers, to the broad uptake of NbS and then explore a set of policy levers and systemic enablers to overcome those barriers.[121]

Structural barriers to broad uptake of NbS can be placed into three broad categories (Figure 30):

**a. Socio-cultural barriers** include constraints related to incentives and behaviours of key groups.

**i.** Many indigenous people and local communities (IPLC) face **insufficient recognition of their rights,** which can prevent, or interfere with, the management intentions of IPLC, including the implementation of NbS.

**ii. Missing social incentives** can exacerbate competition or encourage short-term activities that degrade resources rather than promote more sustainable, long-term stewardship.

**b. Institutional barriers** include obstacles related to the policies, conventions, and rules that collectively shape governance relevant for NbS.

**i. Conflicting policy frameworks** hinder implementation of NbS. Often, existing policies favour *status quo* approaches to solving challenges, such as policies that are well established for engineered interventions but insufficient or absent for NbS approaches. Furthermore, NbS may require more cooperation from more entities – which may be governed by different, or even conflicting, policy objectives. Although a major advantage of NbS is that they can provide multiple benefits, fully planning for these multiple benefits may require involving a greater number of entities (e.g., various ministries) relative to standard approaches, which can complicate selection and design processes. While engineering methods have generally been tested, documented and provide the basis for regulatory standards, NbS approaches may lack the same quantitative rigour in terms of the measurement of performance.

**ii. Limited government capacity** can hinder effective governance and management in general, but can be particularly limiting for transitions to new approaches. Furthermore, there is limited familiarity with, and capacity to propose or manage, NbS interventions within government (and often within the private sector as well). Since NbS approaches are less well known among engineers, planners and decision makers, it less likely that they will be selected or even considered.




**c. Economic barriers** include constraints related to funding and incentive structures.

**i. Cost and benefit calculations may be incomplete.** Many of the diverse benefits of NbS can be difficult to quantify, particularly environmental and social benefits, so these may not be adequately incorporated into decision processes. Furthermore, even if these other benefits could be quantified, mechanisms, such as markets, may not exist to link the beneficiaries of the service with those that provide the service. Meanwhile, due to the common undervaluing of natural capital, the negative impacts on environmental and social resources from *status quo* approaches may be poorly quantified or ignored. Additionally, some NbS approaches, such as dike setbacks and wetland restoration, require more land than do traditional approaches, which can increase up-front costs. While these additional costs of NbS are likely to be fully accounted for, the potential advantage that NbS may have in terms of lower long-term costs for maintenance, rehabilitation and replacement, may not be well represented in benefit-costs analyses. Note that the need for better measurement of natural capital can also be viewed as a technological barrier.[122]

**ii. Insufficient or poorly directed finance** results in limited funding for NbS while, simultaneously, large amounts of public funds flow toward subsidies that are often environmentally harmful. The UNEP report estimates that around US$133 billion per year are directed toward NbS (both mitigation and adaptation), with nearly 90 per cent from public sources. It estimates that, for the world to meet the challenges of climate, nature, and land degradation, this annual amount will need to triple by 2030 and quadruple by 2050, in real terms.[123] Some of the needed boost to NbS investments could come from transfers from environmentally harmful subsides: OECD countries currently spend approximately US$500 billion per year on subsidies that contribute to environmental degradation.[124]

## BOX 8: Adaptation and mitigation

NbS for mitigation and adaptation should be coordinated as much as possible, to minimize competition for land, optimize the quantity of benefits per dollar invested, and diversify funding sources. For example, forest conservation or reforestation can be targeted to provide both carbon sequestration and reduction of risks from floods, landslides, or downstream degradation of water quality from those events.

Seddon et al. (2020b) recommends expanding beyond forests for NbS mitigation projects, and thus also expanding beyond forests for projects that couple mitigation and adaptation benefits.[127] A range of NbS interventions can sequester carbon while also reducing risks of coastal erosion, flooding, or other disasters, such as restoration of salt marshes, mangroves and peatlands. These projects can also reduce the loss of coastal habitat for fish, birds and wildlife. A study by the UK's Royal Society for the Protection of Birds examined the spatial overlap of areas that support high habitat values and also have high potential for carbon sequestration in Great Britain. They found that, among these habitats with multiple values, coastal habitats provided among the highest carbon sequestration potential – and could also help protect coastal property from erosion and storm surges.[128]

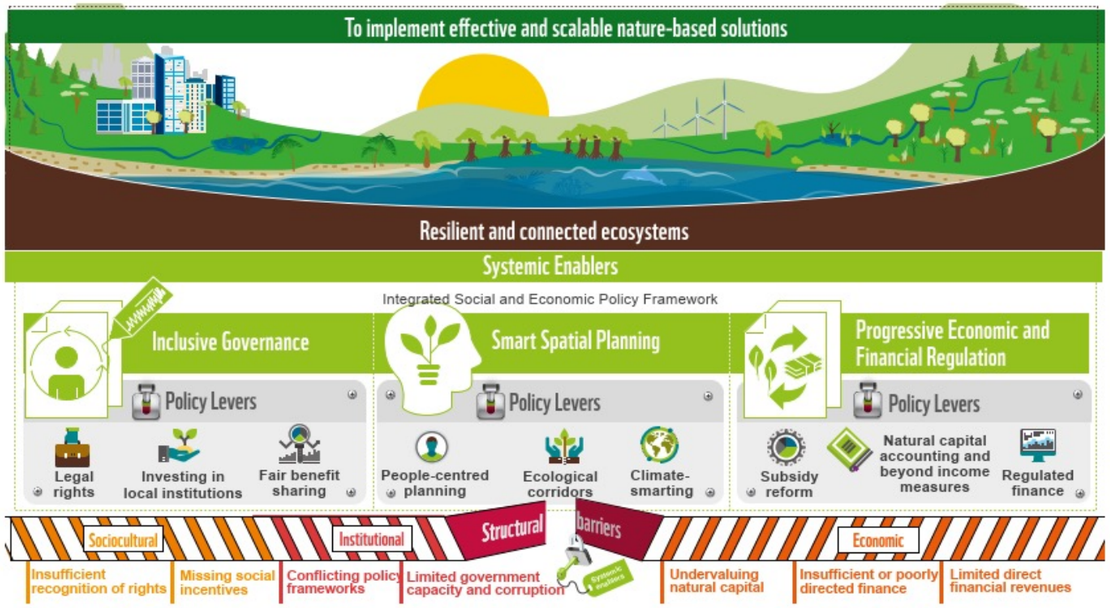



**Figure 31.** An integrated set of policy levers and systemic enablers can overcome the structural barriers to NbS implementation. (From WWF 2021)

The Intergovernmental Panel on Climate Change has described a set of categories of barriers to climate action, largely overlapping with the categories above, that also include *environmental barriers*. Environmental barriers include potential competition for land and water. For example, widespread tree planting in regions that were historically grassland or savanna may increase carbon sequestration but, due to greater evapotranspiration from trees relative to the vegetation they replaced, deplete water resources (and note that the carbon benefits may be ephemeral if the trees, planted outside of a typical forest zone, become vulnerable to disease, beetle infestations, and/or fire). Competition for land may be intense. Proposals to change land use for NbS for adaptation are being made at a time when there are multiple proposals for how land use should change to meet future needs: e.g., proposals for protection of 30 per cent of the planet, plans for expanding agriculture to feed a growing planet, and plans for reforestation for carbon sequestration (see Box 8).

Furthermore, IPLC must be given agency and autonomy over their lands and waters, and how these are managed. All these environmental and social complexities underscore the need for NbS to be planned in a way that can maximize other objectives (e.g., climate, nature, livelihoods) through transparent and inclusive processes that empower IPLC.

To begin to address some of the technical and regulatory barriers, efforts are now underway to more rigorously quantify the performance of NbS projects under various conditions, which will provide engineers and decision makers with a stronger basis for comparing options.[125]

IUCN has offered a standard for Nature-based Solutions, intended to promote sustainable and effective projects that can overcome barriers and to cultivate a "systematic learning framework" that can increase acceptance of, and improve confidence in, NbS among decision makers.[126] The eight criteria of the standard are that NbS programmes and projects should:

- Effectively address societal challenges;
- Be designed in a way that is informed by scale;
- Result in a net gain for biodiversity;
- Be economically viable;
- Be based on inclusive, transparent and empowering governance processes;
- Equitably balance trade-offs between achieving their primary goal and providing multiple benefits;
- Be managed adaptively, based on evidence; and
- Be sustainably mainstreamed within an appropriate jurisdictional process.

WWF (Pérez-Cirera et al, 2021) offers a framework of systemic enablers and policy levers to overcome the common barriers to NbS implementation. The overarching systemic enablers include: (1) inclusive governance; (2) smart spatial planning; and (3) progressive economic and financial regulation. For more details on these, and the associated recommendations for policy levers, see Figure 31 and Pérez-Cirera et al (2021). Additionally, this chapter concludes with a summary of some of the key enabling conditions to promote greater uptake of NbS.

## 5.2 Cost effectiveness of NbS: multiple benefits, multiple funding sources

A key consideration for overcoming constraints to NbS implementation is understanding their effectiveness and costs relative to other options. Many sources have offered generalized statements that NbS are less expensive to implement and/or maintain relative to engineered options, while the evidence for this assertion is limited or mixed.

Chausson et al. (2020) reviewed hundreds of studies of NbS and found that few studies evaluated cost effectiveness.[129] Since they require more land, which can be expensive to acquire, some NbS for flood risk (e.g., floodplain reconnection through levee setbacks) can be more expensive than simply repairing or raising dikes higher. On the other hand, a range of recent studies have found that NbS interventions can be more cost effective than engineered options for flood-risk management[130] and coastal defense[131] – although this advantage may be limited to less extreme events.[132] The Royal Society (2014) conducted a semi-quantitative study comparing NbS approaches to engineered approaches, as well as hybrid mechanisms that integrate NbS and engineering, in terms of their effectiveness and affordability for reducing risk from disasters (e.g., floods, storms and droughts). They found that NbS approaches were less expensive but less effective than engineered approaches and that hybrid approaches had the most balanced performance in terms of effectiveness and affordability.[133]

Though the evidence is still relatively preliminary, a few key themes emerge. First, while the question may be framed as a comparison *between* NbS and engineered approaches, in the words of Natalie Seddon, it is time to move "beyond pitching green solutions against grey".[134] As emphasized throughout this report, NbS should not be viewed as a replacement for engineered solutions (in which case the question "which is best" would be a relevant one) but, rather, as part of a diversified portfolio calibrated to meet the needs of a specific context.

Second, when deciding on the mix of interventions within a diversified portfolio, evaluation of cost effectiveness should consider the full range of costs and benefits. For NbS interventions this will generally mean a quantification of their full range of diverse benefits. And, conversely, the full set of negative impacts on environmental and social resources from engineered approaches should be quantified, such as the loss of habitat and fisheries from water-management infrastructure such as dams and dikes. (Any negative impacts of NbS projects on other resources and co-benefits of engineered structures should also be considered).

Assessment of specific interventions should also fully consider long-term costs for maintenance, repair and replacement. Most engineered structures have a specific lifespan and will eventually require replacement. In contrast, because they are composed largely of living systems and components, NbS may have lower long-term maintenance costs and may not require replacement in the same way as an engineered structure. This difference in maintenance and replacement costs will likely grow due to climate change. Much of our existing infrastructure was not designed for the increased intensity of storms that climate change is already driving – as demonstrated by the failure of two hydropower dams in Michigan in 2020 that led to extensive flooding downstream.[135] Much of the infrastructure currently under development has not been designed for changing hydrology, and in some cases planners struggle with understanding what future conditions they should design for. A report from the OECD notes that NbS can often be "no regrets" options that "assist in managing uncertainty related to climate change by avoiding or delaying lock-in to capital-intensive grey infrastructure, allowing for flexibility to adapt to changing circumstances."[136] For example, there is emerging evidence that, by trapping sediment and building new land, healthy mangroves can keep pace with moderately high rates of sea-level rise.[137]

The full value of NbS interventions becomes clearer when their comprehensive set of benefits are considered. Studies that have accounted for these diverse benefits have reported that NbS can deliver high benefits relative to costs. For example GCA and WRI (2019) reported that mangrove restoration returned benefits valued at ten times the total costs, once the non-monetary benefits, such as fisheries, non-timber forest products and recreation, were included.[138] Similarly, a WRI report that quantified a diverse range of non-monetary benefits concluded that each dollar invested in landscape restoration delivered US$7-30 in benefits.[139] As mentioned in the discussion about barriers, the diverse benefits of NbS can be difficult to measure (a technological barrier) and are often not effectively considered within cost-benefit analyses (an economic barrier). Thus, both technical improvements and economic policy fixes will be needed to more fully incorporate the diverse benefits of NbS into planning and decision processes.

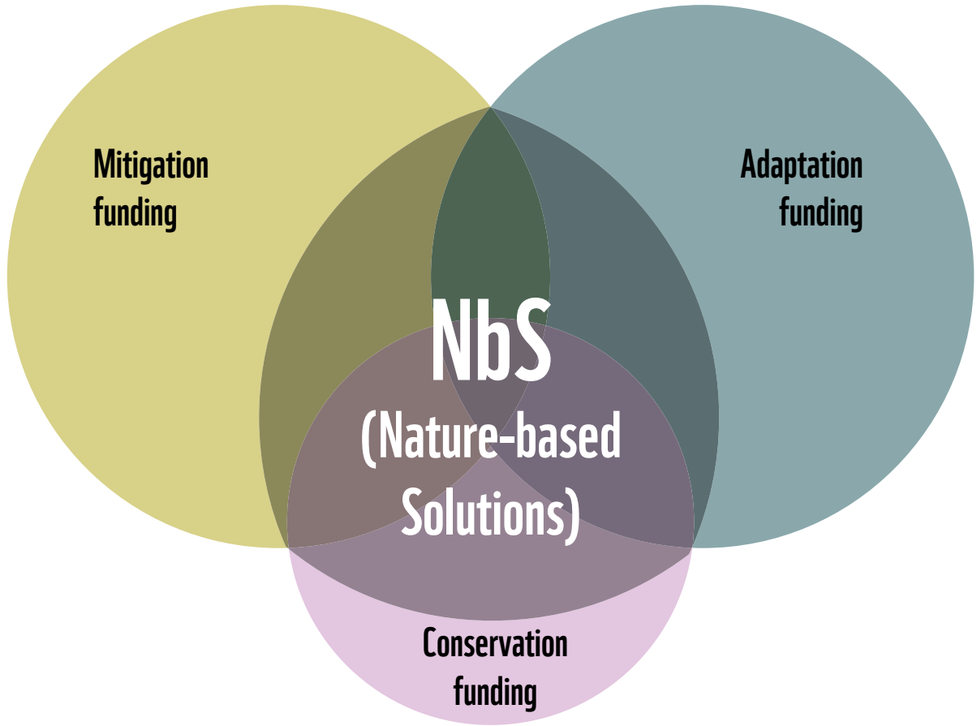



**Figure 32.** A conceptual figure illustrating that well-designed NbS projects can potentially draw on funding from three global sources of funding: climate mitigation, climate adaptation, and conservation. The green box shows that NbS should overlap with projects, and project funding, for all three categories.

These diverse benefits of NbS may also be key to overcoming the barrier of insufficient finance available to support NbS. Because they provide multiple benefits, NbS projects should be able to access multiple funding streams (Figure 32). For example, a dike setback project in California (a hybrid NbS project) received a large portion of its funding from a public funding source for nature conservation because the NbS solution – reconnecting hundreds of hectares of floodplain to the river for conveyance of floodwaters – was also a high priority restoration action in the region.[140] Furthermore, NbS projects that accomplish adaptation and conservation objectives may also be able to tap into climate mitigation finance, as illustrated by the "blue carbon" project of Mikoko Pamoja in Kenya (see section 4.4).

Potentially, well-designed and sited NbS projects could draw on funding from both climate mitigation and climate adaptation as well as conservation. However, because conservation budgets are generally very small relative to budgets for objectives such as disaster risk management, a primary appeal of NbS is that they may be able to fund conservation outcomes without relying on limited conservation funding. That is, if a NbS project is very effective at accomplishing the goal of managing a societal challenge, such as flood-risk reduction, it may be funded through the larger budgets dedicated to that objective. If it is well designed, it may also accomplish significant conservation outcomes without using conservation funding (e.g., much of the hatched area for NbS in Figure 32 that is outside the circle of 'conservation funding' could still be making significant contributions to conservation objectives). At a global scale, this means widespread uptake of well-designed NbS could dramatically increase the total funds flowing toward projects that achieve conservation goals.

# 5.3 Financial models to support large-scale implementation of NbS

Since many NbS projects are intended to produce what have generally been managed as public goods, such as flood-risk reduction, NbS interventions have typically not produced bankable revenue streams – though some may be able to (e.g., see Box 9). As described in the previous section, NbS will often be able to tap into diverse sources of funding, potentially integrating funding aimed at multiple objectives (e.g., climate mitigation, disaster risk reduction and nature conservation). It is increasingly recognized that, for some NbS opportunities, private capital will be needed to help fill the financing gap, driven both by corporations recognizing their own operational risks as well as opportunities for NbS projects that can deliver a return on investment.[141] Blended finance – funding from public and philanthropic sources – will be key to catalyzing increased investment of private capital (Figure 33). Blended finance can be used to de-risk preliminary private investments and help identify and cultivate a pipeline of projects that are likely to be both good investments and directed at addressing priority challenges.

Infrastructure investments – whether that encompasses typical engineered projects, NbS or a hybrid – can be paid for in only three ways: taxes, tariffs, or transfers (the "three T's" proposed by the "Camdessus Panel" of the World Panel on Financing Water Infrastructure; Figure 34):

- Taxation through the fiscus, or targeted levies, such as municipal rates;
- Tariffs or charges, to recover the costs of infrastructure or services; and
- Transfers, including grants and donations, to fund additional costs of robust infrastructure that offer an economic rate of return if the financial return is not sufficient in isolation to attract and repay finance.

Because NbS have the potential to deliver multiple types of benefits, they may be able to draw upon all three of the "T's", and from diverse sources (e.g., public, private, philanthropic). Financing any project, including NbS interventions, comes down to understanding whether it will generate future flows of income that can be monetized in the form of taxes or tariffs. Demonstrating how much money can be raised based on those anticipated future flows can be used to seek out upfront financing. For NbS projects, some of the benefits they provide might produce flows of income that can be monetized, such as ecotourism revenues, urban farming, or carbon credits.

NbS projects may also produce sufficient economic, social or environmental benefits such that governments and/or philanthropists might be willing to contribute to these projects without requiring payback (e.g. "transfers" such as grant funding).

Building a business case for a large-scale NbS project hinges on determining the balance of taxes, tariffs and transfers that could finance the project. Projects may also require the identification of an anchoring institution – an entity that is both creditworthy and trustworthy, capable of receiving and managing funds and implementing the relevant NbS project.

The Kigali wetlands case study (Section 4.3) can be used to illustrate this process of developing a business case and financial model for a large-scale NbS (Figure 35). In this case, the relevant NbS intervention – restoration and preservation of wetlands – could potentially be financed up-front by public entities (through the fiscus), grants or concessional loans. To ensure effective management and implementation of these resources, a fund managed by an anchoring institution (such as Rwanda's existing National Fund for the Environment (FONERWA)) could be used to (i) attract different sources of up-front financing; (ii) channel financing towards relevant projects; and (iii) manage the projects themselves. An anchoring institution could also seek to create new schemes using blended finance approaches – although this is a capability that is currently limited and will need to be built over time.

In the case of the Kigali wetlands, potential revenue sources that could be used to pay back public monies or concessional loans may come from (i) ecotourism revenues, (ii) property taxes, or (iii) urban agriculture. Rwanda may also be able to make the case that NbS interventions sequester carbon thereby allowing them to sell carbon credits.

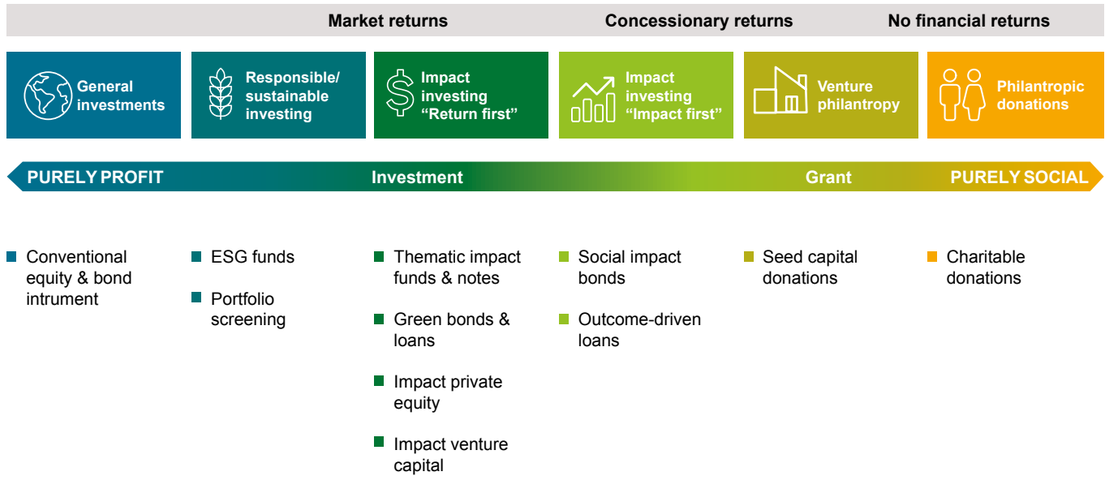



**Figure 33.** The full spectrum of potential funding sources for NbS, from the WWF Bankable Blueprint Book, based on "From philanthropy to ESG" by Credit Suisse.

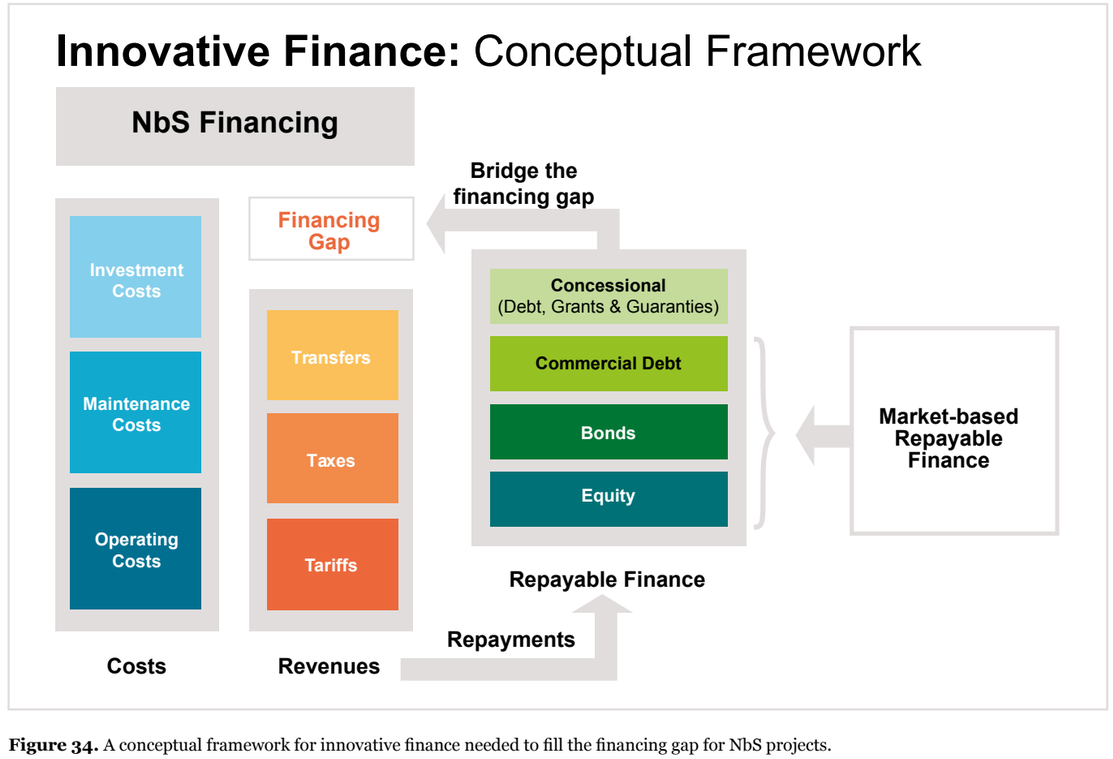



**Figure 34.** A conceptual framework for innovative finance needed to fill the financing gap for NbS projects.

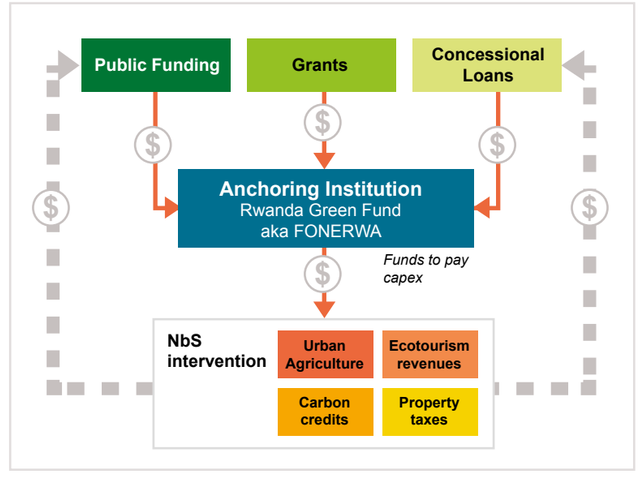



**Figure 35.** A financial model for the Kigali wetlands case study.

## Box 9: Nature-based and Bankable: An example of economically viable nature-based solutions in the Mekong Delta, Viet Nam

The Mekong Delta is one of the world's most productive ecosystems. It produces half of Viet Nam's rice crop, including 90 per cent of its rice exports. The delta is home to nearly 20 million people and accounts for 25 per cent of Viet Nam's GDP. To be stable, deltas require regular deposition of riverine sediment to counteract processes of compaction and erosion from waves and storms (now exacerbated by sea level rise). The Mekong Delta has lost much of its sediment supply due to both sand mining and the capture of sediment within the reservoirs behind upstream hydropower dams. As a result, the delta is sinking and shrinking, contributing to the intrusion of salt water deeper into the delta, negatively impacting agriculture. The delta's long-term viability will require maintaining its current sediment supply and ensuring that sediment can be distributed and deposited across the delta.

WWF and the Dutch Fund for Climate and Development (DFCD) have developed a project intended to demonstrate that agricultural projects can be managed in combination with NbS methods to distribute sediment across farm fields, helping to offset the compaction and sinking of the delta. Crucially, this project is intended to generate a return on investment and therefore it could expand to other properties without requiring public or philanthropic funding.

Current rice growing practices are not environmentally sustainable, requiring large amounts of water and agricultural chemicals. Because rice is grown year-round, it becomes vulnerable to saltwater intrusion during the dry season and requires irrigation with pumped groundwater, contributing to the compaction and lowering of delta land surfaces.

To demonstrate a more sustainable model – in which productive agriculture has lower impacts and actually promotes sediment deposition – the Mekong Delta Integrated Rice and Aquaculture Bankable Project will run three pilot studies totalling 110 ha. These projects will feature the conversion of rice paddies into ponds that support both rice and shrimp aquaculture during different times of the year. Rice and freshwater shrimp will be grown during the rainy season and brackish-water shrimp will be grown during the dry season. Because rice will only be grown during the rainy season, the project will not pump groundwater from the depleted aquifer.

The NbS component of this project is the reconnection of the rice paddies to river channels, allowing floodwaters to flow in and deposit nutrient-rich sediment – helping to counteract the sinking of the delta and also fertilizing both the rice and the shrimp production. Deltares is advising on this restoration of sedimentation and they estimate that the process will raise land elevations by 6 to 10 cm per year, helping to offset the 2 to 4 cm per year of subsidence.

The project will also be bankable. Project design and sustainable practices are predicted to increase yields. Meanwhile, there is growing demand for sustainable shrimp and, particularly if the farms receive certification from the Aquaculture Stewardship Council (ASC), farmers' incomes are expected to rise substantially.[142] If successful – including profit generation – this model for sustainable agriculture and sediment replenishment can expand in other areas of the delta without requiring public or philanthropic funding.


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# 5.4 Scaling up implementation of NbS

As discussed above, numerous reports and other resources offer guidance on the key enabling conditions and policy levers needed to increase uptake of NbS. We conclude this chapter by summarizing a few of the key enabling conditions.

**Ensure alignment of policy, funding and capacity.** Although it is generally noted that NbS programmes suffer from an investment gap, increasing funding without a conducive policy context, or sufficient capacity among decision makers and local managers, can result in ineffective, or even detrimental, outcomes and investments that fail to yield positive impacts. For example, funders such as international donors, NGOs or corporations, have priorities and preferences for their investments, which may or may not be aligned with national or local priorities. So it is important that when external funders prioritize NbS and increase funding for it, their investments should be made through inclusive and collaborative programmes that emphasize gaining government support and building capacity at multiple levels. For example, in Pakistan, the government is receiving significant funding from the Green Climate Fund to improve flood-risk management, including major investments in NbS in the Indus River basin, in a project called Recharge Pakistan that WWF helped design. This project will focus on capacity building of Pakistan ministries that manage resources so that they will have the expertise and capacity to plan, implement and manage NbS projects over the long run.

**Provide the evidence.** Clear evidence of the effectiveness of NbS interventions, and an articulation of the specific benefits that flow to different stakeholders, can help mobilize and sustain support. Therefore, NbS investments should encompass strong monitoring and evaluation programmes so that evidence can be collected and communicated. Private sector interest in NbS will increase if these benefits can be demonstrated credibly, particularly where those benefits are clearly aligned with reducing operational risks and/or corporate water stewardship priorities.

**Close the funding gap by tapping into diverse public and private sources.** Funding from a range of sources will be needed to close the gap in funding for adaptation. Although precise estimates are difficult to derive, the UNEP (2021) reports that existing commitments will not close the current funding gap and needs will rise rapidly.[143] Because NbS projects generally provide multiple benefits, these projects and programmes should be able to draw on multiple sources of funding (e.g., those for climate adaptation, climate mitigation, and biodiversity; Figure 32) from multiple types of funders (Figure 33).

WWF is working to fill in the investment gap in sustainable freshwater management by exploring the potential for Bankable Water Solutions, including the extent to which NbS projects can be funded through these sources (see Box 9). Investors, banks and private companies are investing heavily in water-related infrastructure and they are motivated to invest in more sustainable water projects, but there is a limited pipeline of viable projects. WWF is taking action to vet concepts and support the development of a pipeline of investable or 'Bankable Projects', at the right scale, and to ensure that these are delivering against broader landscape-scale plans to support resilient and sustainable economies and ecosystems.

Although support from international donors, corporations and NGOs will be helpful for getting NbS programmes underway and providing initial demonstrations of benefits, ultimately the greatest impact and long-term viability may come when NbS approaches are fully integrated into the main budgets of ministries that manage rivers, coasts and other resources. For example, the NbS interventions of forest protection and restoration can be built directly into the system planning and operations of water supply utilities. Similarly, flood management agencies can begin to fully integrate NbS into their planning, development and operations.

Ultimately, this mainstreaming of NbS will be advanced on a foundation of a strong evidence base and capacity building, through which NbS will be seen as being aligned with existing development and management priorities, rather than an additional requirement. NbS will reach their full potential when they become standard operating practice – and major components of diversified portfolio budgets and management – of the agencies that manage water supplies, flood risk, urban stormwater and coastal defense.

# CHAPTER 6

## RECOMMENDATIONS FOR SCALING UP NBS TO TACKLE WATER CHALLENGES IN AFRICA

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Africa has a set of water challenges that are projected to increase due to climate change, some quite dramatically. Funding for adaptation in Africa will have to increase by seven per cent per year to keep up with the investments required to build resilient communities. Currently, Nature-based Solutions represent a relatively small fraction of adaptation funding but, if scaled up, they could make important and cost-effective contributions to water security and resilience. To maximize benefits and long-term viability, NbS should be fully integrated into planning for investments in adaptation and infrastructure and designed and implemented in ways that complement the needed expansion of engineered infrastructure.

A hallmark of NbS is that they promote multiple benefits. Well-designed NbS projects can help African countries accomplish a range of policy objectives including water security and risk reduction (to meet goals for the SDGs), climate mitigation (for NDCs) and biodiversity (for Convention on Biological Diversity). If designed and implemented effectively they can meet the objectives of multiple stakeholders and make significant contributions to a nature-positive world.

From the perspective of conservation organizations, NbS offer a way to achieve a potentially substantial portion of their conservation objectives through diverse sources of funding, such as those funds dedicated to reducing disaster risk or securing water supply for people. For agencies and utilities, investing in NbS can make significant contributions to their primary water-management mandates, often through ways that are more resilient and durable than typical infrastructure investments, while simultaneously avoiding negative impacts on social and environmental resources (which can generate conflicts) – and even making positive contributions to those resources. Those positive contributions are what allow NbS projects to help governments achieve multiple objectives (e.g., climate or biodiversity protection goals) through budgets and programmes that have not traditionally made such contributions.

An additional benefit of NbS that will appeal to governments is that they can increase employment. The most job-intensive NbS include reforestation, ecosystem or watershed rehabilitation, and management of invasive species.

The rationale for NbS is clear. Now it is up to everyone involved in the worlds of climate, sustainable development and water to ensure that NbS and improved water resources management are central to efforts to mitigate climate impacts and build resilience in Africa.



## Governments and policy makers must prioritize Nature-based Solutions

Policy makers across Africa must ensure that NbS are a critical component of their water resources agenda and their overall plans to meet sustainable development, climate adaptation and disaster risk reduction goals. This means understanding the evidence for, and communicating the benefits of, NbS for addressing water- and climate-related challenges, as well as challenging current models and thinking that may favour traditional 'grey' infrastructure development.

**In practical terms, policy makers should:**

**Promote NbS alongside more sustainable and resilient 'grey' infrastructure to tackle water challenges and reduce vulnerability to climate change** as well as increase the health and resilience of the continent's rivers, lakes and wetlands, which underpin societies and economies. This should include policies and mechanisms to protect and, where needed, restore free-flowing rivers, an under-acknowledged but potent NbS.

**Invest in adaptive institutional capacity and enabling frameworks for successful and sustainable implementation and management of NbS efforts.** These include effective water management institutions and allocation mechanisms; platforms for stakeholder involvement; and increased monitoring, evaluation and enforcement capacity.

**Ensure budgets include sufficient funding to implement NbS at a scale that can have meaningful, lasting impact on Africa's watersheds and water resources,** and increase financing for water resource management and climate adaptation overall.

**Call for equal investment in mitigation and adaptation, and for a larger portion to fund NbS.**



## Private sector companies must transform their approach to water

Companies across Africa have a critical role to play in pursuing both individual and collective investments in NbS to mitigate water risks, while also supporting the enabling conditions to accelerate adaptation and uptake of NbS.

**Companies should:**

**Understand their water impacts and risks and engage in water stewardship efforts focused on measurable impact in watershed health.** Corporations should begin by understanding material water dependencies and impacts and assessing water risk across their value chains. They can then apply this understanding to build and implement a water stewardship strategy focused on mitigating risks and harnessing opportunities and value through efforts aimed at measurably improving watershed health. Guidance on water risk and water stewardship is available along with tools, such as the WWF Water Risk Filter, to enable companies to assess, value and respond to risks.

**Promote NbS as a critical part of the solution to shared water challenges** facing businesses, communities and economies, and incorporate NbS into their water stewardship strategies, where relevant.

**Use their influence and scale to catalyse collective action on NbS** by engaging in platforms that allow different companies and organizations from across industries and sectors to work together at basin or landscape scales to address shared water risks and have measurable impact.



## Financial institutions must recognise that climate risk is water risk

The financial sector needs to understand that the impacts of climate change will largely be felt through water and that financial institutions need to invest in building resilient freshwater ecosystems to prevent assets and investments from being left stranded, dried out or flooded. The financial sector has a unique role to play in expanding current financing of NbS and developing new, innovative mechanisms for investing in these solutions.

**Financial institutions should:**

**Develop a strong understanding of water risk and financial value,** including the opportunities that exist to create value. Guidance is available on financial value and water risk along with tools, such as the WWF Water Risk Filter and Ceres Water Investor Toolkit.

**Invest in NbS as an opportunity to both create value and mitigate risks** to assets and investments by engaging with existing efforts and mechanisms to fund NbS and creating new offerings and innovative channels for financing NbS – learning from investments that are already working for NbS, such as the Washington DC Water Bond, Nature Insurance Value: Assessment and Demonstration (NAIAD), and WWF's work to mobilize finance for NbS via Bankable Water Solutions.

**Implement and support policies that lay the foundation for credible green investments** since an enabling environment is essential to support the necessary expansion in funding for NbS.

It is critical that the countries of Africa address their growing water resource challenges and accelerate adaptation in the face of climate change. Given the strong evidence base for their effectiveness, NbS must be central to efforts to build more resilient societies and economies, leveraging and maintaining the environment's ability to adapt naturally.

WWF and AB InBev are convinced of the value of NbS to help tackle the continent's water challenges and to support communities and governments in Africa to adapt to climate change. All three are also fully committed to partnerships in this space since – as emphasized by SDG 17 on building stronger partnerships – collective action is essential for creating a more resilient future. Together, we can develop, fund and implement NbS at a scale that helps communities, companies and countries sustainably manage precious water resources and build a climate-resilient future.

# Annex 1: Evidence review

Here we summarize evidence for the effectiveness of NbS to address water-related challenges, drawing on both a global evidence review of NbS (Oxford NbS Evidence Platform; Seddon et al., 2020a) and the first-ever evidence review of NbS for water challenges for Africa (Acreman et al., 2021). Both of these summaries of evidence conducted systematic reviews of the literature, focusing on studies that provided quantitative results of the impact of a NbS intervention, and reported whether the study found a positive or negative (or inconclusive) impact on the intended objective (e.g., whether a reconnected floodplain measurably reduced flood flows).

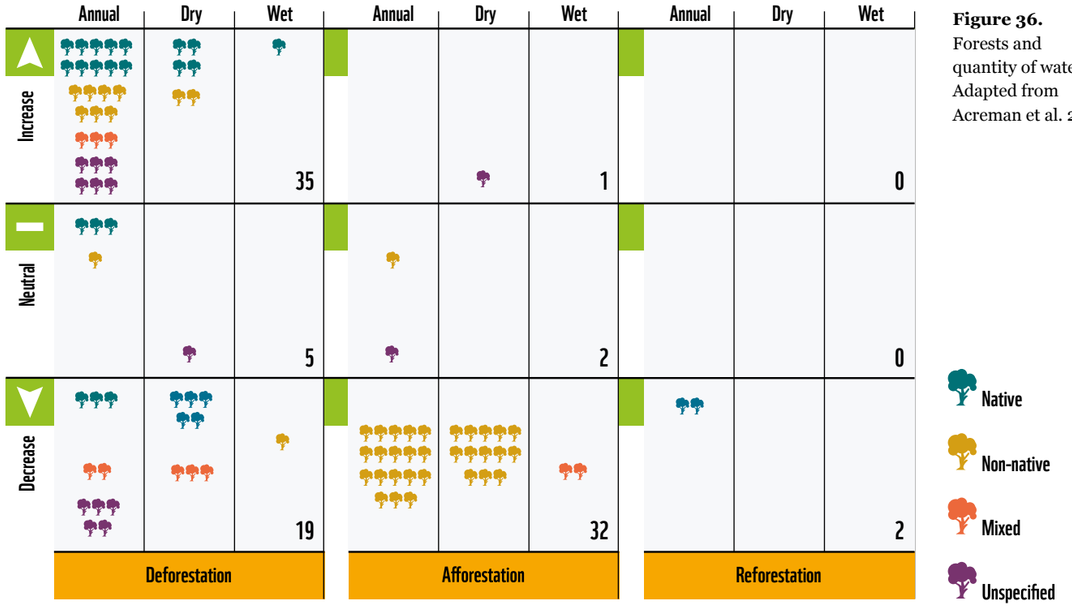



**Figure 36.** Forests and quantity of water. Adapted from Acreman et al. 2021

## WATER SCARCITY

Acreman et al. (2021) reviewing studies in Africa, found that deforestation in often led to increases in total water production from a watershed and that most examples of reforestation or afforestation led to decreased total water production (Figure 36). This is because even though the soils of a healthy forest generally increase infiltration of precipitation, relative to a land cover such as pasture, trees generally evapotranspire more water than do grasses or shrubs. In most of the reviewed cases (15 of 18) the increase in evapotranspiration outweighs (or is equal to) the improved infiltration in terms of overall water balance.

However, it is worth looking a bit deeper into these trends. Nearly all the African studies linking the growth of trees to declining water production were of afforestation with non-native species. Focusing on deforestation, the clearing of non-native trees nearly always led to an increase in water production. The clearing of non-native trees to increase water production is the major NbS featured in the case study from South Africa in Chapter 4.

But note that most African examples (8 of 12) of the removal of forests with native or mixed species led to a decline of dry season flows, suggesting that, the infiltration benefit of some forest soils may be important for increasing flow during dry periods. In some contexts, increasing the availability of water during dry periods may be more important than overall annual water production. For example, unless the stream or river is flowing into a storage reservoir, a reduction in wet season flow may have no negative impact on water users, whereas an increase in dry season flows may have a clear benefit (and note that there is strong evidence for reforestation contributing to improved water *quality* and reduction of flood risk, discussed in the next two sub-sections).

The global review also underscores a hydrological difference between non-native and native forests. The Oxford database found 25 examples of tree planting with non-native species that led to a decline in water availability, and only two examples where afforestation with non-native species increased water availability. In contrast, they found ten examples of forest protection, or reforestation with native species that led to increased water availability and only two examples where those strategies were associated with diminished water availability (Figure 37).

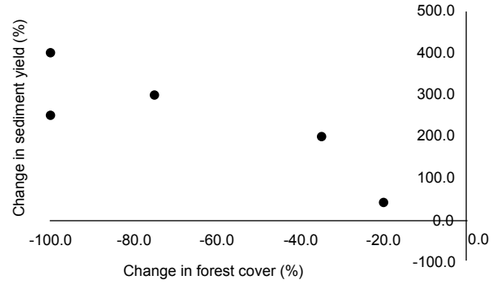



**Figure 38.** Relationship between change in forest cover and sediment yield. From Acreman et al. 2021

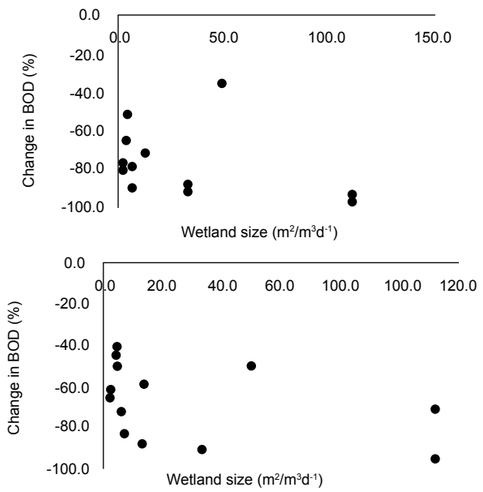



**Figure 40.** Changes in BOD and COD with wetland size. From Acreman et al. 2021

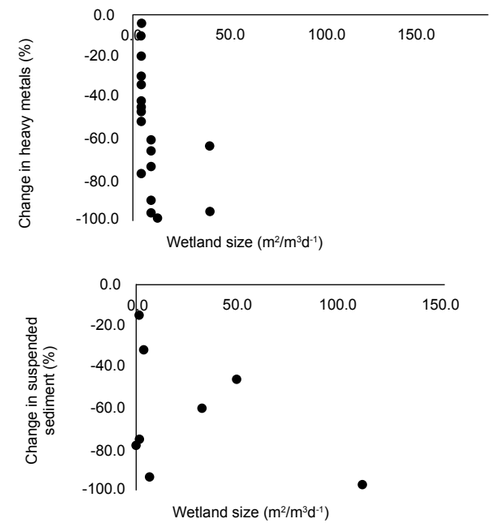



**Figure 41.** Changes in heavy metals and suspended sediment with wetland size. From Acreman et al. 2021

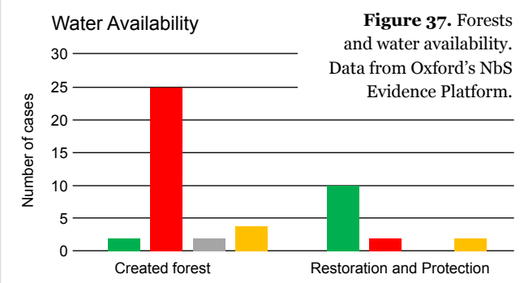



**Figure 37.** Forests and water availability. Data from Oxford's NbS Evidence Platform.

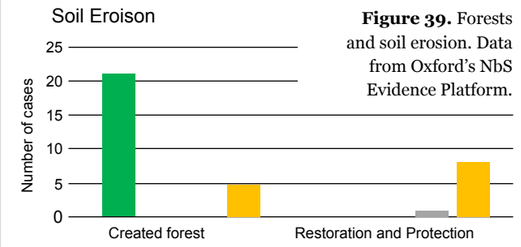



**Figure 39.** Forests and soil erosion. Data from Oxford's NbS Evidence Platform.

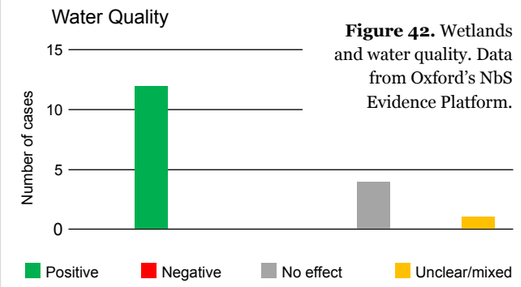



**Figure 42.** Wetlands and water quality. Data from Oxford's NbS Evidence Platform.

## WATER QUALITY

Acreman et al. (2021) found clear evidence that forests are associated with lower sediment yields from watersheds, suggesting that forested areas have lower rates of erosion (from hillsides or streambanks) relative to non-forested land covers. Clear cutting of a forest was associated with increases in sediment yield up to four times relative to areas that remained forested (Figure 38). The global evidence review found similar relationships between forests and erosion, with nearly all examples of reforestation – whether native or non-native – being associated with reduced erosion and sedimentation (Figure 39).

Acreman et al. (2021) also found strong evidence for the ability of wetlands to improve water quality, with the presence of wetlands associated with declines in Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD) (Figure 40) and heavy metals and suspended sediment (Figure 41). The global review also found consistent evidence that wetlands improve water quality, with 10 of 15 cases found to be associated with improved water quality (the remaining five were mostly "no effect" with one example of "unclear/mixed") (Figure 42)

**Figure 43.** Impact of existing floodplains in Africa on flood levels downstream. Adapted from Acreman et al. 2021.

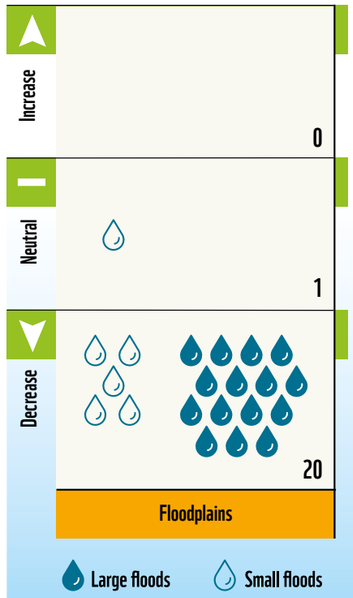



**Figure 44.** Wetlands and flood levels. Data from Oxford's NbS Evidence Platform.

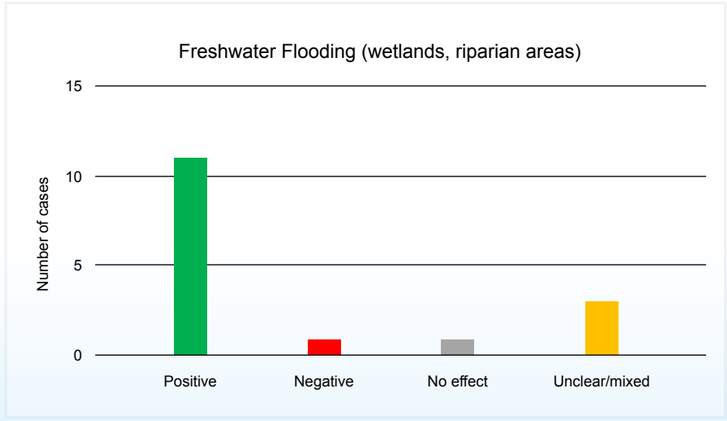
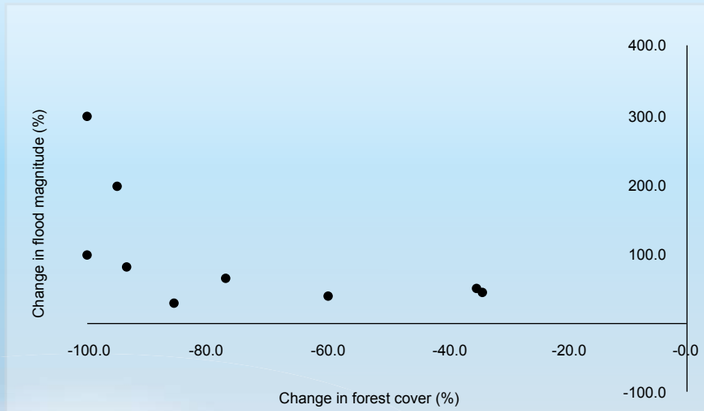



**Figure 45.** Relationship between change in forest cover and change in flood magnitude. From Acreman et al. 2021.




## FLOOD RISK

Acreman et al. (2021) found very consistent evidence that floodplains are associated with reduced flood levels downstream, for both large and small floods (e.g., all 15 studies that included results for large floods found that floodplains reduced flood levels downstream) (Figure 43). Results from the global review drew on a wider range of habitat types that are comparable or equivalent to floodplains (including riparian areas, wetlands, and ponds) found that these features generally were associated with reduced flooding (11 out of 16 studies) (Figure 44).

Both studies also found support that forest cover can reduce downstream floods (Figures 45 and 46). Note however that many of the studies in these evidence reviews did not provide specific data on the magnitude of flooding that was reduced and that other quantitative reviews have found that forest protection, or reforestation, is generally most effective at reducing moderate floods and/or floods arising from smaller watersheds.

## COASTAL PROTECTION

Acreman et al. (2021) did not review the evidence for the effectiveness of mangroves or other coastal features. The Oxford global review had results for several coastal ecosystem types in terms of their association with reduced coastal flooding or erosion – although relatively few for each type. Thus, we combined results from mangroves, salt marshes, coastal wetlands and interventions within deltas and estuaries for each coastal ecosystem type. More than 90% (19 of 21 studies) found that these coastal habitats were associated with reductions in coastal flooding or erosion (Figure 47).

**Figure 46.** Forests and flooding. Data from Oxford's NbS Evidence Platform.

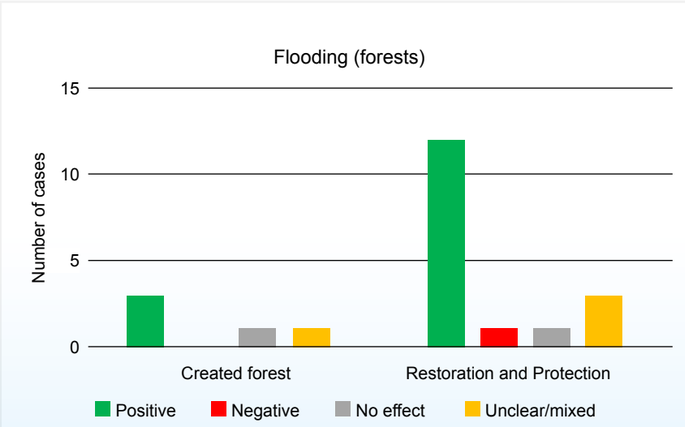
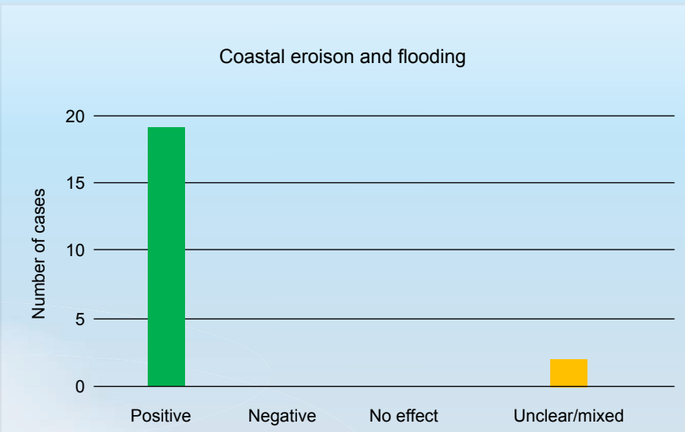
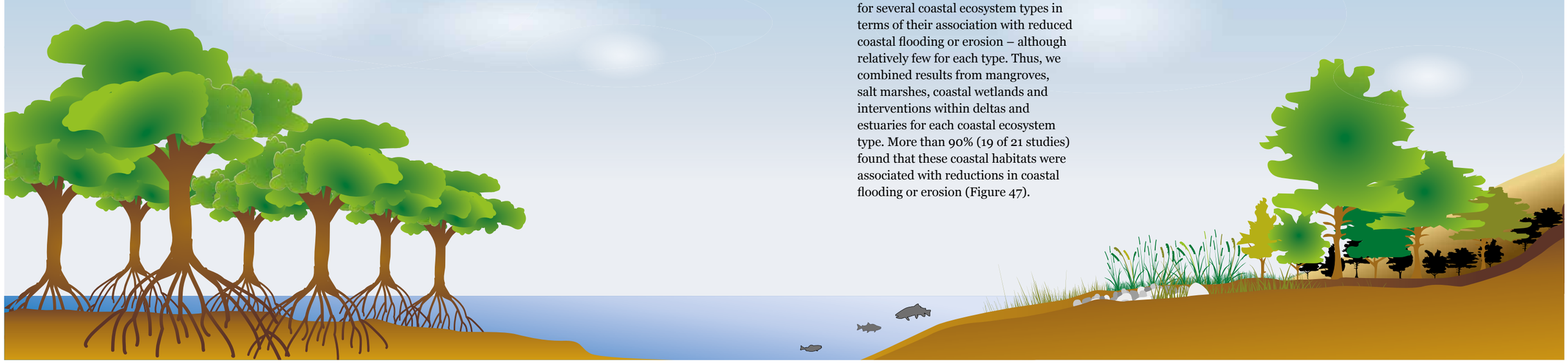



**Figure 47.** Coastal erosion and flooding and coastal wetlands. Data from Oxford's NbS Evidence Platform.



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Here we also used projections of population and GDP based on the SSP2 scenarios to assess the potential impacts of water risks in the coming decades. For more details of the population and GDP projections see Murakami, D. and Yamagata, Y. (2016) Estimation of gridded population and GDP scenarios with spatially explicit statistical downscaling, ArXiv, 1610.09041, URL: https://arxiv.org/abs/1610.09041.

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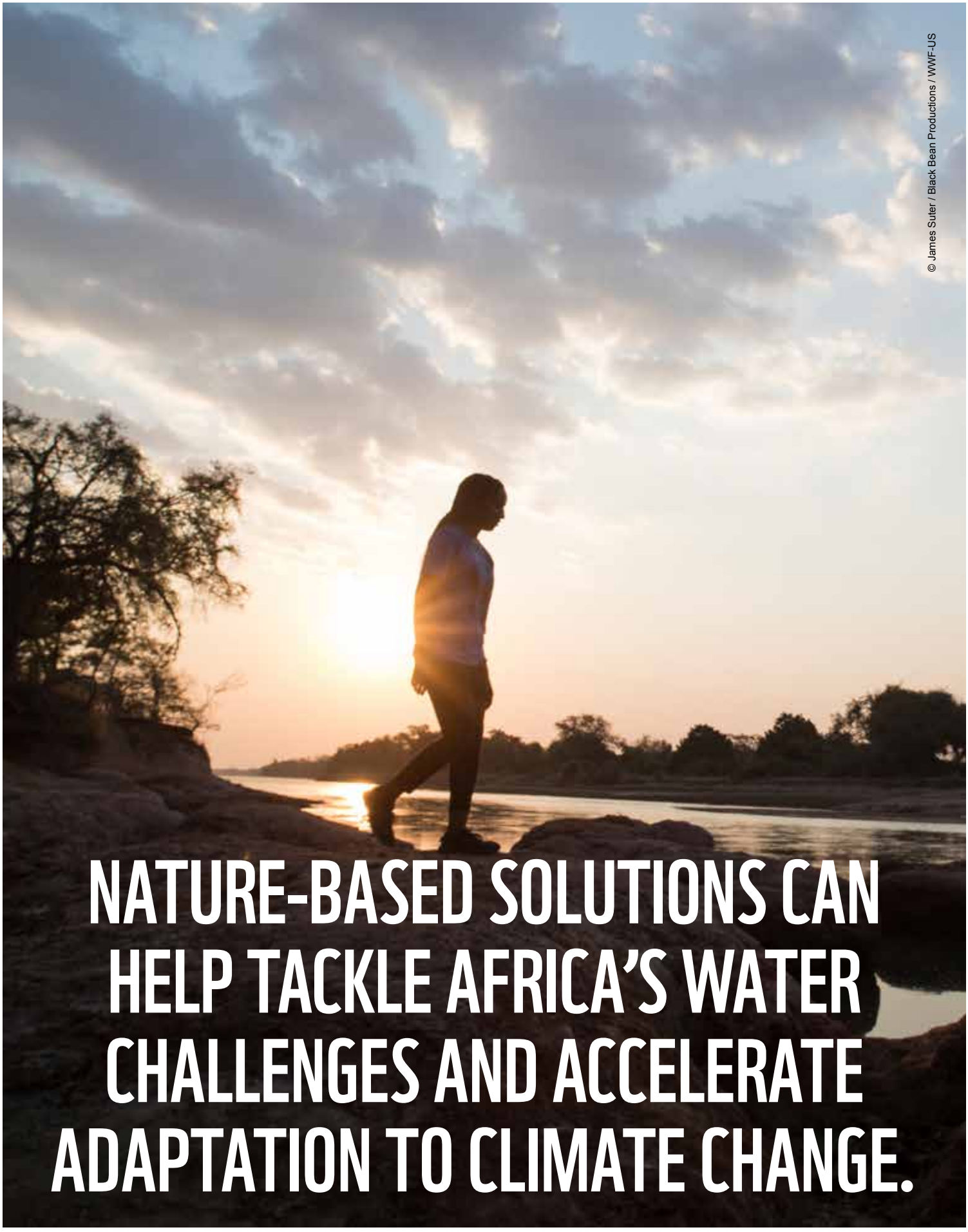
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