NATURE-BASED SOLUTIONS

FOR WATER MANAGEMENT

A PRIMER

UN Environment-DHI Centre on Water and Environment

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United Nations Environment Programme

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TABLE OF CONTENTS

ABBREVIATIONS AND ACRONYMS

CNT	Center for Neighborhood Technology
ESII	Ecosystem Services Identification & Inventory
GWP	Global Water Partnership
IFM	Integrated flood management
IUCN	International Union for Conservation of Nature
IWRM	Integrated water resources management
LPI	Living Planet Index
NBS	Nature-based solutions
PES	Payments for ecosystem services
SDGs	Sustainable Development Goals
TEEB	The Economics of Ecosystems and Biodiversity
UNCCD	United Nations Convention to Combat Desertification
UN Environment	United Nations Environment Programme (previously UNEP)
UNFCCC	United Nations Framework Convention on Climate Change
WBCSD	World Business Council for Sustainable Development
WWAP	World Water Assessment Programme

PREFACE

It is often said that the Sustainable Development Goals (SDGs) will only be achieved through integrated approaches that incorporate the social, economic and environmental dimensions of sustainable development. Nature-based solutions (NBS) for water management constitute just such an approach, providing multiple benefits to basin stakeholders, while at the same time enhancing environmental assets.

Nature-based solutions for sustainable development are not new – there are many examples around the world – but mainstreaming, accelerating and scaling up progress in implementing them remains a challenge. This is to some extent the result of lack of knowledge of their benefits and limitations in water management, but more importantly of the challenges of bringing multiple stakeholders together to agree on integrated solutions and developing innovative financing mechanisms to implement such solutions successfully on a wider scale.

This primer on the multiple benefits of nature-based solutions in water management, which identifies entry points to scaling up implementation, is based on existing integrated approaches to stakeholder participation. It is primarily aimed at water managers in national, local and basin authorities in developing countries, but may also be useful to water management decision makers and other basin stakeholders, such as those in business, industry and energy production, agriculture and forestry, and urban planners and local communities.

The primer supports the 2018 World Water Day theme 'Nature for Water' and supplements the much more detailed *World Water Development Report 2018: Nature-based solutions for water*. It builds on previous work by UN Environment, such as Green infrastructure: *Guide for Water Management: Ecosystem-based Management Approaches to Water-related Infrastructure Projects*, and is in line with UN Environment's Freshwater Strategy 2017-2021.

1

INTRODUCTION

Flamingoes in the salt marshes near the mangroves in Doha, Qatar.

Nature-based solutions (NBS) for water resources management involve the planned and deliberate use of ecosystem services to improve water quantity and quality and to increase resilience to climate change. They are typically adopted in conjunction with conventional water infrastructure to bring about more sustainable outcomes.

Our natural environment has evolved over millennia and the water cycle is a central element that influences the landscape around us. In a healthy ecosystem, rainfall and temperature events are moderated, water flows are slowed, water is stored and filtered naturally, and clean water is gradually released.

Nature performs many functions of direct relevance to water managers, for example:

- Vegetation cover reduces damage caused by heavy rain by slowing run-off, thus reducing soil erosion and the related pollution, mitigating the impact of flash floods, and replenishing groundwater;
- Wetlands hold water back; their rich plant diversity takes up excess nutrients and filters out suspended solids; and
- Flood plains accept large volumes of water during extreme events, delaying or buffering impacts downstream.

In healthy ecosystems, these services are provided constantly at no or low cost and no or low maintenance (see box 1). Human development has had a negative impact on some ecosystem services, often resulting in greater reliance on large infrastructure projects that further impact ecosystem services:

- Wetland ecosystems have declined by 60-70 per cent over the past century, mainly because of conversion to agricultural use (Ramsar, 2015);
- In Europe, up to 90 per cent of riparian floodplains have been lost or functionally impaired (Tockner and Stanford, 2002);
- Loss of biodiversity, habitat destruction and species extinction (see box 2).

Box 1. Ecosystem services

- Provisioning services include food (crops and fish), fibre, fuel and genetic material.
- Regulating services ensure that ecosystems continue to function through changes, and include climate regulation, water regulation, water purification and waste treatment, erosion regulation, natural hazard regulation, and pollination.
- Cultural services may be spiritual and inspirational, recreational, aesthetic or educational.
- Supporting services are functions provided over the long term and include soil formation and nutrient cycling.

(Knoop et al., 2012)

The idea that healthy ecosystems benefit human beings is not a new one – in the past half century, the world's governments have repeatedly agreed on the need for sustainable development (e.g. the Stockholm Conference 1972, the Earth Summits in 1992, 2002 and 2012, and most recently the Sustainable Development Goals). Nor is there any shortage of academic literature or global and regional reports describing the benefits of nature-based solutions and ecosystem services. In recent years, most major international forums have concluded that such solutions should be adopted more widely and they have been incorporated into political commitments such as the Sendai Framework for Disaster Risk Reduction and the United Nations Convention to Combat Desertification (UNCCD), sustainable agriculture forums and through national adaptation programmes of action under the United Nations Framework Convention on Climate Change (UNFCCC) (WWAP, 2018). The business case for adopting nature-based solutions has also been gathering momentum, with case studies from around the world (WBCSD, 2018). Despite this, water resources managers and decision makers on the ground have not commonly adopted them, although there are multiple examples of such practices around the world.

One reason nature-based solutions are not fully exploited may be the complexity of the multiple jurisdictions and stakeholders that need to be engaged to implement them. This challenge also points to one of their main advantages, which is that they typically result in a mix of economic and social benefits to multiple sectors and stakeholders in the water basin (see section 2). This means that they can be used to support goals in multiple policy areas. For example, functioning floodplains can reduce flood risk and simultaneously improve water quality, recharge groundwater, support fish and wildlife and provide livelihood and recreational benefits.

Box 2. The living planet index (LPI)

The global LPI is based on scientific data from 14,152 monitored populations of 3,706 vertebrate species (mammals, birds, fishes, amphibians and reptiles) from around the world.

-38% terrestrial species

The **terrestrial** LPI shows that populations declined by 38 per cent overall between 1970 and 2012.

-81% freshwater species

The **freshwater** LPI shows that on average the abundance of populations monitored in the freshwater system declined by 81 per cent between 1970 and 2012.

-36% marine species

The **marine** LPI shows an overall decline of 36 per cent of populations monitored between 1970 and 2012.

https://www.footprintnetwork.org/living-planet-report/

Lessons on how to work with multiple stakeholder groups and across sectors can be learned from integrated water resources management (IWRM), which adopts a water catchment approach, recognizing the important role of the environment in moderating water resources in the catchment and the significant impact and interest of the stakeholders living and working in it.

There are three main ways in which nature-based solutions can be harnessed by water managers (figure 1):

- Protection
- Restoration
- Extension

Figure 1. Applying NBS through protection, restoration or creation of ecosystem services. (IUCN, 2016)

Using and protecting natural ecosystems.

Existing ecosystem services moderating water in a catchment are identified, quantified, utilized and protected to the extent possible

Restoring ecosystems.

Degraded ecosystems are rehabilitated to restore or enhance ecosystem services.

Creating new ecosystems.

Nature-based solutions are used to reproduce ecosystem services where there are cost-effective benefits for sustainable water resources management.

Nature-based solutions complement 'grey infrastructure'.[1] Each has a role to play in achieving sustainable management of water resources, although regulatory requirements are usually more oriented to grey rather than green solutions. Traditional engineering is still necessary for services, such as the delivery of water to households, seasonal water storage and so on, where there is no ecosystem equivalent. Nature-based solutions may not deliver services at the same predictable rate as built-for-purpose infrastructure, such as reservoirs, dams, levees and canals, but can complement and potentially enhance the benefits of such infrastructure, thus securing return on investment.

Harnessing nature-based solutions can play a major role in combating water-related risks and their detrimental effects, particularly in the face of climate change that will exacerbate existing pressures. Infrastructure portfolios combining built infrastructure and nature-based solutions can provide sustainable water management solutions.

This primer is designed to raise awareness of the multiple benefits of nature-based solutions (section 2).

It provides examples of the nature-based solutions most useful to water resources managers (section 3); and adopts the view that:

- the first point of resilience to climate change is a well-functioning ecosystem (section 4);
- scaling up knowledge and action on nature-based solutions at the local level is most effective through basin water management structures that adopt an integrated approach (section 5);
- protecting or restoring environment services in a water catchment reduces or delays the need for future investment in expensive infrastructure in the future; and
- water management problems can often be addressed more cost-effectively and sustainably by developing nature-based solutions alone or alongside conventional infrastructural solutions.

1. Conventional built water infrastructure such as water treatment plants, flood barriers, etc.

2

NATURE-BASED SOLUTIONS: AN OVERVIEW OF BENEFITS FOR WATER MANAGEMENT AND THE WIDER COMMUNITY

Flood plains accept large volumes of water during floods, and provide habitat for a variety of species.

2.1 BENEFITS FOR WATER MANAGEMENT

Ecosystems manage water supply. Wind, rain and temperature are all moderated by the amount and type of vegetation cover. Vegetation reduces the impact of rainfall on soil and therefore erosion. It also slows run-off, while the open structure of healthy soils facilitates the infiltration of water into the ground.

Box 3. Water supply regulation

Nature-based solutions can help to:

- Sustain (clean) water supplies by increasing the water infiltration and storage capacity of wetlands/soils and the recharge of aquifers.
- Mitigate drought by releasing water from natural storage features, including soil and groundwater, surface water and aquifers.
- Prolong the life of reservoirs by reducing siltation.

At high rainfall intensities, a proportion of the rainfall flows directly off the land into the watercourse and some penetrates the soil, where it may be taken up by plants. A portion moves in the soil towards rivers and streams and another fraction penetrates deeper into the ground, replenishing groundwater. Steady release of water stored underground and in wetlands serves to maintain river flows long after rainfall events. These ecosystem services regulate the impacts of rainfall events and directly moderate the supply of water in the basin (box 3).

Ecosystems moderate water quality. In conjunction with these water flows, the condition of the water in the system may vary dramatically. In a high rainfall event where a catchment has degraded land, the run-off water may have very high turbidity from eroded soils and pollutants washed off the land. This results in siltation of water storage systems and increased costs to water treatment systems. Water that penetrates the ground or is held on floodplains and wetlands allows much of the silt and pollution to be deposited or removed. Water passing through the soil or wetlands is cleaned by physical and biological processes and requires less treatment to reach potable quality. The quality of the catchment therefore affects water quality (box 4).

Box 4. Water quality regulation

Nature-based solutions can help to:

- Treat polluted water from point and non-point sources by trapping and/or containing sediments, pollutants in sediments, soils and vegetation (filtration and chemical conversion).
- Protect groundwater from contamination by removing sediments, heavy metals and other pollutants.
- Relieve pressure on existing water treatment infrastructure through bioretention and infiltration.
- Improve the quality of wastewater, e.g. using constructed wetlands alone or in conjunction with conventional wastewater treatment plants.

Forest rehabilitation activities in Kalimantan, Indonesia.

Ecosystems moderate extreme climate events. Ecosystems reduce the impact of high rainfall events by slowing water run-off and facilitating infiltration into the ground. Flash flooding, landslides and mudflows are often associated with deforestation and land degradation. Floodplains and wetlands along rivers accommodate high water flows, reducing impacts downstream, while groundwater, replenished from infiltration, provides a buffer in times of drought. Floods and droughts may still occur, but a functioning ecosystem is the first line of defence (box 5).

Box 5. Extreme climate events

Nature-based solutions can help to:

- Increase water storage capacity in watershed and urban areas and thus reduce downstream flooding.
- Reduce the flow velocity of flood waters.
- Reduce crop vulnerability to drought.
- Reduce drought impacts by maximizing groundwater storage.

Some specific ecosystems that provide water services are shown in table 1. Nature-based solutions for water management may require the restoration of these ecosystems or the establishment of similarly functioning ecosystems services in new areas. Table 2 gives examples of some constructed nature-based solutions for specific purposes.

Table 1. Ecosystems suitable for restoration as an NBS (adapted from UNEP, 2014).

	Effect on water services			
Ecosystem	**Water supply**	**Moderate extreme events**	**Erosion control**	**Water purification**
Forest and vegetated land				
Soils				
Riparian buffers				
Wetlands				
Floodplains				
Mangroves, marshes, dunes				

Table 2. Some built NBS for specific situations and water services (adapted from UNEP, 2014).

	Water services			
Nature-based solution	**Water supply**	**Moderate extreme events**	**Erosion control**	**Water purification**
Flood bypass				
Green spaces (bioretention and infiltration)				
Permeable pavements				
Farming practices (contour ridging, crop rotation, low till, grazing pressure, etc.)				
Green roofs				

The cell colors indicate level of contribution to water service (white - insignificant contribution, dark - significant contribution).

Nature-based solutions can achieve these benefits and may be more cost-effective and predictable than conventional infrastructure. Nature-based solutions are, however, very site-specific and must take into account the conditions in each location.

2.2 CO-BENEFITS

Nature is far too complex to describe in detail here and, while ecosystems are the underlying structures for the management of water resources, they also enable the continuous functioning of the environment, supporting life as we know it. Two lessons can be drawn from this:

1. **Action to maintain environmental functions in a catchment should be a central pillar of water resources management.** Degradation of the environment in a catchment impacts the water services described above. This will inevitably result in a need for increased investment in water resources infrastructure to address issues such as flooding and poor quality or quantity of source water. Water resources management therefore benefits from engagement with all stakeholders in the river basin in order to influence decisions that affect the environment.

2. Prioritizing nature-based solutions over or alongside grey infrastructure solutions not only benefits water management but has many economic, social and environmental benefits in the catchment. Addressing water resources management issues by using such solutions has the added benefit that they are likely to be supported by other stakeholders because of their positive impacts on the catchment environment and human well-being.

Box 6. Nature-based solutions and the 2030 Agenda

Nature-based solutions are additional tools water managers can use to improve potable water supply, storage and availability in the catchment, reduce water pollution and adapt to climate change.

Nature-based solutions have far-reaching co-benefits (see section 2), contributing to food security, healthy lives, the economy, sustainable use of terrestrial ecosystems and disaster risk reduction.

The broad contribution of nature-based solutions to all the Sustainable Development Goals strengthens the need for intersectoral implementation to ensure maximum impact.

Nature-based solutions for water resources management rarely have only one benefit. For example, unlike a water treatment works for drinking water, which may have a single output of treated water, a wetland may produce clean water, regulate water flow, reuse nutrients to support a diverse plant and animal ecosystem and provide a social amenity. A forest may stabilize land, reduce siltation of dams, clarify water, protect against moderate flood events and provide livelihoods and recreation. It is these multiple benefits that make nature-based solutions attractive as the first line of action, particularly when viewed in the context of the SDGs (box 6). It is important to note, however, that, like grey infrastructure, a nature-based solution has its own limited capacity. For example, a wetland can only treat so much wastewater before it becomes overloaded.

Attending to the good functioning of ecosystem services for the benefit of water management goes hand-in-hand with decisions on investment in other infrastructure, such as reservoirs, water treatment works, wastewater treatment works, flood defences, etc. Nature-based solutions should be considered for the additional benefits they provide:

- They may prolong the life of existing infrastructure (dams, water treatment works).
- They may prove a cheaper and more sustainable option than conventional infrastructure (e.g. constructed wetland for wastewater treatment).
- They can help build climate change resilience in water management.
- They can help to reduce conflict between communities (box 7).

The many social, economic and environmental benefits of increased attention to protecting and enhancing environmental services through a nature-based approach are illustrated by the three main ways in which water managers can harness nature-based solutions (see figure 1):

- **Protection:** Protecting key ecosystems from degradation has obvious benefits for the environment and biodiversity but can also contribute to improved livelihoods (farming, fishing, tourism), social amenities (biofuel, recreation), and well-being.
- **Restoration:** Restoring full ecosystem function to degraded environments can enhance livelihood opportunities, improve resilience to extreme climate events and provide a social amenity.
- **Extension:** Creating new or enhanced ecosystem services for specific water-related services can result in new livelihood (forestry, agriculture, fisheries) and recreational opportunities, increased biodiversity and enhanced protection from extreme climate events.

Box 7. Multi-stakeholder solutions, Guatemala

The overexploitation and pollution of the water resources of the San Jeronimo River, together with agricultural development and massive deforestation, generated conflict between neighbouring communities.

A Basin Committee of the main water users (agricultural irrigation, aquaculture, hydroelectric use, human consumption and tourism) was formed to address the problems.

Extensive benefits resulted, including:

- Pollution from solid waste and other waste reduced.
- Sustainable forestry.
- Expanded fisheries output.
- Many jobs created.
- Water fund established.

GWP Toolbox #321.

https://www.gwp.org/en/learn/KNOWLEDGE_RESOURCES/Case_Studies/Americas--Caribbean/Guatemala-IWRM-successful-experiences-San-Jeronimo-Basin-Baja-Verapaz-321/

A 63-acre wetland restoration project on a farm in the Choptank River watershed in Caroline County, Md.

3

TYPES OF NATURE-BASED SOLUTIONS FOR WATER MANAGEMENT

The examples of nature-based solutions described here influence different aspects of water resources in a water basin but there are many others that may be implemented at different scales to respond to the specific climate, geographic and cultural characteristics of a location.

3.1 RECONNECTING RIVERS TO FLOODPLAINS

Reconnecting rivers to floodplains	
Water management benefits	Co-benefits
▪ Water supply regulation ▪ Flood mitigation ▪ Water purification ▪ Erosion reduction	▪ Biodiversity ▪ Recreation ▪ Nutrient replenishment ▪ Livelihood opportunities ▪ Resilience to extreme climate events ▪ Educational opportunities

Floodplains are areas of low-lying land alongside rivers that have developed over time to receive water that overflows the river course, slowing the flow and thus **reducing flood risk**. Nutrient-rich sediment settles as the flow slows down on the floodplain, which slowly releases cleaner water back into the river system, reducing treatment costs downstream and **maintaining river flow**. Floodplains provide fertile agricultural land, support fisheries and are sites of high biodiversity with diverse habitats, from wetlands to forests.

Canalizing rivers or building levees to protect built infrastructure is a common practice that disconnects rivers from floodplains. The resulting faster flow has impacts downstream. Efforts to reduce flood risk from inland waters include reopening river access to at least part of the floodplain, identifying low-impact areas to be flooded first and protecting high-impact areas (box 8).

The river itself is an important ecosystem that may be significantly affected by management interventions. Flooding, with the transport of sediments, is an important part of the ecosystem of some rivers as the nutrients they bring support fish and other wildlife. As water flows downriver, it acts in a similar way to a wetland: sediments settle or are filtered out and flora and fauna benefit from the nutrients, gradually improving the water quality.

Box 8. Room for the River, Netherlands - opening of the floodplain at Noordwaard

The Noordwaard is an area that borders the Nieuwe Merwede river. In just five years, the polder (low-lying land) has been redesigned and transformed from an area protected by dykes to an area open to high water. Eliminating the polder increased the safety of the downstream area because the river water can now flow in and out of the Noordwaard during high water. The remaining houses at Noordwaard and their foundations had to be able to withstand flooding that could occur once every 25 years. Some homes therefore had to be rebuilt on mounds to prevent flooding.

www.ruimtevoorderivier.nl

3.2 FORESTS

Forest conservation/Reforestation	
Water management benefits	Co-benefits
▪ Water supply regulation ▪ Riverine flood mitigation ▪ Water purification ▪ Erosion reduction (reduced risk of landslides mudflows, etc.)	▪ Biodiversity ▪ Recreation and tourism ▪ Carbon sequestration ▪ Local climate regulation ▪ Livelihood opportunities

Trees (and other vegetation in the catchment), intercept rainfall and increase infiltration, thus moderating both run-off into the river system and storage of water in the soil. The ability of soils in forest areas to store water and release it through seepage, transpiration and evaporation helps to **regulate the water supply** in the catchment. However, plantations or the invasive spread of non-indigenous species may reduce total local annual run-off and groundwater recharge due to increased water loss through transpiration (box 9).

Box 9. Working for Water, South Africa.

In 1995, the Department of Water Affairs established the intersectoral Working for Water programme to destroy invasive alien plants that were drying up streams and using large amounts of water. It has been implemented across the country and involved thousands of local communities. Communities are now being involved by landowners and farmers, as well as by government. There have been measurable increases in streamflow, while benefits to communities include training, employment and livelihoods from the use of 'waste' wood.

http://www.watershedconnect.com

http://www.dwaf.gov.za/wfw/

Establishing or conserving forests (and promoting other sustainable land use activities in the watershed) can help to **improve water quality.** Forests improve water quality by reducing sediment in water bodies and trapping or filtering other water pollutants. A third of the world's hundred largest cities rely on protected forest areas for their source of drinking water. In fact, well-managed forests often provide clean water at costs lower than those of treatment plants (TEEB, 2009). In some places this has the additional benefit of reducing reservoir siltation and prolonging the life of infrastructure.

Forests and areas with good vegetation cover can moderate extreme events by reducing the likelihood or frequency of floods, landslides, mudflows and avalanches, which can cause extensive damage to infrastructure and inhabited areas.

3.3 SOILS AND VEGETATED LAND

Soils and vegetated land	
Water management benefits	Co-benefits
▪ Improved soil structure and stability ▪ Increased drainage and water-holding capacity Reduced rainfall run-off ▪ Reduced pollution of surface waters	▪ Increased crop production ▪ Resilience to extreme climate events ▪ Climate change mitigation

Maintaining good soil structure and vegetation cover has benefits for farming on every scale, from large scale irrigation to rain-fed smallholder systems. Causes of soil degradation include deforestation, extensive cultivation on marginal land and improper cultivation practices such as monocropping, poor manuring, misuse of fertilizers, excessive irrigation, overgrazing and water erosion. As agriculture uses about 70 per cent of global water withdrawals and a large proportion of surface water pollution originates from agriculture, the potential benefits of improved water management in agriculture are enormous.

Low or zero-till systems, mulching, crop rotation and maintenance of vegetation cover (conservation agriculture) all contribute to good soil structure, improve water retention and drainage and reduce erosion and pollution of surface waters. Along with other structural and management interventions, these measures can help improve agricultural productivity, while also improving resilience to drought and flooding.

3.4 RIPARIAN BUFFERS

Riparian buffers	
Water management benefits	Co-benefits
▪ Riverine flood mitigation ▪ Water purification ▪ Erosion reduction (bank stabilization) ▪ Water temperature control	▪ Biodiversity ▪ Recreation

Use of riparian buffers to maintain **water quality in streams and rivers** is a forest and conservation management best practice in many countries and is mandatory in some areas. Riparian buffers are vegetated, often forested, areas ("strips") next to streams, rivers, lakes and other waterways protecting aquatic environments from the impacts of surrounding land use.

Riparian buffers help to maintain water quality in waterways by protecting streams from non-point source pollution (e.g. surrounding agricultural activities). Riparian vegetation cover provides a barrier between sediments, and pollutants such as nitrates and phosphates, washed from the land and water bodies. Temperature moderation from shading creates an important aquatic habitat,

especially for fish and insect life, providing protection from extreme temperatures. During flood events, riparian vegetation slows run-off by absorbing excess water, reducing peak flow and helping to mitigate potential flood damage downstream. Some studies show that riparian buffers can help to reduce the amount of sediment reaching streams by as much as 80 per cent (UNEP, 2014).

3.5 WETLANDS

Wetland restoration/conservation	
Water management benefits	Co-benefits
▪ Water supply regulation ▪ Flood mitigation ▪ Water purification ▪ Water temperature control	▪ Biodiversity ▪ Recreation ▪ Livelihood opportunities ▪ Resilience to extreme climate events ▪ Educational opportunities

The definition of wetlands is very broad but normally refers to shallow vegetated water bodies, swamps and marshes or areas that may periodically be dry, varying in size from a few square metres to many square kilometres. The water regulation services provided by wetlands are often cost-competitive and more sustainable than those provided by conventional infrastructure solutions, at the same time providing a wide range of socioeconomic co-benefits. Wetlands contribute to **water quality** through their natural ability to filter effluents and absorb pollutants. Microorganisms in the sediment and vegetation in the soil help to break down many types of waste, eliminating pathogens and reducing the level of nutrients and pollution in the water. There is a limit to the amount of pollution wetlands can absorb, however. If this tipping-point is reached, their ability to treat pollution may be greatly reduced until they are restored to health, which can be a difficult and lengthy process.

Protecting, restoring or constructing wetlands can help to provide clean water for ecosystems, harvesting biomass, drinking water needs and other uses. The ability of wetlands to store large amounts of water and release it slowly plays a key role in the natural **regulation of water quantity** during periods of drought and flooding. Wetlands also trap sediments and thus reduce their downstream transport.

Wetlands can 'slow' flood waters, **reducing potential flood damage** downstream, and increase resilience to storms, thereby avoiding potential damage to grey infrastructure and human lives. In periods of drought, they can function as 'retention basins', providing water through slow release of stored water. The retention capacity of different types of wetlands varies and needs to be evaluated individually.

Constructed wetlands are created artificially with the aim of simulating the hydrological processes of natural wetlands (box 10). They function as **biological wastewater treatment** 'technologies', either supplementing or replacing conventional treatment plants. They are often used for nutrient pollution control (and thus reduction of eutrophication risk) of various wastewater streams (domestic wastewater, grey water, urban wastewater from sewerage). Constructed wetlands can also be used to reduce flow velocity, remove nutrients and sediments and mitigate surface run-off from agricultural and livestock fields, as well as in urban areas. Their main water management benefits include reduced downstream pollution, improved water quality and flood and drought regulation.

Box 10. Constructed wetland for treatment of wastewater from a flower farm, Kenya

Commercial agriculture around Lake Naivasha produces some 70 per cent of Kenyan flower exports. Untreated wastewater returned to the lake carries agrochemicals and nutrients and this has led to eutrophication and loss of biodiversity. To address this problem, the Kongoni River rose farm has established a constructed wetland for purification of its wastewater. It incorporates both human-made and natural components that effectively remove sediments, nutrients and pollutants from the agricultural effluent. The 'closed loop' water management system reduces the farm's water demand and prevents otherwise untreated effluent finding its way back to the sensitive lake ecosystem.

3.6 NATURE-BASED SOLUTIONS IN GROWING CITIES

Nature-based solutions in urban centres	
Water management benefits	Co-benefits
▪ Reduced storm water run-off ▪ Improved water quality ▪ Groundwater recharge ▪ Flood protection	▪ Cooling effects ▪ Recreation ▪ Human health and well-being ▪ Urban agriculture ▪ Improved habitats ▪ Educational opportunities

As a result of rapid urbanization in recent decades, much of the world's population is now urban, and the proportion is growing, aggravating the concomitant water supply and water quality challenges. Only an estimated 43 per cent of the world's urban population has access to safely managed sanitation in which excreta are disposed of in situ or transported and treated off-site (www.washdata.org), with obvious water pollution consequences. The SDGs specifically highlight the challenges of achieving safely managed water and sanitation and, while traditional infrastructure solutions are an important part of the solution, nature-based solutions can also contribute on both the water supply side and the wastewater treatment side.

Box 11. Nature-based solutions in urban centres, some examples:

Green roofs; tree planting; bioretention and infiltration; permeable pavements; water harvesting; foresting urban catchments and uplands; allotments; drainage systems with reedbeds; ponds.

Nature-based solutions are increasingly used in urban spaces to enhance the quality of life of the urban population and address water issues (CNT, 2010; box 11). However, a recent study of 4,000 cities found that 80 per cent of them could improve water quality and reduce water treatment costs by working closer to the source with water users in the catchment to improve land and forest management practices (Abell et al., 2017). The study also noted that most cities exert little influence over how water sources are managed, possibly because of lack of jurisdiction, a knowledge gap and lack of appropriate financing mechanisms (see 5.2 on financing nature-based solutions).

Constructed wetlands and retention ponds for the treatment and moderation of storm water and grey water (lightly polluted wastewater) are increasingly found within or close to urban communities. These vary from very small wetlands for small communities to very large wetlands, and in coastal areas could include salt marshes. The high nutrient input can result in productive wetlands with high biodiversity of plant and animal life.

Box 12. Nature-based solutions in towns along the Mekong River

A toolkit has been developed for 'greening' town plans. The aim is to achieve ecological sustainability, climate change resilience, community well-being and safety, and environmental quality and beauty by:

- Creating a fabric of interconnected green corridors and spaces.
- Greening core urban areas.
- Greening industrial and business zones.
- Creating beautiful, healthy and green residential areas.
- Creating green community centres.
- Creating networks of connected urban parks.
- Expanding allotments, smallholdings and orchards.
- Creating sustainable drainage systems.
- Greening and rehabilitating urban catchments and uplands.

(http://icem.com.au/resilience/)

Hong Kong Wetland Park - a conservation, education and tourism facility.

Cities increasingly integrate grey and green infrastructure into their urban planning process. Permeable pavements, turning impermeable surfaces into green spaces, tree planting and storage areas for excess run-off are among the grey/green options for reducing drainage system overflows and flooding and relieving the load on existing flood management infrastructure. An apt description of this is the city acting as a 'sponge', soaking up floodwater and releasing it slowly in times of need. Tangible benefits for the population include bringing nature back into the city, increasing biodiversity, lowering air temperature and providing recreational green spaces.

4

NATURE-BASED SOLUTIONS AND CLIMATE CHANGE

Climate change is manifested through more extreme rainfall events and higher temperatures, which may increase the risk of flooding, drought, landslides, and wildfires, among others. Nature-based solutions have an important role to play in increasing resilience to climate change impacts in both the short and long term.

Varying water availability is a major constraint on development and a focus for water managers seeking ways to ensure continuity of supply to users and protection from flooding. Floods and drought are natural events, flooding being seen as a regular, beneficial occurrence in many river basins worldwide, but climate change increases the risk of extreme flood and drought events and may disrupt previously stable systems.

Changes in land use and disruption of floodplain function also affect flood and drought risk. A drought is likely to start earlier if water storage in the catchment has been compromised by the draining of wetlands, disconnection of floodplains from the river, poor farming practices and/or deforestation.

Much work has been done on flood management because flooding has impacts across society and is not solely a water resources management issue. The Associated Programme on Flood Management defines integrated flood management (IFM) as an approach that "integrates land and water resources development in a river basin, within the context of integrated water resources management, with a view to maximizing the efficient use of floodplains and to minimizing loss of life and property. Integrated flood management, like integrated water resources management, should encourage participation of users, planners and policymakers at all levels. The approach should be open, transparent, inclusive and communicative and requires the decentralization of decision-making with full public consultation and involvement of stakeholders in planning and implementation" (Associated Programme on Flood Management, 2009).

Box 13. Nature-based solutions for flood and drought management

Upper watershed restoration; soil conservation measures; wetland restoration; infiltration measures; rainwater harvesting; detention basins; natural drainage path restoration; riparian vegetation restoration; removal of barriers; green roofs; coastal and reef restoration.

(WWF International, 2016)

Unlike floods, which are generally sudden and short-lived, droughts usually build up slowly and last a considerable time. Drought does not only occur in dry areas but also in areas not normally considered water-scarce. Not surprisingly, proactive nature-based solutions for drought are similar to many of those already mentioned for water availability, such as water retention in land (e.g. conservation agriculture, groundwater recharge, sand dams, water harvesting structures). Improved water resources management – preventing overexploitation of groundwater, for example – can also contribute to drought preparedness. Nature-based solutions may be more accessible to vulnerable populations and may also provide more flexibility than conventional infrastructure when dealing with smaller scale interventions and the uncertainty that accompanies climate change impacts. Implementing community (and larger scale) nature-based projects may also provide more opportunities to increase the participation and ownership of women and other vulnerable groups in climate resilience-building and decision-making for better water management.

Even where it is uncertain whether a wetter or a drier climate is likely, well-functioning ecosystem services provide a good starting point for increasing the resilience of water resources to climate change. As described throughout this primer, an environmentally intact catchment can alleviate flood impacts (especially in smaller catchments (WWAP, 2018)), help to moderate the flow of water through it and ensure the replenishment of groundwater. This does not mean that there will be no floods or droughts, but that their impact should be reduced.

5

IMPLEMENTING AND SCALING UP NATURE-BASED SOLUTIONS

THE CHALLENGE

Water catchments can contain a myriad of wild, untouched areas, agricultural areas, settlements, industry, forestry, fisheries, subsistence farming, wetlands, drylands, and coastal zones, and are subject to a plethora of different regulations, owners and organizations. The water resources management system operates within this complex situation, withdrawing and treating water, distributing it to users, managing wastewater and discharging it into the environment. Water services agencies are sometimes completely separate from the water resources authority, further complicating the water resources management system. Cutting across this institutional complexity, nature-based solutions typically have benefits for multiple stakeholders, as discussed in section 2. These benefits can only be realized, however, if there is full engagement with stakeholders to plan, finance and implement nature-based solutions.

While there are examples of nature-based solutions around the world, they are often project-based, with external funding and intensive external assistance. This section offers some practical suggestions for water managers to help them mainstream these solutions into their regular planning and implementation cycles.

5.1 GETTING STARTED WITH SCALING UP NATURE-BASED SOLUTIONS

Tapping into existing integrated approaches

Tackling the complexity of ownership, authority and interests in a watershed and maximizing the positive outcomes of any intervention involves seeking entry points for cooperative decision-making and action. To promote the adoption of nature-based solutions, it is easier to start with existing cooperation structures than try to make new ones.

The need for an integrated, intersectoral, approach to water resources management is well-documented and has resulted in reforms to legal and institutional structures in most countries:

- 60 per cent of countries already have water resources policies based on integrated approaches at national and subnational levels that are used to guide work,
- 81 per cent of countries have national integrated water resources management plans that are implemented by most relevant authorities, and
- 42 per cent of countries have basin or aquifer management plans that are implemented in most basins/aquifers (UN Environment, 2018).

This means that in many countries the enabling environment is likely to be suitable for the development of policy on nature-based solutions. Furthermore, all countries are working towards full implementation of integrated water resources management by 2030 to achieve SDG Target 6.5, so it is expected that the above percentages will increase in the coming years. While nature-based solutions can be initiated at any level and by any agency to address perceived challenges, commitment at the highest policymaking level is desirable for the purposes of scaling them up. National legislation and policy that supports the implementation of nature-based solutions at the local level have proved critical in many countries (WWAP, 2018).

The integrated water resources management approach recognizes the need to engage fully with relevant sectors and stakeholders at all levels to the extent that they are often represented in the decision-making structures of the water resources authority. There are examples in many countries of transboundary river basin organizations, national water authorities, and catchment and sub-catchment organizations that include sectoral representatives able to provide the cross-sector perspective needed to implement nature-based solutions (box 14). For example, 77 per cent of countries have basin/aquifer-level organizations with the mandate and capacity to lead integrated water resources management plan implementation (UN Environment, 2018). Nature-based solutions should be embraced as a key element of the integrated approach, being of clear relevance and benefit to a broad section of water stakeholders, not least water managers.

Box 14. Stakeholder participation in Kenya

In Kenya, local-level stakeholders have taken responsibility for action. Water resources users' associations at sub-catchment level develop and plan improvements in water resources management in their area of jurisdiction, identifying investments and overseeing the regulation of water abstraction. In 2012, 56 water resources users' associations were in place and had developed sub-catchment management plans, half of which were in process of implementation with funding from different sources (Knoop et al., 2012).

Water professionals may not have the expertise to work with multiple stakeholder groups and sectors and require the support of social scientists and facilitators to assist the process. This includes a special focus on ensuring the inclusion of women and other vulnerable groups in the decision-making process and project implementation, and establishing their ownership of and involvement in water resources management on a broader scale.

Assessing the potential for including nature-based solutions in catchment management

Non-structural conditions, such as laws, regulations, codes of practice and behavioural changes, all have a role to play and should be a first step towards addressing concerns about ecosystem/catchment conditions. For example, assigning protected status to a wetland or promoting 'approved' farming practices to reduce erosion and soil degradation may both have the desired effect of preventing the degradation of important ecosystem services.

Costing implementation and maintenance and valuing outcomes is not as straightforward for nature-based solutions as for conventional infrastructure because each solution is site-specific and benefits are less easily measured. Tools are available for assigning a value to the benefits of nature-based solutions and more are being developed – e.g. the Ecosystem Services Identification & Inventory Tool (the ESII Tool), helps businesses, public authorities, and other stakeholders to understand the benefits that nature provides and incorporate the value of nature into decision-making (see ESII Tool in Further Reading section). There are also examples of valuing the benefits of various nature-based solutions in the urban environment (see, for example, CNT, 2010). However, depending on the level of capacity and expertise in the water management authority, it may still be necessary to engage expert assistance to determine priorities for action when assessing the full range of conventional infrastructure options and nature-based solutions.

Box 15. Portland Water District, USA

Deteriorating water quality in the catchment will soon require the Portland Water District to install a membrane filtration plant in its water treatment system. The World Resources Institute estimates that it would save US$12 million - and possibly as much as US$110 million - over the next 20 years if it invested in nature-based alternatives to a membrane filtration plant, including conservation easements, afforestation, culvert upgrades, riparian buffers and forest certification (Talberth et al., 2013).

A sound knowledge of the water catchment is an essential starting point for identifying opportunities for nature-based solutions in a catchment and there are tools available for this – e.g. the Green Guide (WWF International, 2016) has tools for assessing a catchment and selecting structural and non-structural methods for flood-risk management, which may be adaptable for other uses.

Nature-based solutions are relevant to water users and water managers at all levels because the scale of action can vary from the very small to the very large. These solutions generally require a multi-stakeholder approach and can therefore benefit from the integrated approach of integrated water resources management.

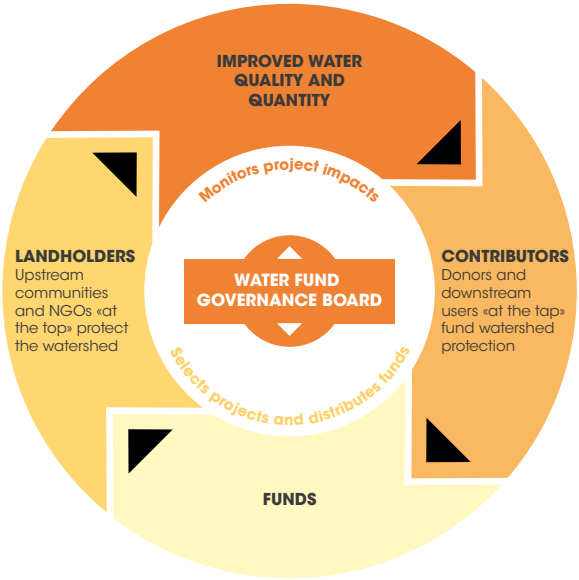
5.2 FINANCING NATURE-BASED SOLUTIONS

Financing nature-based solutions is more challenging than financing conventional infrastructure (Krchnak et al., 2011). Nature-based solutions provide opportunities to work closely with local communities and authorities but involve the corresponding challenge of motivating change, e.g. working with local people to change and adjust land management practices.

Nature-based solutions are often implemented without additional financial inputs, particularly where they involve behavioural change or can be incorporated in the ordinary budget. In urban areas, if they do not involve large infrastructure commitments, they are often implemented under existing budgets and may involve private sector support and investment. Widely used financing systems for such solutions include payments for ecosystem services (PES) and schemes that subsidize communities in a catchment to ensure water services (e.g. through reduced pollution and turbidity). This helps communities understand the value of ecosystem services, while beneficiaries downstream (a city, water utility or hydropower plant) pay for the service. Similarly, landholders may be paid by water utility companies, cities or business interests for stewardship of large landscapes such as forests. These tend to be simple transactions since protection and management costs can be passed on to consumers through utility bills, for example.

The limited data available suggest that investment in nature-based solution is still only a fraction (less than 1 per cent) of total investment in water resources management (WWAP, 2018). Greater recognition of their role and benefits would help to channel a larger share of current water investment funding to them. Accepting nature-based solutions as a viable option alongside grey infrastructure, investigating the benefits and costs of protecting, restoring or creating environmental services, can lead to more cost-effective and sustainable solutions for water management.

Figure 2. The major elements and flows of a water fund (Abell et al., 2017)



Nature-based solutions may broaden financing sources as they are more likely to be suitable for payments for ecosystem services schemes or business investment and financing across several sectors, but appropriate mechanisms are needed to manage the related projects, which are likely to have multiple stakeholders and sources of funding. Water funds (figure 2) are one mechanism based on payment for ecosystem services that work by bridging institutional, jurisdictional, financing and implementation gaps. In addition to channelling money, the water fund is a governance mechanism providing the framework for cooperation between the various interest groups. Management of the fund by a multi-stakeholder structure builds trust and can strengthen the integrated management of water described in section 5.1. (For further details and experience drawn from many water funds, see Abell et al., 2017).

Strategies for investing in nature-based solutions can readily be incorporated into broader infrastructure packages as complementary solutions, as outlined below (adapted from Krchnak et al., 2011):

- **Strategic river basin investment** – a common vision for economic development and environmental sustainability arrived at through consensus-building among diverse stakeholders (cities, farmers and irrigators, industry, water managers, regulators, etc.) and integrated planning can provide the basis for strategic investments in nature-based solutions using a range of different financial instruments and approaches.
- **Public-private partnerships for payment for ecosystem services** – to promote the conservation of upstream areas, and thus ultimately entire watersheds, through compensation for ecosystem-friendly land use practices. Environmental service fees have been established in several places around the globe, particularly in Latin America.
- **Sustainable dam management to help meet water, energy and food demand** – based on designing and regulating new and existing infrastructure projects to incorporate overall system health and solutions that meet society's long-term social, environmental and economic needs.
- **Certifiable standards for watershed stewardship** – to encourage widespread adoption of and investment in sustainable water management practices by companies and utilities globally. Existing private sector standards and market safeguards may not adequately take into account water resources, and this can lead to negative impacts on ecosystems and local communities.

Such broader investment packages that include nature-based solutions may also provide entry points to tackling a wider range of policy objectives (such as the 2030 Agenda or the Aichi Biodiversity Targets) than those that focus only on engineered single-outcome approaches.

Appropriate investment mechanisms are needed that deliver financing for appropriate ecosystem management and support the empowerment and capacity-building needed for implementation. Investment in nature-based solutions may then be best made through approaches that link planning, decision-making and implementation. Critical ingredients include: capacity-building and governance that empower stakeholders to negotiate trade-offs; monitoring the performance of the investment to help tailor approaches and learn and adapt; and developing opportunities for reinvestment. As approaches to financing nature-based solutions are refined, more evidence will be gathered to promote investment in nature-based solutions for water management.

5.3 STRENGTHENING THE KNOWLEDGE BASE TO PROMOTE SUPPORT FOR NATURE-BASED SOLUTIONS

Much is known about nature-based solutions and the benefits of applying them to water resources management (WWAP, 2018) but, if action is to be scaled up, that knowledge must be consolidated and repackaged to meet the needs of the diverse target audience:

- Senior levels of water management need to buy into the concepts of nature-based solutions, whether at catchment, national, regional, or transboundary level. This can in part be achieved by highlighting the consistency of the approach with many 2030 Agenda goals, but also requires the development of appropriate guidance materials.
- Technical and operational tools require further development to respond to different situations and target groups for capacity-building and planning.
- The collection of nature-based solutions case studies should continue so that a comprehensive database can be developed on the degree of success in meeting objectives.
- The relevant professional training institutions should include in their curricula training on the benefits and application of nature-based solutions to ensure that water practitioners are aware of those benefits from the outset.

6

CONCLUSION

Nature-based solutions provide tools for achieving efficient, productive and sustainable use of water resources. They also provide multiple benefits to water resources management and society and can contribute to the achievement of many of the SDGs. There is ample evidence of their cost-effectiveness, and yet they remain underrepresented in development planning and water resources management planning and development. This is mainly due to lack of awareness of the solutions themselves, their benefits and how to plan and implement them.

Emphasizing nature-based solutions strengthens commitment to sustainable development and provides front-line resilience to climate change and extreme climate events, while restoring degraded ecosystems can improve biodiversity and livelihoods.

Nature-based solutions have many benefits that go beyond water management, and their implementation can be facilitated by sectors other than water, although they usually need multi-stakeholder participation such as that envisaged in integrated water resources management. Local budgets have often been sufficient to carry such solutions forward and new financing systems have emerged. In some countries, nature-based solutions are already embedded in certain fields, such as coastal management but, if they are to realize their full potential, they need to be embedded in national and subnational planning systems, not only for water, but also for land, infrastructure and other sectors.

Promoting nature-based solutions will lead to their gradual adoption but the process can be accelerated by identifying suitable entry points where there are already experienced multi-stakeholder platforms. Such platforms have been established for water resources management in many countries at national and subnational levels in the context of implementing integrated water resources management.

Scaled-up implementation of nature-based solutions can be supported by improved and targeted planning, and monitoring and evaluation tools, which can also contribute to the necessary capacity development. Finally, the relevance of nature-based solutions to water, food and livelihoods clearly demonstrates the important contribution they can make to achieving the SDGs, if they are given adequate support.

REFERENCES

Abell, R., et al. (2017). Beyond the Source: *The Environmental, Economic and Community Benefits of Source Water Protection.* The Nature Conservancy, Arlington, VA, USA. Available from https://thought-leadership-production.s3.amazonaws.com/2017/08/15/13/08/06/94ed694b-95aa-457d-a9d0-4d8695cfaddc/Beyond_The_Source_Full_Report_FinalV4.pdf

Asian Development Bank (2015). *Nature Based Solutions for Sustainable and Resilient Mekong Towns, Volume 1 of the Resource Kit for Building Resilience and Sustainability in Mekong Towns.* Prepared by the International Centre for Environmental Management (ICEM). Available from https://www.adb.org/publications/nature-based-solutions-building-resilience-towns-cities-gms

Associated Programme for Flood Management (2009). *Integrated Flood Management: Concept Paper.* World Meteorological Organization. Available from http://www.apfm.info/ifm.htm

Center for Neighborhood Technology (2010). *The Value of Green Infrastructure: A Guide to Recognizing its Economic, Environmental and Social Benefits*. Available from https://www.cnt.org/publications/the-value-of-green-infrastructure-a-guide-to-recognizing-its-economic-environmental-and

Knoop, L., F. Sambalino and F. van Steenbergen (2012). *Securing Water and Land in the Tana Basin: A Resource Book for Water Managers and Practitioners*. Wageningen, The Netherlands: 3R Water Secretariat. Available from http://www.bebuffered.com/downloads/FINAL_tana_manual_digital_LQ.pdf

Krchnak, K., D. Mark Smith and Andrew Deutz (2011). "Putting nature in nexus: Investing in natural infrastructure to advance water-energy-food security», in Background Papers for the Stakeholder Engagement Process, Bonn Conference 2011: *The Water, Energy, and Food Security Nexus:* Solutions for the Green Economy, p. 1. IUCN and The Nature Conservancy. Available from https://www.iucn.org/downloads/nexus_report.pdf

Ramsar (2015). Briefing Note 7: State of the World's Wetlands and their Services to People: A Compilation of Recent Analyses. Available from https://www.ramsar.org/sites/default/files/documents/library/cop12_doc23_bn7_sowws_e_0.pdf

Talberth, J. et al. (2013). "Green-Gray Analysis", in *Natural Infrastructure: Investing in Forested Landscapes for Source Water Protection in the United States,* T. Gartner and others, eds. World

Resources Institute. Available from https://www.wri.org/sites/default/files/wri13_report_4c_naturalinfrastructure_v2.pdf

The Economics of Ecosystems and Biodiversity (2009). *TEEB for National and International Policy Makers – Summary: Responding to the Value of Nature*. Available from http://www.teebweb.org/publication/teeb-for-policy-makers-summary-responding-to-the-value-of-nature/

Tockner, K. and J.A. Stanford (2002). Riverine flood plains: Present state and future trends. *Environmental Conservation*. Vol. 29, Issue 3 (September 2002).

UN Environment (2018). Progress on integrated water resources management. Global baseline for SDG 6 Indicator 6.5.1: degree of IWRM implementation. SDG indicator 6.5.1 status report.

United Nations Environment Programme (2014). *Green Infrastructure Guide for Water Management: Ecosystem-based Management Approaches for Water-related Infrastructure Projects*. Available from www.unepdhi.org/-/.../web-unep-dhigroup-green-infrastructure-guide-en-20140814

World Business Council for Sustainable Development (2018). The Natural Infrastructure for Business platform. World Business Council for Sustainable Development, with CH2M. https://www.naturalinfrastructureforbusiness.org

World Water Assessment Programme (2018). *The United Nations World Water Development Report 2018: Nature-based Solutions for Water*. United Nations World Water Assessment Programme. Paris: UNESCO. Available from http://www.unesco.org/new/en/natural-sciences/environment/water/wwap/wwdr/2018-nature-based-solutions/

WWF International (2016). *Natural and Nature-based Flood Management. A Green Guide*. Available from https://www.worldwildlife.org/publications/natural-and-nature-based-flood-management-a-green-guide

FURTHER READING

In addition to the references listed above, the following publications and websites provide a starting point for finding out more about different aspects of implementing nature-based solutions for water management.

Bullock, J. and H. Ding (2018). *A Guide to Selecting Ecosystem Service Models for Decision-making: Lessons from Sub-Saharan Africa*. World Resources Institute (WRI), Centre for Ecology and Hydrology (CEH), and Ecosystem Services for Poverty Alleviation (ESPA). Available from https://www.espa.ac.uk/publications/guide-selecting-ecosystem-service-models-decision-making-lessons-sub-saharan-africa

Ecosystem Services Identification & Inventory Tool (ESII Tool – http://www.esiitool.com) is an app and web interface that explains the benefits that nature provides and helps people to incorporate the value of nature into decision-making.

Monty, F. et al., eds. (2017). Ecosystems Protecting Infrastructure and Communities: *Lessons Learned and Guidelines for Implementation*. Gland, Switzerland: IUCN. x + 108pp. Available from https://www.iucn.org/theme/ecosystem-management/our-work/environment-and-disasters/ecosystems-protecting-infrastructure-and-communities-epic

Ozment, S., K. DiFrancesco and T. Gartner (2015) The role of natural infrastructure in the water, energy and food nexus. Nexus Dialogue Synthesis Papers. Gland, Switzerland: IUCN. Available from http://www.iwa-network.org/wp-content/uploads/2016/06/Natural-Infrastructure-in-the-Nexus_Final-Dialogue-Synthesis-Paper-2015.pdf

The Rockefeller Foundation (2016). Exploring Incentive-based *Solutions for Freshwater Management*. Available from https://www.rockefellerfoundation.org/report/exploring-incentive-based-solutions-freshwater-management/

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