UN environment programme

How nature can help address water-related challenges

Freshwater ecosystems technical brief

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Freshwater ecosystems and the triple planetary crisis

Our freshwater ecosystems provide the necessary resources and services to ensure safe drinking water and sanitation, food security, sustained industrial and energy production, and climate resilience on which the well-being of our economies and communities depend. For example, an estimated 2 billion people rely on rivers for their drinking water,[1] and hydropower remains the largest source of renewable electricity, generating more than all other renewable electricity sources combined in 2020.[2]

Nature in its entirety supports all dimensions of a healthy and happy human existence – including its non-material and non-quantifiable aspects such as physical and spiritual experiences, cultural and spiritual practices and identity building.[3]

Much of the global ecosystem decline has been driven by socioeconomic development, requiring more land and more resources to feed our unsustainable consumption patterns, including the release of greenhouse gases. This is being compounded by the impacts of climate change. Combined, these challenges manifest themselves in the triple planetary crises we are facing today – climate change, nature and biodiversity loss, and pollution.

The latest assessment from the Intergovernmental Panel on Climate Change (IPCC) has established that the extent and magnitude of climate change impacts are larger than estimated previously. Evidence shows that global warming is causing severe and widespread disruption in nature and in society, and is affecting billions of people. Roughly half of the world's population currently experiences severe water shortages at some point during the year – a result of climate change and extreme events such as floods and droughts. The impacts of climate change are set to intensify as the IPCC predicts that global warming is likely to reach 1.5°C between 2030 and 2052, if current trends continue.[4]

The world's ecosystems and biodiversity are declining at an unprecedented rate. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services' (IPBES) global assessment on the state of biodiversity

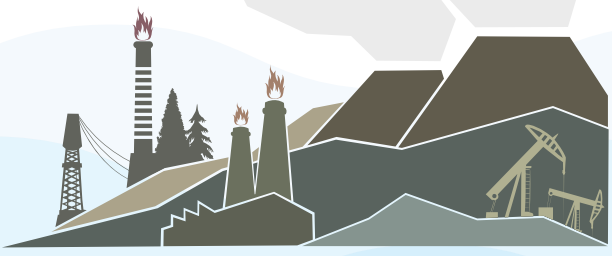
The impacts of climate change are set to intensify as the IPCC predicts that global warming is likely to reach 1.5°C between 2030 and 2052, if current trends continue.

Garbage on the riverbank in Kathmandu. PHOTO: GRIDA

and ecosystem services,[5] reports that more species are threatened with global extinction and that biodiversity is declining at a pace that is tens to hundreds of times higher than ever before in history. One million of the world's estimated 8 million species of plants and animals are threatened with extinction, many within decades.[6] Many species are reaching limits in their ability to adapt to the changing climate – hundreds of local losses of species have already been driven by heat extremes, and mass mortality events have occurred on land and in the ocean. Some losses are already irreversible.[7]

The "toxic trail" of our economic activity and unsustainable consumption patterns is also manifesting itself through increased pollution in air, water and soil. This is leading to an estimated 9 million premature deaths every year. Up to 400 million tons of heavy metals, solvents, toxic sludge and other industrial wastes are dumped annually into the world's waters, and fertilizers entering coastal ecosystems have produced dead zones. Marine plastic pollution has increased tenfold since 1980, with traces of pollution now found in all oceans at all depths.[8] Plastics have accumulated in aquatic environments, and microplastics are also now shown to be found in human bodies.[9] Meanwhile, nearly 1 million people are estimated to die each year as a result of polluted water and lack of appropriate sanitation and hygiene – a large proportion of these children are under the age of 5.[10]

Up to 400 million tons of heavy metals, solvents, toxic sludge and other industrial wastes are dumped annually into the world's waters, and fertilizers entering coastal ecosystems have produced dead zones.



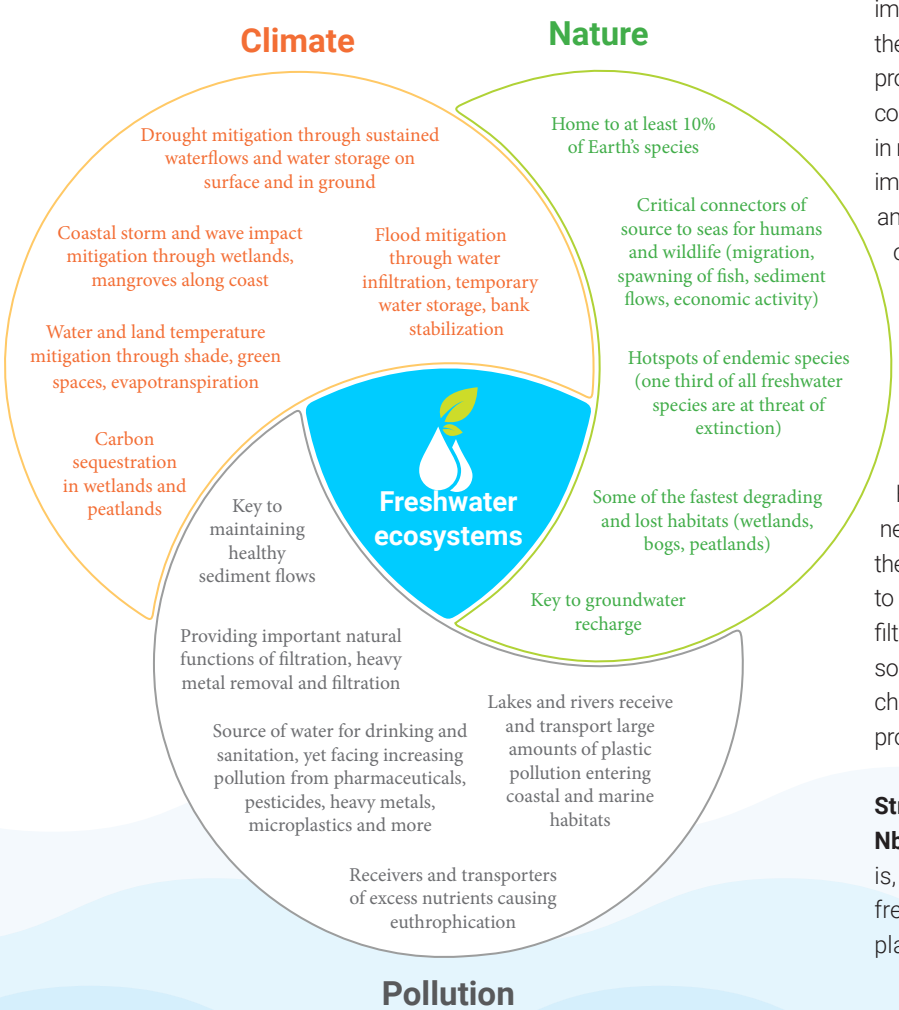
As the world strives to achieve the Sustainable Development Goals,[11] which include action on water, climate, oceans and land, tackling the degradation of nature and ecosystem services is vital. IPBES estimates that the current negative trends will undermine progress towards 80 per cent of the assessed targets of the Goals related to poverty, hunger, health, water, cities, climate, oceans and land.[12] Achieving our ambition on sustainable development thus requires urgent action and a change of course in the ways in which we interact with, and utilize, nature and its benefits.

Above all, this requires protection, restoration and conservation of our freshwater ecosystems so that they can actively help us combat this interlinked planetary crisis.

Freshwater ecosystems harbour key answers

Inland waters and freshwater ecosystems have experienced some of the highest rates of decline. Only 13 per cent of the wetlands present in 1700 remained by 2000 – a decline that has continued since.[13] Biodiversity in freshwater ecosystems is also declining much faster than in our oceans or forests – at the alarming rate of 76 per cent between 1970 and 2016, with freshwater habitats generally in a worse condition than forests, grassland or coastal systems. [14] Key causes of degradation include land-use change, water pollution and over-exploitation, invasive species, and climate change. These negative impacts stretch from source to sea.

Figure 1. What role do freshwater ecosystems play in tackling the triple planetary crisis?



Poor water management, pollution, infrastructure development and unsustainable resource extraction further exacerbate the negative impacts on our freshwater systems, leaving our communities vulnerable not only to a changing climate, but also to food scarcity, health risks and conflict.

Healthy freshwater ecosystems provide key functions that can help address all three of the planetary crises (see figure 1). Yet, research shows that the impacts of the three inter-related planetary crises are acutely, and sometimes disproportionately, felt on freshwater ecosystems.

One of the most acutely felt impacts of the changing climate is the increased frequency and intensity of flood and drought events. These impacts are felt across the globe, bringing about the destruction of crops and infrastructure, proving harmful to human health and life, and compromising food security and fragile peace in many areas. Using freshwater ecosystems to implement nature-based solutions (NbS) for floods and drought risk mitigation has great potential not only to address these immediate concerns, but also to create employment, improve agricultural productivity, create new income opportunities, and create agency for local communities to actively get involved in the sustainable management of their resources.

Healthy freshwater bodies provide the necessary habitats to sustain biodiversity and the related ecosystem services are fundamental to mitigating and regulating pollution through filtration and purification processes in the soils, while also providing resilience to climate change impacts through flow regulation, coastal protection, and water storage functions.

Strategic recognition and application of NbS in freshwater ecosystems and beyond is, therefore, one of the key ways in which freshwater ecosystems can help solve the triple planetary crisis.

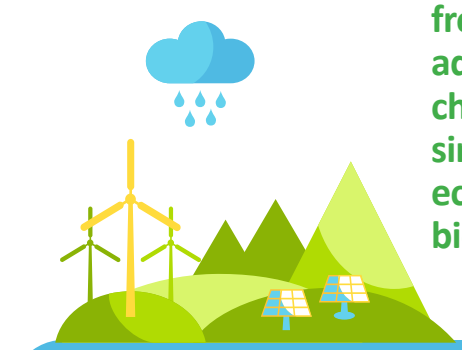
Recognizing the value of NbS at the global level

At the community level, indigenous knowledge has proven fundamental in understanding nature's value for millennia. Solutions that draw upon nature's strengths and positive characteristics have been used widely to support better cropping, soil improvement and stabilization, water storage and flood protection, to name a few. The use of NbS is, therefore, not new, and the potential of ecosystems to provide an active contribution to solving key planetary issues has been known and explored through various related concepts for several decades. Similar approaches have been known for decades in international fora under umbrella terms such as green infrastructure, ecosystem-based adaptation and eco-engineering.

In 2022, UN Member States agreed on a common global definition of NbS (see more in box A - global agreement on definition of NbS): This definition is ensuring necessary recognition of the critical role that nature plays in achieving the Sustainable Development Agenda and tackling climate change. As none of the Sustainable Development Goals can be successfully achieved without healthy ecosystems, the clear link to the other Rio conventions place NbS, though currently under-financed, at the centre of global efforts to strengthen nature, and therefore the efforts towards achieving targets and objectives set out in these global agreements.

At the operational level, the NbS definition provides a shared starting point for NbS implementation. This is important for ensuring that they contribute to all three pillars of sustainable development. The new definition also seeks to address concerns that the concept of NbS can be used for *greenwashing* activities that do not benefit nature and communities as promised.

"Actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems, which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services and resilience, and biodiversity benefits."[15]



Having a universally agreed definition of nature-based solutions is important. When countries and companies claim that their actions are supporting nature-based solutions, we can now begin to assess whether this is accurate and what it entails. This is especially true given the just-released report by the Intergovernmental Panel on Climate Change on the need to scale-up adaptation, for which nature-based solutions will be crucial.

Inger Andersen, Executive Director of UNEP [16]

UNEP supports countries in promoting the management, protection, and restoration of their

A global agreement on the definition of NbS

Despite the wide familiarity with nature-based solutions and their application, there have been challenges, both in upscaling NbS in national and regional level strategies (with appropriate funding), as well as defining and measuring their specific contributions. The wide variety of terms and definitions applied to define what constitutes NbS has also presented challenges in policymaking and potential greenwashing of interventions that do not fully benefit nature and its guardians. A crucial step at a global level has therefore been adoption of a common definition on NbS.

The United Nations Member States formally agreed on a common global definition of nature-based solutions by adopting a resolution on *Nature-based Solutions for Supporting Sustainable Development*. The resolution was adopted at the UN Environment Assembly on 2 March 2022, establishing a multilaterally agreed definition of NbS.

The newly adopted NbS resolution establishes a clear link with the three Rio conventions in the resolution text - the convention on Biological Diversity (CBD), the United Nations Convention to Combat Desertification (UNCCD), and the United Nations Framework Convention on Climate Change (UNFCCC), as well as the 2030 Sustainable Development Agenda, by recognizing the interdependencies between biodiversity loss, pollution, climate change, desertification and land degradation and their interlinkages with human well-being, including health.

A global resolution on NbS is also a timely political signal of the value of ecosystems, as the new set of goals for nature over the next decade are to be decided at the upcoming Convention on Biological Diversity (CBD) COP15, set to take place in December 2022.

freshwater ecosystems,[17] among others by conducting data monitoring and assessment; transforming data into actionable information and decision-making tools; and supporting countries in implementing technology innovations.

Cross-sectoral benefits from NbS involving freshwater ecosystems

UNEP's work with NbS implementation globally has proved that implementing NbS in support of freshwater ecosystems has untapped potential for real livelihood and socioeconomic benefits that can accelerate progress towards the 2030 Agenda, including:

- **Cost savings for critical energy infrastructure operation –** for example, in hydropower plant sediment management, water purification in treatment stations, roadside protection from landslides.
- **The creation of short-term job opportunities in NbS implementation –** for example, jobs created in sustainable tourism and hospitality surrounding restored and protected water bodies, sustainable artisan products made from local materials, short- and medium-term jobs in NbS establishment and maintenance.
- **Smallholder prosperity through expanding access to higher value markets –** for example, through organic and sustainable certification of products to help them command a premium price.
- **Peace and security through reducing risk of conflict, displacement resulting from scarce water resources or water-related disasters –** for example, by increasing preparedness and early warning for droughts and floods, and by implementing sustainable climate resilience measures in local communities.
- **Climate-resilience-building through approaches that actively include and empower women, youth and other vulnerable groups in resource governance and management.**
- **Building sustainable cities of the future through embedding NbS in a forward-looking urban development agenda** – one that recognizes the central values of human health, space for biodiversity, climate resilience and human wellbeing – all via NbS.

An opportunity to redefine our relationship with nature

Making peace with nature is the defining task of the 21st century. It must be the top, top priority for everyone, everywhere.

António Guterres, UN Secretary-General

The UN Secretary-General has called for nations and individuals to reconcile the relationship between humankind and nature as one of the fundamental steps towards addressing the triple planetary crisis. NbS are at the centre of such a transition, allowing us to redefine our view of nature as a most valuable asset which needs to be protected and cherished.

The newly adopted NbS resolution calls on UNEP to support the implementation of NbS in ways that safeguard the rights of communities and indigenous peoples; drawing on their traditional knowledge can help protect nature for common benefits. NbS also offer opportunities to recognize, protect and utilize indigenous knowledge for water management and climate change adaptation in ways that safeguard the rights of these communities and indigenous peoples – local stakeholders can plan, implement and manage many of the interventions. NbS planning and implementation must recognize and uphold the rights of indigenous peoples.

There is huge potential to build a sustainable and climate-resilient future by working *with* nature. In fact, this is the only way to achieve the 2030 Agenda for Sustainable Development, and other commonly agreed objectives.

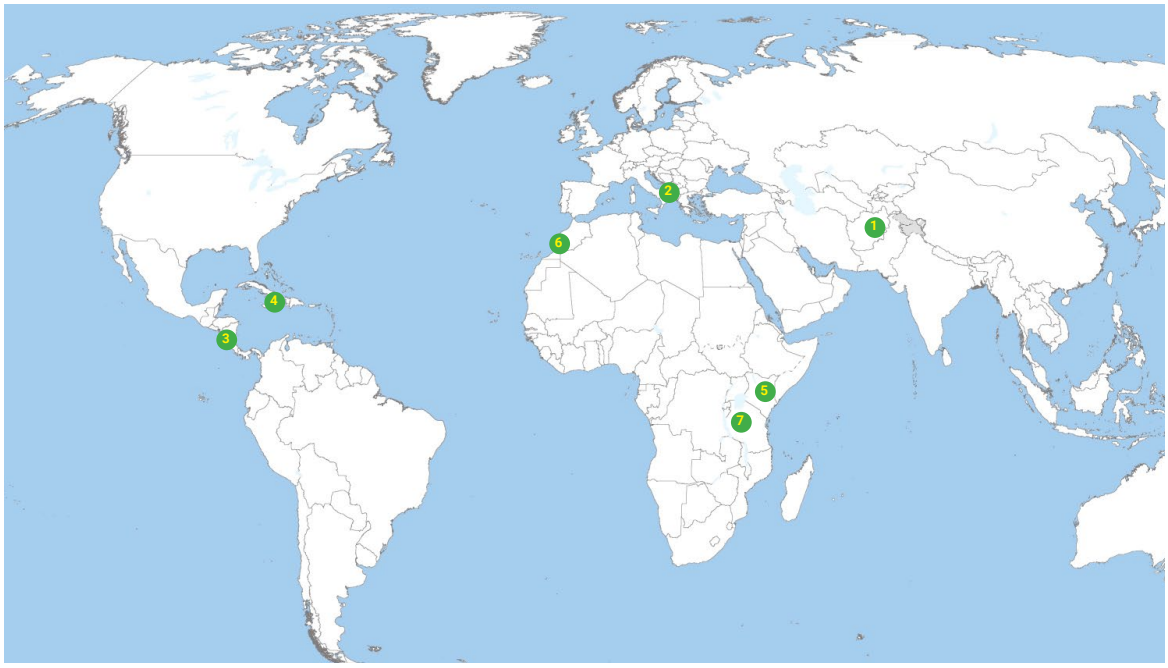
Takeaway messages

- Freshwater ecosystems are declining at an unprecedented rate, but they also harbour critical solutions to all three planetary crises.
- For more than half a century, UNEP has developed and implemented tools and projects that protect, restore and sustainably manage our freshwater ecosystems. Building on this vast experience and toolboxes will be crucial for upscaling NbS within freshwater ecosystems globally.
- Empowering local communities to engage in the design, implementation and sustainable management of freshwater ecosystems – especially in relation to safeguarding indigenous people's rights and custodianship of natural resources – needs to be a central element of NbS implementation everywhere.
- NbS is more than protection and restoration: strategic development and upscaling of NbS action can pave the way for prosperity through job creation, premium market access for smallholders, and the creation of new and more sustainable livelihoods, for example in tourism and hospitality, as well as production of sustainable artisan goods, which are made and sold from local materials.
- NbS alone is not a silver bullet for addressing the triple planetary crisis. Addressing the underlying causes of freshwater ecosystem decline – through strong action on climate change mitigation, unsustainable production and consumption patterns, and inequalities within and among countries – needs to go hand in hand with NbS.

Read more about UNEP's work to support NbS implementation across the globe:

Water and climate action
Water and nature action
Water and pollution action
World Water Quality Alliance
Integrated Water Resources Management
Monitoring water quality
Addressing water-related conflict and disasters

Case studies: NbS in action



1. Afghanistan
2. Albania
3. El Salvador
4. Haiti
5. Kenya
6. Morocco
7. United Republic of Tanzania

1. NbS for climate and environment action: AFGHANISTAN

Ecosystem-based Catchment Restoration in the Pamir Mountains of Afghanistan

Location: Pamir Mountains, Afghanistan
Implementation timeframe: 2019 - 2020
Funding: European Union
NbS: Rangeland restoration, contour bunding, land terracing, gully plugs and check dams, reforestation (woodlots).

Setting

In Afghanistan, communities living in remote mountain regions frequently face risks of floods, landslides, avalanches and droughts. These hazards devastate farmlands and homes, harm livestock and cause human casualties. The ability to respond to these risks has been weakened by decades of political instability and armed conflict which left institutions and infrastructure damaged, and has fostered unsustainable agricultural practices and competition over natural resources.

UNEP and the Aga Khan Foundation partnered with the Government of Afghanistan and local communities to pilot ecosystem-based approaches to address these challenges and build resilience in the Deh-shahr catchment in the northeastern province of Badakhshan, in the Pamir mountains. The catchment is about 60 km^2 with a population of some 3,000 people. The watershed regularly overspilled during floods, depositing debris over prime agricultural land used by communities to live in, farm and raise livestock.

NbS interventions

The project used a mix of NbS and targeted constructed interventions in all parts of the Deh-shahr catchment to build watershed-level resilience. In the upper catchment, a one-hectare rangeland biomass monitoring site was established to demonstrate the regeneration potential of native plant species. In addition, a 150-hectare livestock exclusion zone was designated to rehabilitate rangeland and reduce soil erosion and landslides.

In the middle catchment, three types of contour bunds (placement of lines of stones along the natural rises of a landscape) were used: 740 soil and stone bunds, 58 conservation ditches, and 440 terraces were constructed, and 7,700 tree saplings were planted on the terraces.

740 soil and stone bunds, **58** conservation ditches, and **440** terraces were constructed, and **7,700** tree saplings were planted on the terraces

To reduce pressures of reforestation, woodlots were established on 41 hectares (ha) of rain-fed and irrigated land to provide local communities with dedicated access to fuel and timber. About 46 ha of rain-fed land was also reforested with indigenous walnut, almond and apricot saplings. The aim of these interventions was primarily to slow water run-off, improve groundwater recharge, prevent soil erosion, and create new sources of food and income from the fruit trees. The NbS interventions were supplemented by the construction of gully plugs, woodlots and the rehabilitation of an irrigation channel.

In the lower catchment, 5 ha of land was reforested to buffer debris flow and floods, establishing in the process a recreational riparian zone. This was supplemented by a one-kilometre-long flood protection dike and installation of solar heaters to reduce the community need for reforestation for fuelwood.

The benefits

In the rangeland protection zones, over time, the local community was able to observe the regrowth of native plant species. This provided tangible evidence to the communities of the real impact of uncontrolled grazing, making a strong case for adopting less intensive pasturing and grazing practices to allow the soils and plants to recover. Contour bunds in the middle catchment are helping to reduce the amount of soil erosion and contributing to water availability by improving the penetration of rain, snow, and ice into the soil and to recharge groundwater aquifers. The planted fruit trees are thriving even without irrigation due to the natural water-retaining properties of the bunds themselves, which further makes the case for holistic approaches and the sustainability of these types of NbS.

Land terracing provides similar benefits to the bunds, and is aimed at reducing soil erosion and improving groundwater storage and recharge by storing run-off waters. Because the terraces are generally larger structures and involve the construction of small terrace walls filled with soil, they also provide possibilities for productive crops, forestry and fruit trees.

To mitigate the damaging erosion effects from gullies and associated landslides and avalanches, gabions and check dams were placed at the top of the gullies to slow the downstream flow of water and debris.

Challenges with implementation and lessons learned

Active involvement of local community members in the planning, decision-making, implementation, and maintenance of all project activities has been a critical element of the project and helped to engage local community members to become environmental stewards for the benefit of all residents. As part of the holistic planning approach, the local communities were closely involved in the identification of hazard hotspots and selection of response options, making use of an innovative relief model that visualized the landscape as understood by the community. This allowed for participation of community members across all groups, regardless of literacy or status within the community.

The selected watershed and interventions provided a way of demonstrating the interlinkages between ecosystem services and natural resource management as they occur in the upper, middle, and lower catchment areas – making the case for watershed-level planning of interventions. This was particularly important, as deforestation and rangeland degradation in Deh-shahr's upper catchment was one of the key factors contributing to the soil's ability to absorb water, leading to severe landslides and floods downstream in the lower catchment. The need for holistic planning at the landscape level – bridging environmental issues and interventions across upper-, middle-, and lower-catchment areas – was one of the key lessons learned.

All saplings planted during this project were nurtured by a group of 30 women who were supported by this project to establish greenhouse nurseries. This helped to increase women's participation in environmental planning, implementation and decision-making, giving them an active role in project implementation.

The project also faced some challenges along the way. For example, the villagers were often reluctant to travel to remote project sites, such as the rangeland exclusion zones in the upper catchment as this meant a time-consuming trek, requiring them to forego potential wage-earning opportunities. In some areas, the newly planted seedlings died in the try summer heat, as they lacked timely and sufficient water, necessitating a change of target locations during the project. The time window for project implementation was very short due to the long and harsh winters. Careful planning and scheduling was critical in ensuring that all activities could be completed within the short window.

Scale-up

During the project, the involvement of local communities enabled the formulation of a common vision for better natural resources management in the community, with new activities. For example, following project workshops, the project team and local community members established Farmer Field Schools to impart new land, water and forest management skills to build local capacity for better landscape management, including building knowledge on drought-resistant fodder crops.

Source:
https://wedocs.unep.org/handle/20.500.11822/39982

2. NbS for climate and environment action: ALBANIA

Coastal dune rehabilitation for climate resilience and sustainable livelihoods

Building the Resilience of Kune-Vaini Lagoon through Ecosystem-based Adaptation (EbA) In Albania. PHOTO: UNEP

Location: Kune-Vain lagoon, Albania
Implementation timeframe: 2016 - 2020
Funding: GEF Special Climate Change Fund
NbS: Coastal dune rehabilitation and reforestation

Setting

Albania's coastal communities are highly vulnerable to the impacts of climate change, and the country's 427 km long coastline is a coastal erosion hotspot in Europe. Coastal erosion, accompanied by climate-induced storm surges and rising sea levels, exacerbates flood risks and saltwater intrusion. Freshwater supplies are also affected as a result of decreasing precipitation in the country. These risks are exacerbated by degradation of the coastal lagoon ecosystems, which are under increasing pressure from a growing population and agricultural land expansion into the lagoons. This is also the case with the Kune-Vain Lagoon system in the Lezha region of Albania – one of the most important ecosystems in the country. Covering around 4,000 hectares, it is a biodiversity wonder, home to around 200 bird species, and provides an ecological corridor for migrating birds. It also protects local communities from storm surges by acting as a natural buffer.

NbS interventions

To preserve local ecosystems and livelihoods, the Ministry of Environment of Albania and UNEP undertook an ecosystem-based adaptation project in three sites at the Kune-Vain Lagoon system. Revegetation activities were designed to strengthen the dunes and their ability to withstand erosion. To ensure sustainability of the plants, indigenous tree species that are both flood and salt tolerant were used.

The benefits

Seven hectares of a degraded riparian forest were reforested around the Ceka lagoon, and 2,000m of degraded coastal dunes were reforested within the Kune-Vain protected area. To build local capacity in sustaining and upscaling such interventions, 30 government staff and 250 community members were trained on the implementation and financing of ecosystem-based interventions. Reforestation and revegetation activities were accompanied by construction of a new tidal inlet channel between the Ceka Lagoon and the Adriatic Sea to allow for better exchange of water between the lagoon and the sea – a measure that also improves the water quality of the lagoon.

Challenges with implementation and lessons learned

The project has also informed investigations into potential upscaling to other lagoons in Albania. Several sites have been proposed for intervention replication. It has been noted that important contributors to increased erosion risk and coastal flooding are illegal logging practices, which need to be addressed as part of the long-term sustainability of these projects. While the tidal channel was found to be successful overall, it also demonstrated the need for improved pre-feasibility site planning, which included hydrodynamic modelling. Current observations at the site show that siltation at the mouth of the "tidal cut" constantly requires opening via dredging, and engineering interventions may also be needed to stabilize "walls" at the mouth of the channel. This is particularly relevant for the summer months, when the opening needs to be maintained to avoid the risk of eutrophication.

Scale-up

Replication or upscaling of the intervention in other sites would need to ensure that no down-drift impacts on sediment transport occur. One of the key factors for sustained project success and upscaling was identified to be political will in supporting NbS interventions, both at national and local levels.

Sources:

Up-scaling Ecosystem-Based Adaptation A Strategic Framework for Albania: Final Report

Albania: How a lagoon became a frontline defence against climate change

Project brief: Albania Ecosystem-based Adaptation

3. NbS for climate and environment action: EL SALVADOR

Using nature to fight floods in 'sponge city' San Salvador

In San Salvador, a degraded watershed will be restored with reforestation and conservation agriculture approaches. This will reduce runoff and erosion during heavy rainfall and increase ground water recharge. PHOTO: CITYADAPT

Location: San Salvador, El Salvador
Implementation timeframe: 2017–2022
Funding: GEF
NbS: Urban gardens, riparian revegetation, sustainable land use, absorption wells and rainwater collection

Setting

San Salvador, the capital of El Salvador, is located in the Boquerón Volcano Valley. In addition to the generally hilly terrain, limited drainage on the slopes of the mountains and unplanned settlements, as well as more intense rainfall, have caused numerous, devastating flood and landslide events. During the recent tropical storms ***Amanda*** and ***Cristóbal*** that hit El Salvador in 2020, almost 30,000 families were directly affected, with more than 150 landslides and 20 major floods tearing apart infrastructure. The total rainfall for one week (29 May to 6 June) was more than 800mm in San Salvador and the floods and landslides caused severe casualties and 30 deaths. In recent years, the changing climate has made storms like this more common in El Salvador. Unplanned developments and increases in concrete-covered areas are exacerbating factors that reduce the surface area able to absorb excess rainfall.

NbS interventions

To increase the city's climate resilience, UNEP, together with San Salvador City and its surrounding coffee farms, is working to implement NbS to mitigate flood risks as part of the CityAdapt project. The project implemented a variety of interventions across the city, including working with coffee plantations to restore ecosystems and improve drainage management, with the main goal being to improve the city's ability to absorb excess rainfall. A total of 1,150 hectares of coffee farms and ecosystems were restored, and 62 km of infiltration trenches were created to mimic the drainage that streams provide naturally. It is estimated that each linear kilometre of infiltration trench allows 140m³ of water to infiltrate into the soil, making a significant contribution to increased infiltration capacity, even with about half of the coffee farms taking part in the project.

The benefits

An important NbS element of the project includes riparian forest restoration and revegetation to improve water flow, stabilize slopes and improve connectivity of the green areas in the city. More than 5,000 metres of ravine were restored and more than 4,500 forest and fruit trees planted. In addition to these NbS interventions, the project saw the building of a 19m high storm-water retention pond, with a reservoir capacity of 220,000 m³.

By improving the soil's ability to absorb water, the risk of erosion and landslides was reduced. Importantly, this also reduces the extent to which topsoil is washed away during flooding – an important factor for maintaining the fertility of the coffee plantations. Combined, the NbS interventions are estimated to have reduced the climate vulnerability of 115,000 people in the city of San Salvador.

Scale-up

The project provided an opportunity for joint, watershed-level decision-making, particularly in the process of coffee plantation restoration. This related to the selection of coffee varieties to be planted, the techniques to be applied for creating the infiltration trenches, fruit tree selection, etc. This also created awareness of how individual decisions on farms affect the watershed, and the way in which co-benefits are shared within the entire basin, including metropolitan areas.

Sources:
CityAdapt

CityAdapt Ecosystem-based Adaptation in El Salvador, Mexico and Jamaica

https://cityadapt.com/wp-content/uploads/2020/09/Brochure-City-Adapt-El-Salvador-VF.pdf

https://storymaps.arcgis.com/stories/8e79beedb50042ac802845954c992c2e

https://cityadapt.maps.arcgis.com/apps/Cascade/index.html?appid=18afd2ddea874133881f0c12baa7cfe7

4. Ridge to reef ecosystem-based adaptation: HAITI

Thousands Displaced Due to Flooding in Cap-Haïtien, Haiti. PHOTO:UN

Location: Haiti
Implementation timeframe: 2013-2016
Funding: European Commission
NbS: Reforestation and revegetation along river mouths and the shoreline, sustainable fisheries

Setting

Haiti is extremely vulnerable to the impacts of natural hazards and climate change. It lies on the pathway of tropical storms originating in the Atlantic Ocean, with coastal hazards such as floods, hurricanes, and tropical storms being common occurrences. On average, one hurricane or tropical depression strikes Haiti every two years. The impacts of these events include floods, landslides and resulting disease outbreaks, with climate change likely to make these impacts both more frequent and intense. The effects of even smaller intensity events can be devastating, exacerbated by the fact that many human settlements in Haiti are concentrated along the coastline, in floodplains, and along rivers. Widespread ecosystem degradation from hills to coastlines is also an exacerbating factor. This is because degraded ecosystems lose their capacity to act as natural buffers against hazard impacts. The sedimentation washing out in the coastal areas further inhibits coral, algae and seagrass growth, thereby reducing the productivity of marine ecosystems, which are key to local livelihoods.

In partnership with the National Government, the Municipality of Port Salut, and local partners, UNEP and the European Commission implemented a pilot demonstration project on ecosystem-based disaster risk reduction in Port Sault. The project used a ridge-to-reef approach to demonstrate the effectiveness of NbS in preserving biodiversity, and mitigating the risk of coastal hazards. This project was implemented within the Côte Sud (South Coast) Initiative, a larger programme of UNEP and partner organizations in the coastal zone of southern Haiti.

NbS interventions

The project included three key NbS components 1) revegetation and sustainable vetiver farming to reduce the risk of upland erosion and inland flooding; 2) coastal revegetation to create natural buffers against coastal hazards, such as storm surges and coastal flooding; and 3) sustainable and resilient fisheries to increase local resilience to disasters. In addition, the field activities were used as a basis for capacity-building and advocacy for eco-disaster risk reduction nationally.

The benefits

The project resulted in more than 140 hectares of reforestation in areas exposed to coastal hazards and flooding. These included planting fruit and forestry trees on riverbanks for soil erosion control, as well as planting mangroves and sea grape trees on shorelines and river mouths to mitigate storm surge and flood risk. To support these activities, a tree nursery was established, producing 137,000 seedlings of coastal and riparian species and fruit trees, directly benefiting 200 households.

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In the upland watersheds, sustainable vetiver farms were established on 6.5 hectares to demonstrate effective soil erosion control on hillsides and reduce sedimentation rates downstream, as well as associated siltation and pollution at the coast. Finally, the project also focused on creating sustainable fisheries, while incorporating participatory action planning, shelter creation, boat improvement, and safety training.

Challenges with implementation and lessons learned

The pilot project was able to demonstrate that NbS interventions were successful and provided valuable learning experiences through the challenges experienced. In the first year, the survival rate of the trees in the nursery was just over 68 per cent due to delays in contracting processes which caused some seedlings to

be overgrown by the time of transplanting. Community based organizations (50 members, mostly women) were actively involved in the transplantation of the mangroves, seagrape seedlings as well as bamboo and other forest tree species produced in the nursery on the shoreline and river mouths, which reduced the impacts of storm surge and flood risk. Monitoring revealed that these seedlings had relatively low survival rates – only 57 per cent survived. The causes were determined to be an unfavourable planting season, inadequate planting skills – community members were mainly accustomed to planting ornamental trees – as well as human and animal disturbance. For example, some of the planted areas were damaged by the free grazing of goats, burning of solid waste on the shore and trampling by children. This proved the significance of, and further need for, awareness-raising and training of the local communities in increasing the success of the project and similar projects in future.

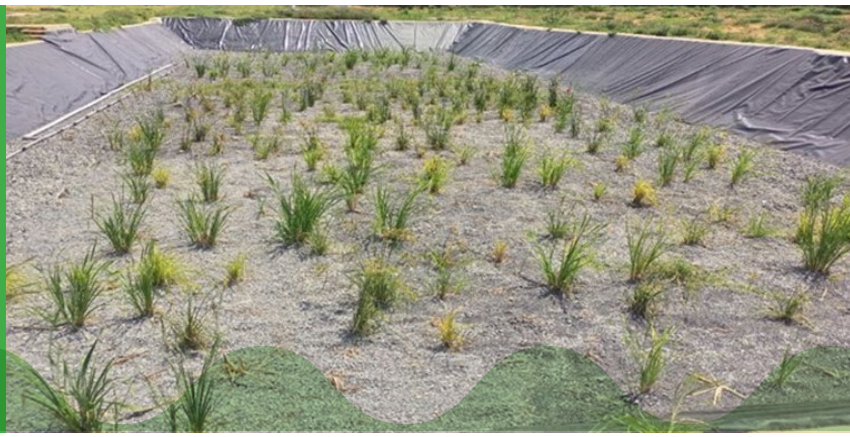
Source:
Haiti_Eco_DRR_case_study_2016.pdf (unep.ch)

Scale-up

Having learned from these experiences, UNEP partnered with the Botanical Gardens of Les Cayes to strengthen local capacity. In doing so, the organization held training seminars for staff and nursery managers and local NGOs. This was supported with the replanting of mangroves in some of the most affected areas, in order to replace the dead seedlings. This produced much higher success rates. The pilot project in Port Sault also served as an entry point for raising local and national awareness about NbS, thereby making the case to further strengthen local community and national government capacities in upscaling similar NbS approaches to disaster risk management and ecosystem protection.

5. Nature-based solutions for pollution and environment action: KENYA

Constructed wetlands to address sewage challenges in the Shimo la Tewa Prison



The Shimo La Tewa waste treatment plant under construction, July 2022.
Photo credit: Kenya Marine and Fisheries Research Institute.

Location: Mombasa, Kenya
Implementation timeframe: 2020–2023
Funding: GEF, UNEP, KMFRI
Nature-based solutions (NbS): Constructed wetlands

Setting

The Shimo la Tewa Prison in Shanzu, Mombasa County, Kenya, has a population of 3,000–5,000 people. The prison facilities produce 300–400 m3 of wastewater a day. Prior to a project to build a specially designed wetland, wastewater was partially treated by a dysfunctional treatment facility and discharged into Mtwapa Creek.

The prison's septic system had collapsed due to overuse. Every day untreated sewage from the prison flowed into Mtwapa Creek and the Indian Ocean, threatening fishing grounds, waterside hotels and restaurants, and the tropical reefs of Mombasa's protected marine park – a key tourist attraction. The smell and sanitation situation in the surrounding area was so bad that government lodgings used by prison wardens and hospital staff were deemed uninhabitable and subsequently abandoned.

NbS interventions

The project set out to pilot and test an innovative wastewater treatment approach using constructed wetlands – shallow-water ecosystems that mimic natural wetland processes, such as water filtration through vegetation and soil, and enable effective removal of wastewater pollutants.

A key objective was to improve water quality in the creek. The project set out to improve sanitation in the prison, and food security, by using treated water from the wetland for fish and crop production. The project also sought to raise awareness and share information about these constructed wetlands for the benefit of other stakeholders.

The proposed system will allow the prison to complete the whole water treatment cycle on site producing nearly 110,000 m3 per year of treated effluent suitable for agricultural irrigation. This quantity of water is adequate to irrigate 45 hectares of farmland that may be planted with horticultural crops. The vegetation to be used for treatment includes: Typha grass (*Typha latifolia*), Cattail *(Carex/Scirpus/Sceleria* species), Flat sedge (*Cyperus involucratus)* and Vetiver grass (*Chrysopogon zizanoides*), all of which are available in the local area and have been used successfully in comparable settings.

The benefits

A partnership was set up between project implementing partners the Kenya Prison Service (KPS), the Kenya Marine and Fisheries Research Institute, and the National Environment Management Authority, ensuring high-level management commitment and specific roles, all of which were key to the success of the project.

The project was able to deliver important benefits for local ecosystems and communities. The creek and marine ecosystems improved in quality. Measurements taken before and after construction of the wetland showed significant improvement in all water quality parameters, with most now meeting standards set by the authorities. For example, total suspended solids decreased from 2,304 (mg/L) before wetland construction to just 6 (mg/L) after, with similar significant reductions in the concentrations of nitrates (1,251 to 3.7), ammonia (1,180 to 4), nitrogen (2,431 to 8) and total coliforms (>1,000 to 2).

Apart from the construction of the wetland, bathrooms and toilets in the prison were also improved. Construction has also been started on water storage facilities and a network of pipes for greening and irrigation. Once certified as suitable, treated water will be redirected to grow food crops at the prison farm to improve food security and nutrition at the prison. There is also a plan to use the treated water for aquaculture by constructing, stocking and managing a fishpond at the prison. The fishpond is anticipated to initially generate about 300 kg of fish in seven months but annual production is expected to rise.

Improved ecosystem health contributes to improved sanitation and food production for the 3,000–5,000 residents of Shimo la Tewa, but also has benefits for the 60,000 inhabitants of Mtwapa and the 1,500 tourists who expect clean beaches and a pleasant environment. Furthermore, it is expected that reduced wastewater pollution can increase fish populations and the livelihoods of the 300–500 local fishers.

Scale-up

KPS also designated 14 staff to be involved in the project: they were trained on how to operate and maintain the new facilities, with daily, weekly and monthly maintenance schedules to ensure the project's long-term sustainability. A draft operations and maintenance manual has been produced. Furthermore, KPS committed to budget for the operation and maintenance of the constructed wetland after the end of the project.

Future plans, subject to resource availability, include improvement of sludge management through the construction of a sludge-drying bed to facilitate production of biomass briquettes. There is also an ambition to convert the constructed wetland into a recreational facility, thereby transforming a smelly wastewater pool, into a park.

By successfully showcasing this constructed wetland technology, it is hoped that the hospitality and other sectors can also benefit from, and upscale, this innovative approach, which is also being promoted in educational and research establishments in Kenya.

Sources:

Mwangi S., Kenya Marine and Fisheries Research Institute, WIOMSA 12th Scientific Symposium, October 2022

Kenya jail goes green to fix sewage woes and protect sea

Using green technology to improve water quality in Kenya's Mtwapa Creek

6. NbS for nature and biodiversity action: MOROCCO

Reuse of wastewater for afforestation in the city of Ouarzazate

Ouarzazate, located in the middle of a bare plateau south of the High Atlas Mountains. PHOTO: Visualhunt

Location: City of Ouarzazate, Morocco
Implementation timeframe: 2012-2017
Funding: Korea Forest Service
NbS: Afforestation using the city's treated wastewater for irrigation

Setting

Located on a bare plateau high in the Atlas Mountains, the city of Ouarzazate (known as "the door to the desert") in Morocco is **vulnerable to encroaching desertification and periodic dust storms,** and is combating land desertification and loss of biodiversity. Home to 60,000 people, Ouarzazate is also one of southern Morocco's major tourism destinations. Environmental degradation and storms are affecting both the city's residents and guests.

NbS interventions

To address these challenges, the Government of Morocco, with support from UNEP and Korea Forest Service (KFS), set out to establish a green belt surrounding the city, by planting trees. The objective of the pilot project was to stall desertification, decrease land degradation, and mitigate impacts of the strong winds and dust clouds on the city. The pilot approach was to **green the drylands surrounding Ouarzazate, making use of treated wastewater and clean (solar) energy as a source for irrigation of the green belt**. The trees in the green belt would act as a buffer to dust storms, while also creating areas for recreation and habitats for biodiversity.

The benefits

With the city's chief water source, El Mansour Eddahbi dam, already under strain from competing demands for domestic water use, irrigation, and industrial uses at the nearby solar power plant, it initially seemed that ensuring sufficient water for irrigation of the green belt would not be feasible. **The solution was found in using recycled wastewater for irrigation.** The wastewater is collected from households and filtered in a series of lagoons, before being pumped to the project site using clean solar power. Since its inception, the project has relied on traditional knowledge and the expertise of local populations in implementing and maintaining sustainable activities.

The first phase of the project set out to plant 635 hectares of trees. **Involvement of the local population in implementation, and creation of local job opportunities also ensured a strong feeling of local ownership** and high community engagement in looking after the trees – this was a key factor for success. The green recreational spaces have also proved important in awareness-raising and education on the importance of trees for protecting against dust storms and desertification.

Challenges with implementation and lessons learned

An unforeseen challenge faced by the project implementers was the skyrocketing of land prices that followed tree planting. This posed challenges to project upscaling. Land prices were originally US$1,000 per hectare, but by the end of the project, they reached US$60,000 per hectare. However**, the project also created temporary and long-term employment for local community members** in tree planting, green belt maintenance and protection.

Scale-up:

The project activities are set to continue, with a focus on awareness-raising, partnerships, and sharing experience with other regions in Morocco and abroad. The city has also increased its wastewater treatment capacity, to support the green belt in Ouarzazate and beyond, so that there is sufficient water to extend irrigation to trees within the city. This has enabled local NGOs to plant trees in schools and along streets, thereby helping to boost honey production and provide more room for crucial pollinators.

Sources:
https://www.unep.org/pt-br/node/20757

https://www.unep.org/news-and-stories/press-release/moroccan-city-defies-desertification-harnessing-solar-power-and.

7. NbS for climate and nature action: TANZANIA

Restoring mangrove habitats and coral reefs to build coastal resilience

Location: Coast of Dar es Salaam, Tanzania

Implementation timeframe: 2012-2019

Funding: GEF Least Developed Countries Fund (GEF LDCF) & Adaptation Fund (AF)

NbS: Mangrove and coral reef restoration, shoreline stabilization via revegetation

Setting

Tanzania's 800 km coastline is home to 25% of the population, 75% of its industries, and is a source of 32% of national income. Yet, climate change is increasingly threatening local livelihoods and ecosystems, causing damage to infrastructure and ecosystems alike. Rising sea-levels are causing saltwater intrusion in wells, which in turn has led to crop failures, livestock diseases, and health issues in the local communities. Sea-level rise has damaged infrastructure, as well as coastal ecosystems which act as natural buffers against wave surges. Coral reefs and mangrove forests are also suffering from unsustainable harvesting practices as demand for fuelwood, timber and charcoal and other resources grows.

To respond to the urgent need for adaptation action along the coast, and in line with the National Adaptation Plan of Action (NAPA), the Government of Tanzania secured funding from the AF and the GEF LDCF in 2012 for **two interlinked projects** in the coastal districts of Dar-es-Salaam. The projects, implemented by UNEP and a range of local partners, focused on combining ecosystem-based adaptation interventions and coastal defence structures to protect coastline integrity and freshwater supply, and restore ecosystems.

NbS interventions

NbS interventions included mangrove forest and coral reef restoration, and revegetation of slopes with deep-rooted flora. In all, some 1,000 hectares of mangroves, 3,000 m^2 of coral reefs, and 30,000 m^2 of shoreline vegetation were rehabilitated. The coral reef at the Sinda and Mwakatunde island marine reserves near Dar es Salaam was rehabilitated by transplanting and grafting bleaching-resistant corals from other locations.

People can now get fresh water from wells that had turned salty due to sea water intrusion, thanks to a mangrove resforestation project supported by UNEP in the Kisakasaka community in Zanzibar. Photo credit: UNEP

Indigenous trees and grasses were planted in select locations, including along seawalls, with the aim of stabilizing soils against erosion. Mangrove forests were rehabilitated through the planting of resilient seedlings, dredging, and the creation of no-take buffer zones. Restoration was carried out using locally available, climate-resilient species, and is estimated to have benefited some 8,600 people via flood protection and livelihood opportunities, while also providing habitats for wildlife. To address unsustainable harvesting practices, no-take zones were established with the aim of reducing deforestation by 40 per cent in the restored sites, and 87 community groups were created to manage the mangroves.

NbS interventions were implemented, alongside the construction of other infrastructure, including seawalls, groynes and dikes to mitigate coastal erosion, saltwater intrusion and flooding – a total of 2,400m of protection structures. Projects also installed rainwater harvesting structures, boreholes and drainage channels.

The benefits

One of the key factors marking project success was the consistent engagement of district and community stakeholders. At least 140 people were trained in coastal and climate vulnerability-mapping and by the end of the project, 38 community-based organizations had been registered or were in the process of registration. More than 40 students from the University of Dar es Salaam were involved in field research at the project sites, and documented their findings.

The chances of mangrove seedling survival were improved by using adaptive management techniques: testing different varieties of mangrove plants and experimenting with spacing during plantation. This approach allowed excess seedlings to be used in other locations.

Challenges with implementation and lessons learned

The two projects offered many lessons in upscaling NbS. They highlighted the critical role of community involvement in implementing projects, thereby contributing to these projects' success and ownership, while also shedding light on the need for further management and governance interventions to address broader underlying issues of degradation that might affect the newly restored ecosystems. Such causes of degradation include untreated sewage, cattle encroachment, and illegal logging, which caused high mangrove seedling mortality rates in some districts. The projects also shed light on the challenges faced by local community organizations owing to slow registration processes, the varying capacities of these organizations, and logistical and cost challenges.

Scale-up

Combined, the two projects provided significant benefits in terms of reducing the coastal vulnerability of populations. The NbS interventions were successfully implemented, with high community involvement. To reduce the vulnerability of larger ecosystems, replication and upscaling will be needed.

Sources:

Lessons Learned: Climate Adaptation in Tanzania with Ecosystem Restoration & Flood Defence Infrastructure (unep.org)

Ecosystem-based Adaptation in Tanzania | UNEP - UN Environment Programme

'Seawater is coming into our farms and killing the plants'

Terminal Evaluation Report.

More information sources available from:

https://www.unep.org/explore-topics/climate-action/what-we-do/climate-adaptation/ecosystem-based-adaptation/ecosystem-5

Endnotes

1 WWF, 2022: https://www.worldwildlife.org/initiatives/free-flowing-rivers, accessed 7.11.2022

2 IEA, 2021. Renewables 2021: Analysis and forecasts to 2026.

3 Link to the UNEP's original source for the triple planetary crisis

4 https://www.ipcc.ch/sr15/resources/headline-statements/

5 IPBES (2019): Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.

6 United Nations Environment Programme (2021). Making Peace with Nature: A scientific blueprint to tackle the climate, biodiversity and pollution emergencies. Nairobi, Kenya

7 IPCC, 2022: Summary for Policymakers [H.-O. Pörtner, D.C. Roberts, E.S. Poloczanska, K. Mintenbeck, M. Tignor, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem (eds.)]. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Cambridge University Press, Cambridge, UK and New York, NY, USA

8 United Nations Environment Programme (2021). Making Peace with Nature: A scientific blueprint to tackle the climate, biodiversity and pollution emergencies. Nairobi, Kenya OECD (2022), Global Plastics Outlook: Economic Drivers, Environmental Impacts and Policy Options,

9 OECD Publishing, Paris. and https://www.theguardian.com/environment/2020/aug/17/microplastic-particles-discovered-in-human-organs

10 https://www.who.int/news-room/fact-sheets/detail/drinking-water

11 https://sdgs.un.org/goals

12 IPBES (2019): Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services

13 IPBES (2019): Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.

14 https://www.worldwildlife.org/initiatives/freshwater

15 https://www.unep.org/environmentassembly/unea-5.2/proceedings-report-ministerial-declaration-resolutions-and-decisions-unea-5.2

16 https://www.unep.org/news-and-stories/press-release/un-environment-assembly-concludes-14-resolutions-curb-pollution

17 UNEP 2022. Freshwater Strategic Priorities 2022–2025 to implement UNEP's Medium-Term Strategy, March 2022

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