FROM GREY TO GREEN INFRASTRUCTURE

What are the opportunities and challenges of using green and grey infrastructure to increase flood resilience?

IFRC

Flood Resilience Alliance

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Bangladesh *A strong storm surge from cyclone Yaas swept away the embankment that protects Gantirgheri village. © Paulus Enggal / IFRC*

Key messages

- Floods are already the most common natural hazard worldwide and climate change is leading to even more intense and frequent flood events. People are affected globally, but the most affected are the most vulnerable.

- A new generation of infrastructure projects is necessary to build climate resilience against flood events. Green, blue and hybrid infrastructures have great potential to reduce flood risks while maintaining the functioning of society and offer many advantages over traditional grey infrastructure.

- Compared to grey infrastructure, green and blue infrastructures can be a cost-effective solution to reduce social and environmental vulnerabilities against flood risks and can bring multiple social, economic and environmental co-benefits such as improving human well-being.

- To shift from traditional grey infrastructure to green, blue and hybrid infrastructure, we need to value these new types of infrastructure, strengthen policies, leverage partnerships, and develop community-based approaches.

1. INTRODUCTION

Flood-related disasters have increased by 134% since 2000, compared with the two previous decades, affecting 1.6 billion people (WMO, 2021). Without adequate adaptation to this risk, the costs, loss of livelihoods and lives will escalate. Traditionally used grey infrastructure is no longer sufficient in the face of flood risks and can no longer provide the climate resilience and level of services required now and in the future (World Bank Group, 2019). Green and blue infrastructure, which can be considered nature-based solutions[1], offer a solution that is often cheaper and provides additional co-benefits such as improving human well-being.

However, green and blue infrastructure are often insufficiently recognized as a viable solution. A paradigm shift is needed to increase the use of green and blue infrastructure and/or the combination of hybrid green/blue and grey infrastructure in the future. To achieve this, we need to demonstrate the benefits of nature-based solutions and the steps needed for better implementation.

This paper discusses how we can support a shift from grey to green, blue and hybrid infrastructure and what the necessary economic, political, and social steps are. It is the result of an event that took place on the 9th of November 2021 as part of the Development and Climate Days at UNFCCC COP26 (see information below). Four different speakers from environmental and humanitarian organizations, representing community and private sector voices, discussed key steps, best practices and lessons learned in increasing flood resilience through green infrastructure.

"What are the opportunities and challenges of using green/ grey infrastructure to increase flood resilience"

An event at Development and Climate Days on 9th of November 2021 in close collaboration with the Zurich Flood Resilience Alliance.

Speakers involved:

Anita van Breda (Senior Director Environment and Disaster Management, WWF)
Colin McQuistan (Head of Climate and Resilience, Practical Action)
Michael Szönyi (Flood Resilience Program Lead, Zurich Insurance Company)
Brenda Avila Flores (Community Resilience Programs Coordinator, Mexican Red Cross)
Watch the recording online.

The paper begins by talking about flood risk in a changing climate (chapter 2). We then discuss why green and blue infrastructure are needed to enhance flood resilience in the future and what the advantages are over grey infrastructure (chapter 3.1). We then show how a paradigm change is needed from grey to green/blue infrastructure (chapter 3.2). Lastly, we discuss the necessary steps, best practices and lessons learned for implementing these solutions as part of disaster risk management (chapter 4).

1 Definitions available on page 3

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About the Zurich Flood Resilience Alliance

The Zurich Flood Resilience Alliance is a multi-sectoral partnership focusing on finding practical ways to support communities in developed and developing countries to strengthen their resilience to flood risk. The Alliance works to increase public and private investment in evidence-informed community-based flood resilience with the goal of shifting focus from flood response and recovery to pre-event risk reduction so that floods have no negative impact on people's and business' ability to thrive.

Find out more on their website.

Flood Resilience Alliance

2. FLOOD RISK IN A CHANGING CLIMATE

Climate change related rising temperatures and changing rainfall patterns are contributing to more intense and frequent flood events. In the absence of major additional adaptation efforts, risks are expected to significantly increase and annual flood damages are expected to multiply (IPCC, 2019).

The susceptibility of a community to negative consequences of flooding depends heavily on their socio-economic, environmental, political and physical circumstances. While countries at all levels of development and all across the globe face flood risk, the vast majority of the world's flood exposed people – 89% – live in low- and middle- income countries, particularly in South and East Asia (see figure 2) (Rentschler & Salhab, 2020a).

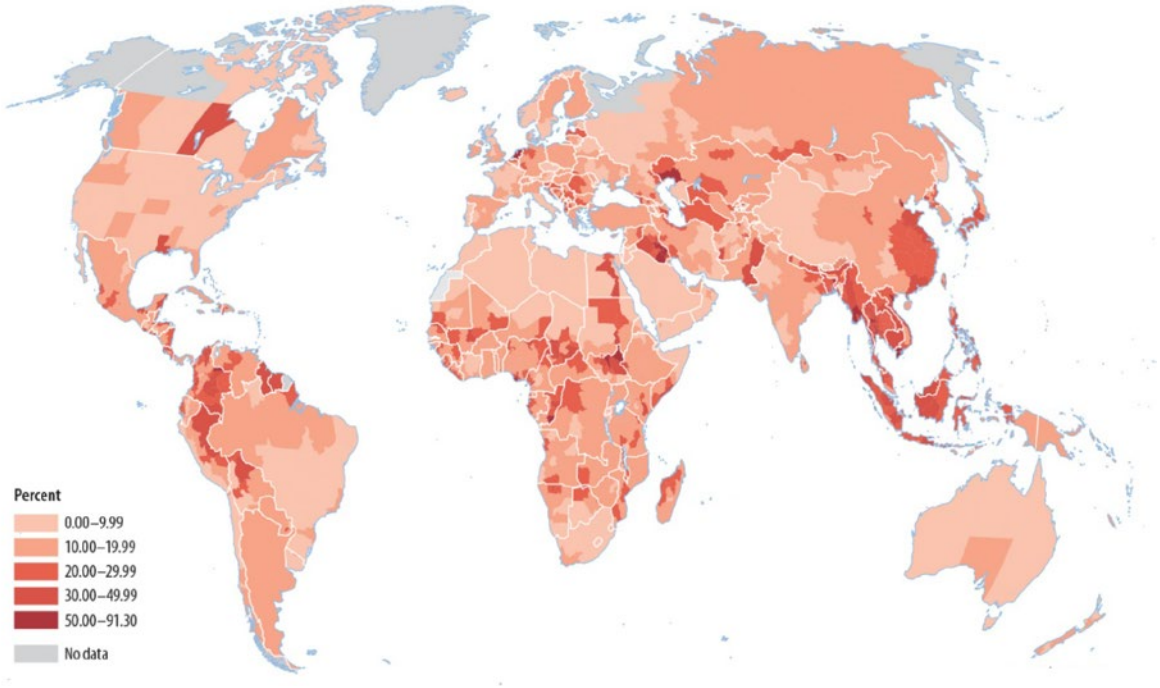

Figure 1: *Share of total subnational population that is exposed to significant flood risk (percent). Source: Rentschler & Salhab, 2020b*

In 2020, 201 devastating floods happened across the globe, making it the number one most common natural hazard related disaster worldwide (see figure 1). Floods were also the second deadliest type of disaster accounting for 41 per cent of total disaster-related deaths in 2020. The number of people affected by floods is much higher with an annual average of 82.3 million people (Rentschler & Salhab, 2020a).

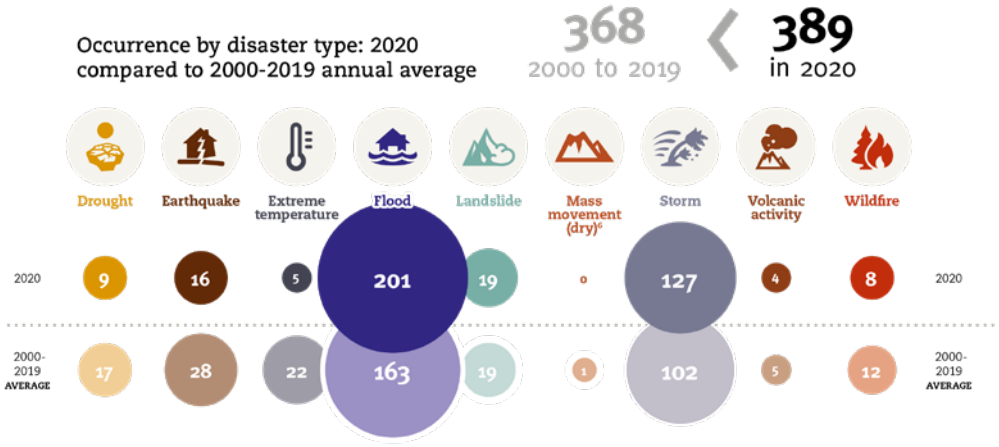

Figure 2: *Occurrence by disaster type. Source: CRED & UNDRR, 2021*

3. SHIFTING FROM GREY TO GREEN

3.1 Why green infrastructure

The impacts of climate change call for changes in flood protection. A new generation of infrastructure projects is necessary to achieve development goals, including water security, disaster risk reduction, poverty alleviation, and resilience to climate change (World Bank Group, 2019). Nature-based solutions, including green, blue and some hybrid infrastructures have great potential to reduce flood risks (see figure 3 for applications), now and in the future, while maintaining the functioning of society. Green and blue infrastructure does not only protect against floods, it also offers many advantages over traditional grey infrastructure.

Definition	Examples
Nature-based Solutions are "actions to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits.". (IUCN, 2016) This includes most green, blue and hybrid infrastructure (UNDRR, 2021).	see figure 3
Green infrastructure is a subset of nature-based solutions that "intentionally and strategically preserves, enhances, or restores elements of a natural system, such as forests and agricultural land". (World Bank Group, 2019).	Conservation, sustainable management and restoration of forests, Parks, Trees, Plants, Sand Dunes etc. (UNDRR, 2021)
Blue infrastructure is a subset of nature-based solutions that highlights the water-based elements in the landscape. (UNDRR, 2021).	Conservation, sustainable management and restoration of coastal areas, Peatlands, Rivers, Marshes, Lakes, Floodplains, Mangroves, Coral reefs, Seagrasses etc. (UNDRR, 2021)
Grey infrastructure is built structures and mechanical equipment" (World Bank Group, 2019).	Reservoirs, Embankments, Pipes, Pumps, Water treatment plants, Canals etc. (World Bank Group, 2019)
Hybrid green/blue Infrastructure is natural blue and/or green infrastructure combined with built grey infrastructure or – ecologically engineered infrastructure.	Green roofs, Green facades, Sustainable drainage systems, urban wetlands, permeable pavements etc. (UNDRR, 2021)

Research shows that in many cases, green and blue infrastructure are less expensive than grey infrastructure, and provide a wide array of co-benefits for local economies, the social fabric and the broader environment (EEA, 2015). Green and blue infrastructures are ready-to-use, (often) technically simple, cost-effective, more robust and more sustainable solutions. There is growing evidence that green, blue and some hybrid infrastructures can cost-effectively deliver what would otherwise require expensive investments in grey infrastructure or other energy-intensive measures (UNEP, 2021). Besides reducing social and environmental vulnerabilities against flood risks, green and blue infrastructure can bring multiple social, economic and environmental co-benefits such as improving human health and well-being, providing jobs and business opportunities and mitigating climate change (EEA, 2021). Grey infrastructure solutions on the other hand typically only fulfill single functions such as drainage (EEA, 2015).

> *"Nature-Based Solutions (NBS) can help address disaster risk reduction, flood risk management, water security, and resilience to climate change. However, in practice, these measures are still being applied at a slow rate while traditional grey infrastructure remains as a preferred choice.*
>
> — Colin Mc Quistan, Head of Climate and Resilience, Practical Action

Green and blue infrastructure for flood resilience can be achieved in various ways. Some examples include: watershed, wetlands, coastal and reef restoration, rainwater harvesting, soil conservation measures, natural drainage path restoration and removal of barriers (WWF, 2016) (see definitions above for further examples).

> *While floods often cause serious problems to residents, to infrastructure and local economies – floods can also be a natural process that can play an important role in a community for example by depositing nutrients necessary for agriculture – that's why it is critical to understand what contributes to flood risk, how to minimize potential damage and how to maximize potential benefits of flood waters*
>
> — Anita van Breda, Senior Director Environment and Disaster Management, WWF

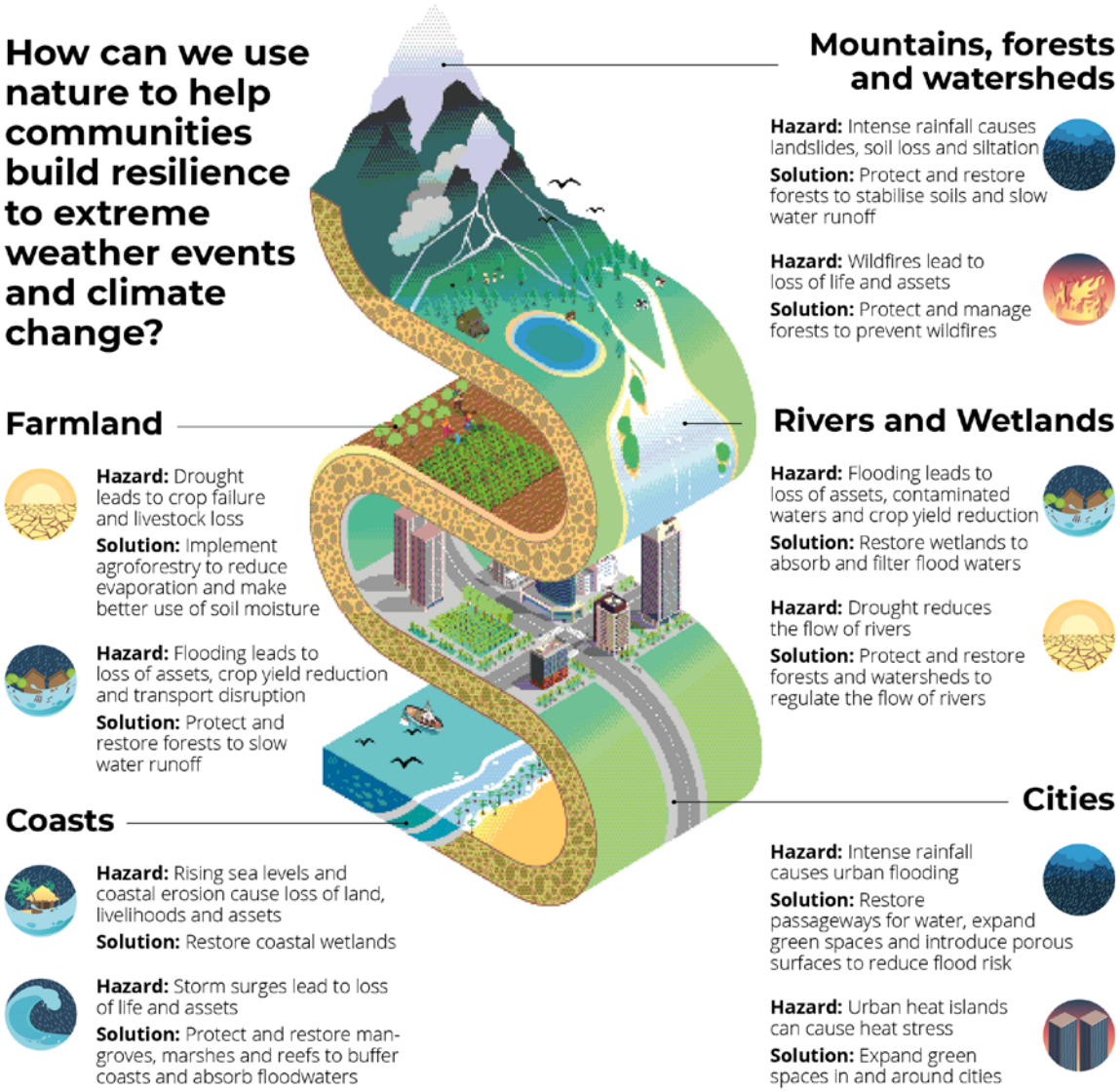

Figure 3: *Source: IFRC, 2021; adapted from Global Commission on Adaptation, 2019*

3.2 Shifting paradigms for a more resilient future

To promote nature-based solutions, including green and blue infrastructure, they must be accepted and valued as viable solutions. There must be active collaboration with and development of nature-based solutions for flood resilience. To increase and manage the use of green and blue infrastructure in general infrastructure programs, they must be as thoroughly evaluated and carefully planned as grey projects (World Bank Group, 2019). Planners should compare green/blue and grey infrastructure and identify new opportunities for nature-based investments, including a combination of green/blue and grey approaches when nature-based solutions alone are not sufficient (see figure 4) (EEA, 2015). Combining green/blue and grey infrastructure can provide next-generation solutions that improve system performance and better protect communities , lead to cost savings, and significantly reduce overall risk (World Bank Group, 2019; WWDR, 2018).

Service	**Grey Infrastructure Components**	**Examples Of Green And Blue Infrastructure Components And Their Function**
Coastal Flood Protection	Embankments, groynes, sluice gates	**Mangrove forests**: Decrease wave energy and storm surges and thereby reduce embankment requirements
Urban Flood Management	Storm drains, pumps, outfalls	**Urban flood retention areas**: Store stormwater and thereby reduce drain and pump requirements
River Flood Management	Embankments, sluice gates, pump stations	**River floodplains**: Store flood waters and thereby reduce embankment requirements

Figure 4: *How Green and Grey Infrastructure can work together. Source: adapted from World Bank Group, 2019*

However, in managing disaster risk, a prioritization of measures is recommended for flood risk management: Non-structural methods, including nature-based solutions, should be used first, alongside green and blue infrastructure. If green and blue infrastructure cannot provide enough protection, hybrid infrastructure should be added. Last, and only if necessary, grey infrastructure should be used (see figure 5).

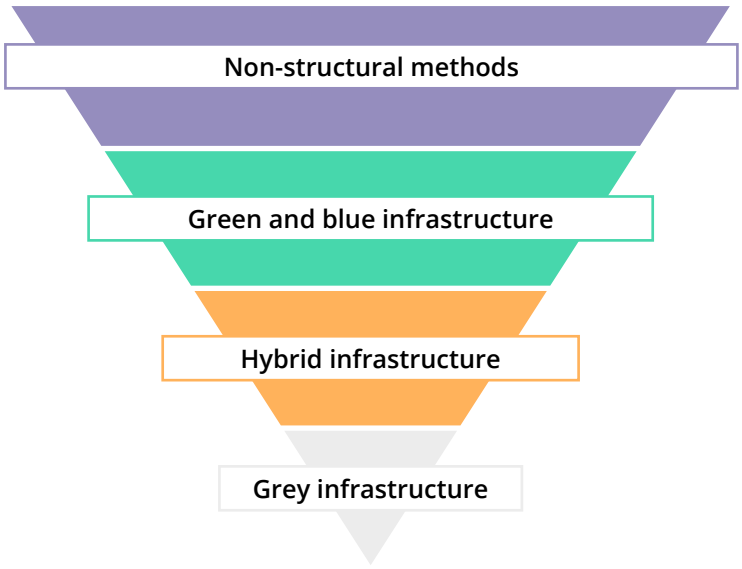

Figure 5: *Source: adapted from WWF*

Case Study

Bio-dykes for flood resilience in the Terai of Nepal (Practical Action)

The Terai plains in Nepal are inhabited by indigenous communities that farm soils, which are enriched by annual floods. However, climate change is leading to more catastrophic flooding, severely impacting the communities. To protect their productive agricultural lands and to strengthen food security and rural livelihoods, bio-dykes have been implemented as a risk mitigation measure. Bio-dykes aim to reduce bank erosion, flood levels, and the velocity of the flood pulse. They can take different forms and be adapted to protect critical local assets. Bio-dykes also deliver economic and biodiversity benefits to communities over time.

The construction and maintenance of bio-dykes is notably cheaper than the construction of concrete measures. This makes them well suited for remote locations. The construction relies on traditional knowledge and skills and can be built by local people. The bio-dykes are more sustainable than concrete measures and do not significantly disturb natural processes along the riverbank.

> *"Bio-dykes are raised dams made of earth and material held together by bamboo. Where there is a risk of erosion, large boulders are used. Bio-dykes are considered green infrastructure because they are constructed entirely of plant materials such as bamboo, ratan, and tree roots. The living component of the bio-dykes provides some maintenance to the structure. Many plants and products are beneficial to the local community. They visit the bio-dykes regularly to harvest and can simultaneously evaluate if any erosion has occurred and if so it can then be remedied by the community itself. Gray infrastructure, on the other hand, cannot be monitored and maintained by the local community, and over time loses its ability to protect against flooding.*
>
> — Colin McQuistan, Head of Climate and Resilience, Practical Action

One successful implementation of bio-dykes happened in the community of Bangalipur village in the Bardiya district of Nepal. The community was hit by damaging floods in 2008, 2009 and 2014 that washed away crops, destroyed houses and removed top soil, depositing in its place gravel, stones, and debris covering the fields. Together with Practical Action, several villagers constructed a bio-dyke to protect their village. The construction involved people from every household working collectively over 25 days to build the 220-meter-long living barrier. Since its construction, erosion has been halted and community members feel safer. The bio-dyke has not stopped the floods altogether, but has greatly reduced their impact.

Photo: Bio-dyke construction work at Bangalipur, Bardiya **Source:** *Practical Action, 2021*

4. THE WAY FORWARD

Climate change is leading to an increase in floods, some with devastating impacts, making it the main natural hazard causing loss of livelihoods and lives. Traditional grey solutions are no longer sufficient. This section shares some necessary steps, best practices and lessons learned in using nature-based solutions and green/blue infrastructure for flood resilience:

- **Paradigm shift that values and promotes nature-based solutions and green/blue infrastructure.** A cultural shift is needed, and the case for green and blue infrastructure must be made to communities, the private sector, and decision makers. At the community level, perceptions need to be changed and livelihood benefits of green/blue infrastructure demonstrated; decision-makers and the private sector need data and scientific evidence, as well as economic arguments. Risk perceptions need to change, traditional sustainable practices need to be reintroduced, and the value of the environment needs to be demonstrated.

> *"To make green solutions perform even better, we need to change the way costs and benefits are calculated. We need better "counting" of what "is good" – Traditional cost-benefit analysis is based on traditional grey infrastructure approaches and hence misses a lot of green benefits and underestimates a lot of cost that grey has – we simply need a new checklist of what is cost and what is benefit for any approach, any "infrastructure" – be it grey or green - that helps with climate change adaptation.*
>
> — Michael Szönyi Flood Resilience Program Lead, Zurich Insurance Company

There is a need to accept and value nature-based solutions and green/blue infrastructure as viable solutions. Only when green and blue infrastructure is as thoroughly evaluated and carefully planned as grey projects can we drive active collaboration and development of nature-based solutions.

> *"The move to nature-positive activities and values are essential, not only but certainly for achieving the climate goals, and the private sector must take an active role, from two perspectives, a) actively working with and developing NbS, and I am looking at the construction and engineering industry (they implement and develop NbS), and b) accepting and valuing these as viable solutions, and I am looking to the finance and insurance industry for that (banking, mortgages, investing etc.).*
>
> — Michael Szönyi, Flood Resilience Program Lead, Zurich Insurance Company

- **Give incentives at community level.** Policymakers and public and private finance sources need to incentivize and enable conditions to establish solutions that combine green/blue and grey infrastructures (World Bank Group, 2019).
- **Partnerships**. Green and blue infrastructure require careful spatial and project planning as well as collaborative, participatory and multilevel governance across sectors. Policymakers and finance must set the incentives and enable conditions to guide their appropriate use in mainstream infrastructure programs.
- **More knowledge sharing and learning is needed.** At all levels, from communities to regional planners and national policymakers, there is a lack of awareness, communication, and knowledge about what nature-based solutions can really offer (WWDR, 2018). More information is needed on the synergies and trade-offs that can arise when nature-based solutions for climate change adaptation and disaster risk reduction are combined with grey infrastructure (EEA, 2021).

> *Risk perceptions need to change: what is the real value of natural capital? Long-term natural benefits need to be translated into livelihood benefits.*
>
> — Brenda Avila Flores, Community Resilience Programs Coordinator, Mexican Red Cross

- **More research is needed.** The value of green/blue infrastructure, in terms of social, natural and financial benefits, needs to be captured more accurately. Local and regional data and modeling, development of tools and life-cycle analysis to assess the short- and long-term benefits of green and blue infrastructure are needed.

> *Barriers to nature-based solutions range from political and governance barriers to social and technological know-how and understanding.*
>
> — Colin McQuistan, Head of Climate and Resilience, Practical Action

- **Community-based approaches.** Working on nature-based solutions and increasing resilience to flooding starts at the community level. For short- and long-term sustainability, it is most important to engage with the people directly affected by climate change and prioritize their needs, benefits, and buy-in. Together, nature-based solutions specific to their community can be found.

> *The key is to find the right combination of options to meet your specific challenges while being flexible enough for future changes such as changes in land use or climate and ultimately making your community stronger, safer, and more resilient. Forward looking, practical and nature-based solutions are needed for communities all over the world.*
>
> — Anita van Breda, Senior Director Environment and Disaster Management, WWF

- **Scale up**: Flood resilience solutions are ideally planned at the watershed level from the bottom up – from the community level to relevant planning levels.

Strengthening community resilience against flood risks requires valuing and promoting nature-based solutions and green/blue infrastructure. It requires a multi-pronged approach that strengthens policies, leverages partnerships, and develops community-based approaches to enable implementation on the ground. This new generation of green/blue infrastructure projects has the potential to reduce flood risks, reduce social and environmental vulnerabilities, and be cost-effective. They provide an opportunity that we can harness and scale-up – and to do that, we need to work in partnership across sectors and stakeholders.

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