THE BLUE GUIDE
TO COASTAL RESILIENCE

Protecting coastal communities through nature-based solutions

A handbook for practitioners of disaster risk reduction

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Acronyms

BCR	Benefit-cost ratio
CBA	Cost-benefit analysis
CSO	Civil society organization
CVCA	Climate vulnerability and capacity assessment
DRR	Disaster risk reduction
EIS	Environmental impact study
EVCA	Enhanced vulnerability and capacity assessment
GDP	Gross domestic product
IFRC	International Federation of Red Cross and Red Crescent Societies
IPCC	Intergovernmental Panel on Climate Change
LMMA	Locally managed marine areas
MCA	Marine conservation agreement
MPA	Marine protected area
NbS	Nature-based solutions
NGO	Non-governmental organization
TNC	The Nature Conservancy
USAID	United States Agency for International Development
USD	United States Dollar
WWF	World Wildlife Fund

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These toolboxes contain a rich array of tools, templates, presentations and manuals to apply the Blue Guide and train others in its use.

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Foreword

Climate-related disasters are increasing in frequency and intensity. According to the World Meteorological Organization, more than 11,000 disasters over the last 50 years have been attributed to weather-, climate- and water-related hazards. This has led to 2 million deaths and USD 3.6 trillion in economic losses.

The most climate-vulnerable communities — those who do not have access to resources to adapt to climate change — are disproportionally affected. In 2018 alone, approximately 108 million people required help from international humanitarian organizations as a result of storms, floods, droughts and wildfires.

Under current climate projections and a business as usual scenario, the number of people affected by these climate disasters could increase by 50% by 2030, requiring approximately USD 20 billion a year in humanitarian aid.

One powerful and cost-effective way to reverse these trends and losses is by using nature-based solutions (NbS) for disaster risk reduction (DRR). NbS focus on using the power of trees to slow water runoff during storms, reduce droughts and lower temperatures, using wetlands to absorb flood waters and using mangroves and reefs to protect coasts from erosion, storms and associated flooding.

NbS can also provide multiple other benefits, such as jobs that focus on restoring this natural infrastructure and jobs that support livelihoods connected to agriculture, fishing, and tourism. When these systems are healthy and productive, they also provide increased food security and support biodiversity. Though restoration may take time, this proactive and cost-effective approach to DRR provides many advantages and long-term dividends.

The Blue Guide to Coastal Resilience illustrates this approach, providing DRR planners with step-by-step guidance for implementing various NbS in coastal areas — where 600 million people, nearly 10% of the world's population, live under constant threat of storms, flooding and rising sea levels.

The guide integrates all relevant tools and processes into a single source to help conservation and humanitarian DRR planners determine whether and how NbS can be used to harness the protective benefits of coastal ecosystems and reduce the risks of climate-related hazards to vulnerable coastal communities, homes and other assets.

The guide helps DRR planners assess the context, risk and possible NbS for a specific location, as well as the costs of using them and the conditions that need to be in place to be successful.

Its approach is highly participatory, requiring planners to work closely with local stakeholders, including communities and government decision makers, to ensure support and sustainability.

The guide includes inspiring case studies that demonstrate how NbS have simultaneously increased food security, strengthened the social fabric of a community and delivered economic benefits in locations around the world.

Using the Blue Guide, DRR planners can help vulnerable coastal communities implement NbS, along with other strategies, to shift the paradigm from growing losses of lives and livelihoods to increased resilience and security for vulnerable communities along the world's coastlines.

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INTRODUCTION

Learn how nature-based solutions reduce disaster risk, and how this guide can help you implement suitable solutions.

- **USING THIS GUIDE**
- **THE EVIDENCE: THE CASE FOR NATURE-BASED SOLUTIONS**

Where land and water meet, there is **unparalleled potential**. Drawn by access to marine resources and trade routes, people have settled along the world's coastlines throughout history. In today's globalized world, **37% of humans live along the coast**.[1] The combined values from shipping, tourism and commercial and subsistence fishing mean that living by the sea offers great opportunity.

Coastlines are also frontlines: it is here where many hazards cause the greatest havoc. In 2004, the Indian Ocean tsunami killed at least 228,000 people and caused estimated losses of USD 15 billion. On a much more regular basis, cyclones and hurricanes kill and destroy as they reach land with maximum speed.[2] In many places, the combination of land subsidence, poor water management, degradation of ecosystems and sea-level rise combine to increase vulnerability to extreme weather events and greater exposure to stressors.

Healthy coastal ecosystems such as mangroves, reefs, dunes and swamps **help protect people and assets** from damaging forces. Yet for numerous reasons, these valuable ecosystems remain unprotected and continue to be destroyed.

The good news is that much can be done to regain nature's protective benefits. Nature-based solutions (NbS) are actions that address **societal challenges** (such as climate change and disaster risk) by protecting, sustainably managing and restoring natural or modified **ecosystems**.[3]

They can be categorized into four groups:

- **Fully natural solutions** that utilize naturally occurring systems, such as coral reefs, marshes and mangroves;
- **Managed natural solutions** that utilize interventions, such as artificial coral or shellfish reefs, renourished beaches and dunes, planted marshes and mangroves;
- **Hybrid solutions** that combine structural engineering ("gray infrastructure") and natural features ("green infrastructure"), such as marsh-levee systems or dune-dyke systems; and
- **Environment-friendly structural engineering** that is beneficial to natural systems, such as vegetated engineering or bamboo sediment fences.[4]

Aside from reducing climate-related disaster risk, NbS typically enhance food security, water security, social and economic development and human health. In short, NbS **increase resilience through nature**.

The case for nature is strong, and NbS can be integrated into wider **disaster risk reduction** (DRR). This guide shows you how to do that, taking you through the eight stages towards increased coastal resilience. **Let's get started.**

USING THIS GUIDE

Who should use this guide

This Blue Guide is primarily **designed for practitioners**, particularly those in the humanitarian sector supporting coastal communities. This includes technical experts and project managers who will be able to follow the various stages in this guide, who can integrate NbS into DRR planning, implement such plans, and scale up good practices. To use this guide, expertise in ecology and prior knowledge of NbS is not necessary. However, prior knowledge of project management is required.

The guide is also useful for:

- **Community members** who co-design efforts towards safer and greener coastal communities with humanitarian organizations;
- **Government staff** who work with humanitarian organisations on efforts to reduce disaster risk; and
- **Staff/volunteers of NGOs or National Red Cross and Red Crescent Societies** working in coastal communities and supporting risk reduction or wider resilience efforts.

1. See United Nations Ocean Conference fact sheet 2017 here.
2. As an analysis of disaster data related to cyclones, hurricanes and typhoons shows (based on the EMDAT database), the number of average annual fatalities has decreased from 20,600 (1990-99) to 2,800 (2010-19), while economic losses have starkly increased over the same period (from USD 16.4 to 69.6 billion). Although two storms (Bangladesh 1991, Myanmar 2008) caused more than 130,000 deaths each, advances in early warning and preparedness have lowered the fatalities: less than 5% of global annual disaster deaths of 60,000 (2010-19) were related to storms.
3. IUCN 2016
4. Pontee et al 2016:30.

For DRR practitioners, this guide is a formidable resource to bring calls for more transformational changes to life. In the face of growing **climate change** impact, the International Federation of Red Cross and Red Crescent Societies (IFRC) argued that the first priority must be the long-term reduction of vulnerability and exposure (IFRC 2019:23). Integrating nature-based solutions can help achieve both.

As many examples from around the world have shown, NbS can be powerful and cost-effective means to help communities adapt while lowering hazard-related damages and losses. The challenge is to bring such solutions to scale, and to do so fast.

Over the past three decades, DRR has been successful in reducing fatalities. The next task is to also halt and reverse the trend of globally increasing livelihood losses. **This shift** requires the formation of new alliances - for instance, between humanitarian and environmental organizations. It requires learning and adoption of new techniques.

This is where the Blue Guide comes in. The process it outlines can be **used around the world**: after all, no matter where you live, NbS can be implemented with great effect. Yet, **local context** matters — and the guide offers a wide range of actions for the various ecosystems, as well as practical case studies from many regions of the world.

Alignment with other guides

You may be familiar with other guidance documents on community-based programming. The Blue Guide generally aligns with and complements the IFRC Road Map to Community Resilience, the WWF Green Guide on Flood Management, and CARE's Climate Vulnerability and Capacity Assessment manual. Where relevant, the Blue Guide shows how its steps relate to those in the above manuals.

How to use this guide

Navigating the Blue Guide is easy. We encourage you to read it from start to finish, of course. However, the guide is also designed to be your companion as you progress through the stages and steps. Therefore, the guide includes interactive features to jump to the relevant section as you go along the process.

These are:

- The **navigation bar** at the top of each page lets you switch to the other sections of the guide.
- Two types of **links** are used, all are underlined. Items printed in blue lead you to external resources, while those printed in purple direct you to another section of the guide.
- The main text is kept short and includes the essentials that are needed by all readers. Additional **step-by-step guides** for specific ecosystems are in appendix A.
- **The sidebar** features additional information, such as useful tips, warnings, case study overviews (with links to the full case study), external links and footnotes.
- **The glossary** explains all key terms. All terms that are marked like this example are included in the glossary, which you can access via the link in the top navigation bar.
- The **icons** below are used to help you navigate the guide.

ICONS used in the Blue Guide

- Tool
- Further details
- Connection to other manuals
- Useful tip
- Process navigator

DEFINING NATURE-BASED SOLUTIONS

Nature-based solutions (NbS) 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**.

Common societal challenges are climate change, food security, disaster risks, water security, social and economic development as well as human health.
(IUCN, 2016)

Inspired and supported by nature, NbS are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience.

Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions.
(European Commission, 2019)

Figure 1 | **The eight stages towards enhanced coastal resilience**

The eight stages towards enhanced coastal resilience

STAGE 1 | IDEATE & SCOPE

Step 1.1 **What is the problem?**
Step 1.2 **What is the context?**
Step 1.3 **What could be done?**
Step 1.4 **Who may be partners?**

STAGE 2 | ENGAGE OTHERS

Step 2.1 **Consult government agencies**
Step 2.2 **Initiate community engagement**
Step 2.3 **Map and engage stakeholders**
Step 2.4 **Explore technical support**
Step 2.5 **Form a steering committee**

STAGE 3 | ASSESS CONTEXT

Step 3.1 **Assess community risk**
Step 3.2 **Assess ecosystems**
Step 3.3 **Assess the external context**
Step 3.4 **Define your objectives**

STAGE 4 | IDENTIFY SOLUTIONS

Step 4.1 **Confirm & clarify objectives**
Step 4.2 **Explore feasible measures**
Step 4.3 **Screen for suitability**
Step 4.4 **Develop options**
Step 4.5 **Develop scenarios**
Step 4.6 **Estimate benefits and costs**
Step 4.7 **Compare options**
Step 4.8 **Check for sustainability**
Step 4.9 **Decide on and refine your solution**

STAGE 5 | MAKE A PLAN

Step 5.1 **Build your logframe**
Step 5.2 **Build your work plan**
Step 5.3 **Develop the budget**
Step 5.4 **Secure funding**
Step 5.5 **Search for long-term support**

STAGE 6 | IMPLEMENT & MONITOR

Principle 1 **Invest in your team**
Principle 2 **Monitor to manage**
Principle 3 **Use tangibles as mobilizers**
Principle 4 **Build & maintain trust**
Principle 5 **Nurture stewardship & cohesion**
Principle 6 **Ensure high technical quality**
Principle 7 **Adapt to remain agile**

STAGE 7 | ANALYZE & LEARN

Step 7.1 **Systematically analyze outcomes**
Step 7.2 **Conduct hazard event reviews**
Step 7.3 **Learn & adjust to maximize impact**

STAGE 8 | SHARE & EXPAND

Step 8.1 **Document your experience well**
Step 8.2 **Share openly and widely**
Step 8.3 **Advocate for & support replication**

The eight stages to enhanced resilience

The Blue Guide takes you through the process of increasing coastal resilience through eight stages, each of which is broken down into several steps (see figure 1).

At the start of stages 2-7, there is an overview on how that stage of the Blue Guide relates to the Road Map to Community Resilience and the WWF Green Guide on Flood Management. Look out for this icon:

Every location, every context is different. The single most important aspect is arguably the identification of locally suitable, effective and sustainable solutions.

Amongst other factors, that aspect is determined by

- the **prevailing risk** — what is the problem that you seek to address?
- the **ecological setting** — what ecosystems are or have been in place, and what is their current status (intact/degraded)?
- the **local capacity and willingness** — to what extent are communities and stakeholders capable and willing to engage and maintain the solution for the long run?
- the **strength of enablers** — to what extent are frameworks, interests and plans of local government supportive?

The Blue Guide's eight stages describe a **general process** that applies to all readers and contexts, and it includes interactive tools to support decision-making — look out for the decision compass icon: .

Specific guidance on solutions (such as mangrove afforestation) is in appendix A. After all, you should not have to read much about mangroves if your local context is not suitable to plant or rehabilitate them.

Throughout its eight stages, the Blue Guide offers **case studies** that show how specific actions have been applied in practice. These are to inspire and showcase how ideas have been put into practice by colleagues from around the world.

All actions **start with an idea**. You may have identified a problem already — for example, declining fish stock, bleached coral reefs, increasing damage from storms, more frequent floods, polluted beaches. You may even have thought of a possible solution, but will need to convince others to turn your idea into practice.

In the description of stage 1, you'll learn how to sketch out a rough idea and how to identify possible partners. Your idea does not have to be perfect and elaborated yet, but it is very useful to have a basis for discussions with the wider community, government agencies, businesses, and organisations.

A local Red Cross chapter in Vietnam did exactly that. Its idea eventually turned into a 9,000 hectare mangrove forest that continues to protect communities while offering many other benefits (see photo and case study B.1).

The Blue Guide is your companion helping you along the way towards increased resilience. In a moment, let's start going through the eight stages.

But before we do so, let us look at the case for nature-based solutions. What makes them so effective for coastal resilience? After all, familiarity with the evidence and some general concepts can help you enlist support.

From little things…

…big things grow. In Vietnam's Nam Dinh province, guard Cao Thanh Son looks for the "fruit" of the mangroves, long pods that he can plant into the mud. He has been working here since 1997, when Vietnam Red Cross started planting mangroves to protect dykes and communities.
Photo: Thorkell Thorkelsson, Icelandic Red Cross

Read the full case study B.1 on page 76.

5. In their meta-analysis of 27 studies on coral reefs and wave attenuation in the Indian, Pacific and Atlantic Oceans, Ferrario et al. (2014) compared the wave energy and height reduction by reef crests (the seaward barrier of the reef), the reef flat (the expanse of the reef) and the whole reef.

   Most of the energy is absorbed by reef crests (86%), although the width of the reef flat also makes a difference on wave energy and wave height reduction (for reef flats less than 1,000 meters wide).

THE EVIDENCE: THE CASE FOR NATURE-BASED SOLUTIONS

Nature-based solutions offer multiple benefits: they **reduce damages** in communities in the event of severe weather while offering **economic**, **social** and **environmental benefits** in an ongoing manner. Many studies of NbS focus on protective benefits and cost effectiveness (i.e. dividing the expected benefits by the associated costs). Although they show high benefit-cost ratios (BCR), the case for NbS is even stronger when other benefits are also included.

Let us first explore the benefit types one by one. We will then summarize the value of NbS and also highlight the 'cost of doing nothing'.

How nature protects people: **protective benefits**

To understand how nature protects, let us look at the mechanisms at play, learn how to value benefits, review evidence, and look at the cost comparisons between structural and nature-based solutions.

Mechanisms of protection

At its simplest, mangroves, reefs and other coastal ecosystems act as 'speed brakes': they stand in the way of an incoming force. A meta-analysis of **coral reefs** in the Indian, Pacific and Atlantic Oceans revealed that on average, reefs dissipate 97% of wave energy that would otherwise impact shorelines.[5] The authors estimate that at least 100 million people benefit from reef protection — primarily in Indonesia, India and the Philippines.

Figure 2: How mangroves and reefs prevent erosion and reduce the force of waves, storm surges and flooding. Losada et al 2018:7.

Closer to the shoreline, **mangroves** do their part to reduce hazard exposure by reducing wave heights and retaining sediments, thereby decreasing the impacts of flooding and erosion (Losada et al 2018: 5).[6]

In other ecological settings, **marshlands** and **seagrass meadows** have similar effects towards retaining sediments, and have some effect on wave attenuation (Björk et al. 2008:17).

On the shoreline itself, **dunes** can act as natural dikes that reduce exposure to flooding. **Coastal forests** and **shelter belts** act as wind breaks. Windspeed (and thus the load on roofs of houses during storms) is reduced over an extensive area landward — up to 30 times the height of trees (Wight/Stuhr 2002).

How to value protective benefits

The protective benefits of coastal ecosystems are calculated by comparing different scenarios and the respective damages and losses in adjacent communities. For instance, one can compare hazard losses in communities that are protected by a coastal ecosystem with those in unprotected communities and take the difference as the protective benefit. Such techniques are explored when discussing cost effectiveness in stage 4.

Results from around the world

Analyzing protective benefits, let us first look at those of specific ecosystems (i.e. irrespective as to whether there was a nature-based intervention). This then informs the analysis of cost effectiveness and how green solutions (NbS) compare to gray (structural) and hybrid efforts.

Amongst the various ecosystems, the protective benefit is best documented for **mangroves**. A 2018 global study concludes:

- that mangroves reduce flooding to at least 18 million people,
- that without mangroves, 39% more people would be flooded annually, and that flood damages would increase by 16% and USD 82 billion annually (Losada et al. 2018:31-33).

Another study estimates that 100 million people receive protective benefits from existing **coral reefs** (Ferrario et al. 2014:6), though it did not quantify the benefits.

While comprehensive global valuations of overall protective benefits from the various coastal ecosystems remain elusive, there is an abundance of case studies that demonstrate strong protective benefits of ecosystems and nature-based solutions.

For instance, the protective benefits from mangrove reforestation in Vietnamese communities exceeded associated costs by factors between 1.6 and 58.5 (IFRC 2011:21). Conservatively assuming a ten year-return period for major typhoons, the overall avoided losses of USD 37.8 million identified in five (of the project's 166) communities alone exceeded the total program cost 4.2 times (ibid).

Cost effectiveness: Green, gray and hybrid

Because local conditions vary so much, it would be misleading to say that one type of protective measure is more cost-effective than another (Pontee et al. 2016:8). Green solutions (NbS) are constrained by the suitability of the habitat to the environment at a site. For instance, you cannot plant mangroves if soil and tidal conditions are simply not right. In certain conditions, structural or hybrid measures may be the most cost-effective.

That said, structural solutions tend to require a higher initial investment. A study focusing on the Caribbean concluded that coral reef and mangrove restoration projects in that region are 10 to 100 times cheaper than artificial coastal defenses (Narrayan et al. 2019: 1).[7]

As we will see in stages 3 and 4, assessing specific conditions and is critical to finding the most cost-effective and sustainable solution in any given context. As a cost comparison between reefs and breakwaters (Ferrario 2014:5) shows, there is a huge range of costs for both green and gray solutions.

6. The mangroves' effect on wave attenuation depends in particular on the width of the mangrove belt (from sea to land) as well as its composition. Relatively narrow belts can reduce the height of wind and swell waves. A 2012 study of these waves (with an initial height of up to 70cm) found that belts 100 meters in width reduced wave height by 13 - 66% (McIvor et al 2012:3). Wider mangrove belts can also attenuate storm surges; rates of surge height reduction have been recorded at 4 - 48 cm per kilometer of passage through mangroves (Spalding et al. 2014: 51).

7. For instance, the study concludes that the median costs for coral reef restoration in the Caribbean are USD 1 million per linear kilometer (assuming a width of ten meters), compared to USD 19 million for artificial breakwaters and levees.

   For mangrove afforestation, median costs of USD 2,000 were identified for all areas outside the Caribbean (mainly South-East Asia and the Pacific) and between USD 14,000 to 32,000 in the Caribbean. The study notes enormous economies of scale — the larger the afforested area, the lower the per hectare costs.

   One hectare is an area of 100 x 100 meters, so protecting one linear kilometer of coastline with a 100 meter-wide mangrove belt equates 10 hectares. This would cost between USD 20,000 (non-Caribbean) and 320,000. By comparison, the costs for a seawall range between USD 5.7 and 19.8 million per kilometer.

THE TRIPLE DIVIDEND OF RESILIENCE

Many cost-benefit analyses focus on the protective benefits — avoided losses and lives saved.' A 2015 paper argues that this practice underestimates the benefits. Aside from the protective benefits (the **first dividend**) that only materialize when hazards hit, the paper makes the case that investments have two further dividends that materialize in an ongoing manner (Thanner et al. 2015).

The **second dividend** is about unlocking economic potential: whereas few would invest in a hazard-prone area, economic potential is unlocked if the same area is better protected. For instance, one may not build a hotel if there is substantial flood risk, but may do so if the risk is significantly reduced.

The **third dividend** concerns numerous other benefits – organizational, social, environmental and economic. These tend to be very high in the case of NbS — for instance, intact reefs may mean more fish stock and greater potential for tourism.

8. Mangroves can provide benefits to lives and livelihoods, and thus reduce socio-economic vulnerability. Poor people suffer disproportionately from natural hazards because a) they are exposed to floods and storms more often, b) they lose more as a share of their wealth when hit and c) they receive less support for recovery. For an excellent summary of the disproportional effect of disasters on poor populations, see Hallegate et al. 2017: 25-62. As Losada et al. (2018:35) note, mangroves contribute most to countries with high hazard exposure and high socio-economic vulnerability.

9. Several case studies in this guide demonstrate the strong social benefits of NbS. See case studies B.1 (Vietnam), B.3 (Papua New Guinea) and B.4 (Belize).

Thinking of overall cost effectiveness, there's also a big 'but': So far, we have only looked at the protective benefits of NbS. Naturally, these benefits (avoided losses) only materialize in a hazard event.

But compared to 'gray' options for coastal protection, 'green' solutions offer much stronger ongoing benefits. These can be grouped as economic, social and environmental in nature.

Economic co-benefits

Since protective benefits are primarily of an economic nature, we refer to other ongoing gains from NbS as 'co-benefits'.

These include:

- **Fisheries and aquacultures**: Intact and healthy ecosystems are habitats for a wide range of fish species as well as crabs and molluscs. The gains in terms of aquatic abundance provide strong benefits to these industries. In the Caribbean alone, this overall value has been estimated at USD 110 million for coral reefs and 66 million for mangroves (Heck et al. 2019: 7).

- **Tourism**: Intact coral reefs attract not just more fish, but also more tourists. The gains from coral reef tourism in the Caribbean are estimated at USD 5.7 billion annually (ibid). Coral reefs attract foreign and domestic visitors and generate revenues, including foreign exchange earnings, in over 100 countries and territories. Globally, the benefits are estimated to be worth USD 35.8 billion per year, with the highest shares in Eqypt, Indonesia, Mexico and Thailand (Spalding et al. 2017:109).

- **Unlocking development potential**: As a spin-off from their protective function, NbS create safer housing and development zones that raise property values and increase development opportunities. With NbS, property along the coast may be flooded less frequently, allowing those who live there to have more secure housing and businesses in this zone.

  Meanwhile, agricultural productivity and yields may increase as a result of both combined protective function and improved environmental conditions (e.g. lower risk/prevalence of saline intrusion). These '**second dividend**' gains (see box and Thanner et al 2015: 21-24) have yet to be further quantified but can be reasonably expected to be very substantial.

Food access: **benefits on food security**

There are numerous other benefits of NbS for human well-being, including positive outcomes for health, nutrition, and food security. A recent study estimates that 10% of the world's population depends on the ocean as a source of protein and employment — and identifies an impending crisis of marine food insecurity as a result of climate change, ocean pollution, and environmental degradation (Taylor et al. 2019).

Although the quantification of the role of coastal ecosystems on food security itself remains elusive, aside from the direct use value of increased fishstock (Barbier et al. 2011), it is evident that NbS have substantial benefits to the food security of coastal communities. This benefit can be particularly strong in communities with high marine food security dependence (Taylor et al. 2019:1408).

In fact, the food security benefits of NbS have a social dimension: with improved fish and aquatic stock, the poorest and most marginalized community members have greater access to an alternative food source, while collection of non-timber forest products (NTFP) can provide an additional source of income. Importantly, the access to food from coastal ecosystems can raise the capacity to cope with stressors, in particular when other food sources fail to suffice.[8]

Nurturing community spirit: **social benefits**

Much more than structural solutions, NbS require collective engagement and action of the wider community. Numerous case studies have shown the sense of pride and satisfaction when an ecosystem has been restored as a result of strong community stewardship.

Structural measures such as dams and breakwaters require heavy equipment and are owned by the government. By contrast, NbS require many hands, and many communities see the resulting solutions as theirs.[9]

Green lungs: **environmental benefits**

NbS also offer a wide range of environmental benefits, both locally and globally.

Locally, reefs, mangroves, seagrass, marshlands and swamps add nutrients, filter water, prevent soil erosion and sustain or rehabilitate local biodiversity of the wider flora and fauna. In the Caribbean, the value of local biodiversity protection from coral reefs has been estimated at USD 251 million per year (Heck et al. 2019:5).

Globally, these ecosystems play a crucial role in carbon sequestration, as well as biodiversity. On average, mangroves absorb as much CO_2 per hectare as tropical rainforests. Mangroves cover 13.7-15.2 million hectares globally (equal to the size of Bangladesh) and are estimated to sequester 31.2 - 34.4 million tonnes of carbon annually. They are amongst the most carbon-rich ecosystems on the planet (UNEP 2020:5).

In the Caribbean, the value of carbon sequestration from mangrove ecosystems is worth USD 6.7 billion per year.[10]

In Vietnam, the 9,000 hectares of mangroves planted through a Red Cross project sequesters USD 13.4 million worth of carbon per year (annualized average 2011 - 2025).[11]

FOOD SECURITY A fisherman in West Sumatra, Indonesia, processes dry fish. Globally, 10% of the population depends on oceans as a source of protein and income. NbS can help retain the role of marine ecosystems in food security. Photo: Samadhi Marr, Banyaneer

The plants that villagers from 166 communities once put into the mud now absorb the CO_{2e} emissions of 425,000 Vietnamese each year (at 2005 emission levels, without land use change).

The bottom line: **combined benefits**

Measuring benefits of ecosystems is not easy — and unsurprisingly, no comprehensive valuation of coastal ecosystems exists that would show the combined value of all coastal ecosystems for all benefit types listed here.[12] Globally, the annual total value of ecosystem services provided by coastal areas and wetlands was assessed at USD 54.1 trillion in 2011 (Costanza et al. 2014:156) — equivalent to 72% of the world's combined GDP in the same year. Mangroves account for almost

10. 2019 USD, on the basis of USD 15/t CO_2. See Heck et al 2019:5.

11. Figures based on IFRC 2011:22, adjusted to USD 15/t CO_2.

12. Most valuation studies either focus on geographical areas, particular ecosystems, or specific types of benefits, or some combination thereof. Barbier et al. 2011 is an exception, but it excludes protective benefits.

PROCESS NAVIGATOR

- **Coastal ecosystems** offer numerous benefits, including protection from severe weather. But they are under threat.
- **Understand them.** No two contexts are the same — make sure you know dynamics and conditions.
- **Protect them** so they can protect you.
- **Leave them, if** they are intact. On its own, preservation is the cheapest and most cost-effective option.
- **Restore them, if** they are degraded - then monitor, manage and maintain outcomes.
- **Rebuild them, if** they are defunct. This is the most challenging option.
- **Integrate them** into wider solutions — such as mixed models (also called hybrid or green-gray).

half of that (USD 24.8 trillion), followed by coral reefs (USD 9.9 trillion) and seagrass (USD 6.8 trillion) (ibid). However, these calculations do not include any protective benefits.

Despite these limitations, we can safely conclude that coastal ecosystems offer enormous **value to humanity** through environmental, economic, social and protective benefits. Yet, **coastal ecosystems continue to be at threat**. Between 1997 and 2011, some 34 million hectares of coral reefs and 37 million hectares of mangroves have been lost (ibid).

Protection of existing mangroves, reefs, and other coastal habitats **is the most cost-effective option** for maintaining and strengthening these benefits. The cost for restoring coastal ecosystems that have been lost or degraded is always greater than preventing this loss in the first place. As a user of this guide, you should always strive for protective arrangements being part of your overall solution. If ecosystems are intact, focus on protection. If they are degraded, combine efforts of restoration and protection. This guide cannot tell you what the best solution is for your context. Instead, it guides you through the process of finding it, and then implementing it to the best possible outcome in terms of combined benefits.

Doing nothing: **counterfactuals**

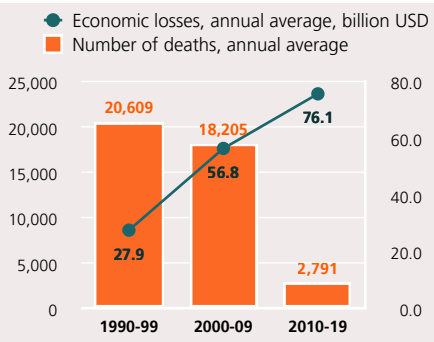
There is one more thing to raise before we launch our journey through the eight stages. Imagine you live in or work with communities along the coast that have high hazard exposure, partly as a result of severely degraded and defunct ecosystems.

Maybe your reef has been suffered bleaching, maybe shrimp farms now line the coast where mangroves once were. One could of course decide to do nothing. Maybe NbS seem too hard. Maybe you prefer DRR solutions you have more experience in. Life vests and megaphones, training response teams, and setting up evacuation systems and routes: maybe they seem to be more feasible. They are all valid and good options. But on their own, few of these measures will **truly transform conditions, reduce exposure, reduce vulnerability, and enhance resilience** in the long run. Integrating NbS into more conventional DRR enables coastal communities to improve long-term protection of lives and livelihoods, while addressing related climate and development challenges.

Fig. 3 | **Storm toll**

Progress in DRR over the past decades led to fewer deaths from tropical storms. However, economic damages have risen sharply over the same period.

Source: EMDAT.
All USD values have been adjusted for inflation to 2020.



The impacts of **climate change** are felt already by communities around the world, including those along the coast. While you may not notice a 20-centimeter increase in sea level directly, you notice the impacts: increased erosion, salty groundwater from wells, reduced crop yields, more intense or frequent storms, more drought. Fortunately, over recent decades, life vests and megaphones have helped reduce the number of storm-related fatalities (see figure 3).[13] But with economic damages continuing to the rise, the focus must be expanded to protecting livelihoods as well. This requires an expansion of the conventional DRR toolkit.

The 2019 report 'The Cost of Doing Nothing' warned that by 2050, 200 million people may be in need of post-hazard humanitarian assistance each year, with expected losses steeply rising (IFRC 2019:23). The first priority, the report concludes, is to **reduce long-term vulnerability and exposure** — exactly what NbS are able to do.

So, let's embark on our journey **towards enhanced resilience**. It is the best way forward.

13. The UNISDR's 2019 Global Assessment Report on Disaster Risk Reduction warns that 92% of fatalities since 1990 have occurred in low- to middle-income countries (all hazard types), and that economic losses continue being under-reported (ibid:vii).

The eight stages towards enhanced coastal resilience

SHADED, PROTECTED Two women monitor the health of local mangroves. Photo: The Nature Conservancy

STAGE 1 IDEATE & SCOPE

Learn how to form an idea and to come up with a rough sketch.

Like all journeys, our journey towards enhanced resilience starts with an idea: where exactly do we want to go?

Like all journeys, our journey has a starting point: from where do we start?

Like all journeys, our journey needs a route: how do we best get from here to there?

Whatever you plan to do or achieve in terms of enhancing resilience, you will need to engage and convince others — the wider community, government agencies, local businesses, and so on.

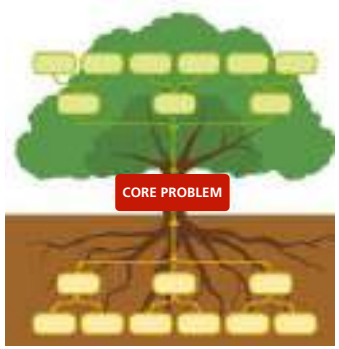
Before you approach others, you should have a rough concept of what you would like to propose as a basis for early discussions. Your idea does not need to be perfect or detailed yet. Instead, you should expect that it will evolve and change as inputs and insights from others are gathered.

Step 1.1 | Ask. What is the problem?

You may already have one thing (or more) in mind that you regard as a **problem for the community** or a particular location. You may have observed increasingly salty groundwater, more storms, floods or damage to nearby ecosystems. If you don't have problems in mind yet, ask yourself, and possibly friends or neighbors: what are the issues that hold the community back from becoming more resilient?

In most cases, you may find several problems. You could rank them by priority/urgency, or even try to do an early sketch of a **problem tree**. In such a sketch, you visualize the links between your observations: What may be the causes (shown as the roots)? What is the core problem (the trunk)? What are the consequences of the core problem (the branches)?

Watch a short video on problem trees (with examples) if you can. Again, at this early stage, don't spend too much time on this analysis. You are unlikely to have the full information yet. At stage 3, the views and the knowledge of others will be used for a more detailed analysis.



Step 1.2 | Brainstorm. What is the overall context?

Now move beyond the main issues and reflect on these three aspects — your community, your environment, and your external settings. Here are some questions you may want to think about. It's fine to not have the answers to all of them yet.

- **Your community:** In your community, who are the main players or groups affected by the problem, or possibly contributing to it? Try to think of different perspectives (e.g. women/men, different livelihood groups such as those making their income from fishing, agriculture, tourism).
- **Your environment:** What are the ecosystems in or around your community? To what extent has their health or status changed over the years? If their status has declined, why has this been the case? What functions have these ecosystems played traditionally? To what extent do they continue to play these functions?
- **Your external settings:** What agencies are in charge of managing the ecosystems? What regulative/protective frameworks or management plans exist? To what extent are these enforced? What other plans exist (land use/development)? Are they in line with the frameworks or do they compete? What funding exists for managing ecosystems, and what could be potential additional sources of funding?

Write down your notes on a simple piece of paper or download and fill out the **idea scrapbook** (appendix F.1).

Step 1.3 | Form ideas. What could be done about the problem?

The next step is about the formation of ideas as to how the problems you have identified may be solved in your given context. Based on your experience and on what you have read so far, maybe you already have something in mind?

You should first define your objective, then explore ideas as to how that objective may be achieved.

Define your objective as a status in which the main problem has been addressed. This can be a very broad objective (e.g. "enhanced community resilience"), focus on concrete results for the community (e.g. "reduced damages and losses from storms"), or have the local ecosystem itself as the focus (e.g. "improved status of mangroves").

Next, **think of actions** that would be needed to reach your objective. To get ideas, you may want to have a peek ahead at the start of stage 4to see an overview of nature-based solutions.

Usually, several different actions are needed to reach your objective, so you may want to list a couple of possible actions.

Let's think of our example objectives.

- **Improved status of mangroves:** combine direct actions (active restoration) with indirect actions (regulations or measures that prevent further damage).
- **Reduced damages and losses from storms:** this objective is broader, so you may need further actions in addition to mangrove reforestation. These could include structural measures (e.g. reinforcement of houses), trimming of trees around houses, as well as preparedness measures (early warning systems, evacuation systems, response teams).
- **Enhanced community resilience:** this the broadest objective and may include all the actions above, as well as further measures to improve overall conditions. Depending on the problems you identified, this may include food banks or saving groups (to raise coping capacity), health and hygiene promotion, or the construction of wells and latrines.

Whatever you come up with is your perspective and yours only, and will be are very **useful as a basis for discussion**. Again, don't spend too much time on it. Recognize that you may not have the full information yet. The insights of others around you will make the eventual action plan richer and better informed (we'll get to planning at stage 5).

Step 1.4 | Scope. Who are the stakeholders & potential partners?

For now, you should think about those you would like to discuss your ideas with. Consider the following entities and groups:

- **In the community:** leadership (mayor, village head, council, elders and informal leaders), groups (e.g. cooperatives, business associations, disaster management teams, civil society/interest groups, social, cultural, religious groups)
- **Government:** local authorities (lowest administrative levels), specialized departments and agencies at relevant level (e.g. planning, natural resources/environment, fishery, disaster management, economy & trade, public works).
- **Other stakeholders:** NGOs with relevant expertise, Red Cross/Red Crescent, tourism and industry associations.

Congratulations! You now have a rough sketch of problems, context, ideas for possible actions and a list of stakeholders and possible partners. At the next stage, we'll learn how to best engage with others and collectively take the idea forward.

TOOLS: IDEA SCRAPBOOK & PROBLEM TREE

Download the **idea scrapbook** (appendix F.1) to write down your idea, going through the key elements:

- Problems
- Context
- Possible solutions
- Stakeholders & possible partners

In addition, you may want to develop a **problem tree**. Two versions are available in the application toolbox (appendix F.2a, appendix F.2b).

USEFUL TIP

As part of your scoping, you may already be able to identify peer organizations such as local NGOs or associations with objectives similar to yours (such as marine conservation). Explore existing initiatives and consider forming partnerships early on.

Such partnerships could save you a lot of research and would help you prepare for meetings with government agencies (see step 2.1).

STAGE 2 ENGAGE OTHERS

Learn how to approach, convince and engage the key stakeholders.

Engaging, convincing and collaborating with communities, government agencies and other key stakeholders is not just a 'nice to have'. It's a must. In fact, where NbS have failed to succeed, a key reason is not having brought all parties on board, local communities in particular. (UNEP 2020:17).

But how do you start and where? You already have a rough idea of the stakeholders and potential partners you should consult. Of course, the list of stakeholders may be long, so it's good to be strategic.

Generally, it's a good idea to **start with the government** side: take your idea to the local authority as well as the department you think is most relevant for your proposed action. Start with bilateral meetings and build trust. Government agencies and authorities may: a) have information on related frameworks and policies, b) know about projects that are underway or planned, and c) be able to point you to others who know more in relation to your proposed idea.

The engagement with others is a process of **gradual upscale and reiteration**: over time, you will consult more entities and people, until you have all the critical people on board. This process takes time. Allow for at least one month of initial meetings and discussions before you proceed further.

Two points should be highlighted. First, make sure that you include actors with **technical expertise** in the process. Failing to understand the inherent complexities of ecosystems may lead to ineffective actions and frustration amongst all involved.

Second, whether you are familiar with the target communities or not, ensure that **community engagement** is both broad and inclusive. Avoid working with just a few people (which may seem easier and faster).

Let's go through this process together.

Principles & tips

- Identify government **regulations and policies** that may be relevant to the actions you are considering.
- Ensure that you are **inclusive** in your engagements in terms of gender (women, men), age (young, old), income level (high to low), profession, disability, power (influential, marginalised), as well as relative exposure and vulnerability.
- Seek and use **technical support**. Many of the techniques for preservation, restoration or rehabilitation require specialised knowledge and skills. In many cases, these can be sourced locally and will promote long-term relationships and increased benefits of projects.
- Gradually build the engagement and work towards a **common understanding** of problems and possibilities.
- **Be sensitive** to local customs, processes, relationships and interactions.

Step 2.1 | Consult government agencies

Before your first meeting, get prepared: have your proposal ready, learn about the agency/authority and its mandate. If possible, study existing laws, policies and plans at the national level and in the area in which you'd like to solve a problem.

A good understanding of how government agencies work — and their motivations — is important to ensuring positive partnership outcomes. Start with bilateral meetings and then extend the group of departments/agencies as relevant.

Consider the institutional boundaries and mandates to ensure that you work with the most relevant agencies. Some organisational policies compel agencies to share information with each other when making decisions that may have a broader impact.

Among other functions, government agencies implement and enforce policy. Learn about the overall **structures** — the

different **administrative levels** (e.g. national, provincial, district, sub-district), as well as the different **functional departments** (e.g economy, fisheries, agriculture, education). You can think of administrative levels on a vertical axis (on top of each other) and of functional departments on a horizontal axis (next to each other). The overall structure of departments and levels may initially appear confusing, but it's good to understand it since different departments at different levels may have some mandate over policy areas that are relevant to your idea or concern.

Many departments can support discussions and add value, so scope broadly. For instance, the departments of the environment and the department of tourism may both be interested to contribute to support reef preservation or restoration, as this would relate to the mandates of both.

Look for **laws and policies** that relate to disaster risk reduction, agriculture, water, aquaculture/fisheries, climate change, health, infrastructure and economic development.

Assess the **understanding** of NbS among departments. Some departments may already be implementing or supporting NbS. If there is limited understanding or experience, explain what you know — awareness-raising and advocacy can be powerful!

The commonly high benefit-cost ratios of NbS can be useful leverage. Similarly, if policies already promote the use of NbS, or where NbS would run in support of policies and plans, you may have a good entry point to gain support from government departments. **Make the case** for NbS where suitable.

NbS have long progressed from niche towards mainstream, and there is increasing understanding and recognition of their cost effectiveness.[14] Capacity-strengthening of government through involvement in NbS is often a by-product of positive engagement. Remember that many departments are staffed with people who have specialised technical skills — they may already understand NbS and become key allies.

It is useful to **map government agencies** and identify key allies, linkages between departments and policies that can support or enhance NbS. You should do this with key agencies to ensure an accurate understanding of how departmental mandates link to each other, and across levels. This can later be incorporated into stakeholder mapping (see step 2.3).

In **urban contexts**, administrative structures and departmental responsibilities tend to be particularly complex. Nevertheless, it is no less important to engage with government and industry to ensure effective planning. This requires the involvement of city actors such as local government agencies, universities, business and industry.

A practical example comes from a climate resilience program in Southeast Asia. This established 'climate change core groups'. Each core group consisted of 20 - 40 members from municipal and provincial governments, technical institutes and NGOs. Through their engagement, members learned about the benefits of NbS and green infrastructures as foundations in urban planning (see Asian Development Bank 2016).

In urban contexts, links among government agencies are more dense, diverse and dynamic. Establishing strong relationships with these agencies here is especially crucial for ongoing success.

Step 2.2 | Initiate community engagement

Few nature-based solutions can be implemented without the support of nearby communities. In fact, their active support is often required. Thus, fostering community ownership and long-term commitment always important to a project's success.

HOW STAGE 2 LINKS TO...

The Road Map to Community Resilience (IFRC 2020)
The Blue Guide's stage 2 broadly links to the Road Map's stage 1 ('engage and connect'). However, the steps (and their order) are slightly different.

This is because the Road Map is geared towards Red Cross and Red Crescent Societies, whereas the Blue Guide addresses a broad spectrum of users (you may be from a community, the government, a RC/RC Society or an NGO).

Both manuals however include three aspects of engaging the wider community, government and stakeholders. In addition, the Blue Guide highlights the inclusion of agencies with technical support, which is important due to the complexity of NbS.

You may chose to follow the order in the the Road Map, as long as the technical expertise is on board.

The Flood Management Green Guide (WWF 2016)
The Blue Guide's Stage 2 links to several areas in the Green Guide, including:

- Chapter 3, section 3.7: cross-cutting issues;
- Chapter 5, section 5.8: resources and cost planning in selection and implementation of structural methods;
- Chapter 6, section 6.6: urban flood governance; and
- Appendix B: the six domains of gender analysis.

14. See the CBD Technical Series No 93 (2019):19-36 for a useful 'primer for policy-makers' on the benefits of nature-based solutions.

LISTEN, DISCUSS, ENGAGE Local residents and the TNC project team in Micronesia during a community meeting. Photo: The Nature Conservancy

Communities should be engaged throughout the entire process, so go beyond initial community consultation. They must be part of assessments and decision-making (stages 3-4), planning (stage 5), implementation and monitoring (stage 6), as well as analysis and systematic learning (stages 7-8).

Externally-funded projects always have an end. Communities, by contrast, will be there for good. Local ownership — the willingness and capacity to sustain outcomes and continue pursuing activities — is therefore critical.

You should consider some key concerns about community engagement. First, it must be **inclusive** and representative of all groups in the community. This means that women and girls, men and boys, people living with disabilities, marginalized groups and older men and women are represented. In urban contexts, this can be more challenging. Working with existing groups, such as those linked to educational and faith-based institutions, childcare facilities, or hobby groups and city clubs, can be a way to overcome this.

Second, do not assume that local communities do not know anything about NbS — they may simply use a different term. Explore and harness **indigenous knowledge and practices** of the restoration and protection of natural environments. In many cases, such practices are known and have been implemented long before NbS came along, though some may have been lost or discounted as a result of colonization, modernization and migration. When promoting indigenous practices, ensure that consent is obtained from community leaders.

Third, consider when is the best **timing** for community meetings to ensure safety and enable access for all community members. At what times of the day and parts of the year are people available?

Meet with formal and informal **community leaders** first. Explain your concern and seek support from leaders to identify a good and representative cross-section of the community. Be specific about who should be involved.[15] You will need strong support from them to manage community consultation and participation effectively. You may also need to get their consent to engage with the community they lead.

If you are not familiar with the local communities and customs, gather **background information,** including community location, population size, major occupations, and key stakeholders. Learn about ecosystem zones and their boundaries, as well as systems of **informal governance** over natural resources.

15. A common pitfall at this early stage of engagement is over-reliance on community leaders in the selection of people who are to be consulted. To avoid this, have a strategy in mind for selection — for instance, stipulate the criteria and then work with community leaders how these criteria can be met. Criteria may include balance by gender, geography, income, and livelihood/professional group.

Identifying **social groups** and major **decision-makers** will be critical for community-based processes.

Once you have a good understanding of the local context, dive deeper and explore the following questions with a representative and inclusive sample of the community:

- How do you use your coastal areas? Who has control on how to use or manage these areas?
- Has the shoreline, reefs, seagrass, mangroves etc changed over time? If so, how? What may have caused this change?
- If changes are negative, what have you done to try to address these changes?
- What weather, seasonal and natural hazard events have impacted the coastline?
- How do you think climate change will impact on your coastline?

You may choose to ask these questions in a) a broad focus group, b) through a series of smaller focus group discussions (based on specific groups within the community), or c) a set of interviews with individuals.[16]

Try to disaggregate responses by social characteristics (gender, age, ethnicity and other social differentiation) to capture the perspectives of different people in the community.

Initial sessions with community representatives should include a brief overview of main challenges, including those related to hazard exposure, damages and losses, and aspects related to adjacent coastal ecosystems. Be sure to invite community members to conduct a more detailed assessment later on (see step 3.1).

Step 2.3 | Map and engage stakeholders

Stakeholders are individuals, groups or entities who may not belong to the local community but who are engaged in or have an interest within the locality and have influence over activity, people and practices. Stakeholders also include local groups of people who identify as part of a collective, such as fishing cooperatives or religious associations.

Engaging stakeholders is critical, as their interests and influence on a community may be a force that can be supportive, unsupportive, or opposed to the overall process and outcomes.

Take your initial list you created in step 1.4 and discuss with community and government leaders what additional parties may have a stake in the community or target area. Here are some examples as to who you should think of:

- Estuary or coastal zone users (recreational, industry, cultural)
- Land and sea managers and regulators
- Title holders, neighbors
- Potential project funders
- Potential supporters and volunteers
- Subject matter experts (e.g. marine ecologists, biologists, resource managers, fishers)
- Potential spoilers — those who who benefit from the current state, and may thus be opposed to your planned efforts.

Explore each stakeholder's potential gains and losses from your planned efforts, as each may turn out to become a partner, supporter, funder, or spoiler towards your planned efforts.

Next, identify which stakeholders are likely to be affected by the proposed actions, either positively or negatively. For those affected negatively (the potential spoilers), consider what actions or arguments would be needed to work with the community towards more beneficial solutions.

USEFUL TIP: ENGAGING YOUTH GROUPS

In many places around the world, groups of teenagers and young adults have become a strong voice for action on climate change and conservation. Explore whether such groups exist in your area, connect, and involve these groups. See two case studies as great examples.

Case studies

- **Read B.2 'Recovered reefs, raised resilience'.**
- **Read B.4 'Young stewards with a passion'.**

16. You should opt for separate groups (option b) or individual interviews (option c) if you can reasonably assume that at least one of the following conditions prevail in your context:
    - Some groups are hindered from voicing their concerns and insights (e.g. women's voices are not heard in the presence of men)
    - Specific groups of the community have significantly different perspectives or are affected by key issues in different ways.

TOOL: STAKEHOLDER MAPPING TEMPLATE

Use the **stakeholder mapping template** (appendix F.3) to:

- Identify and list stakeholders.
- Group them by priority (levels 1-3).
- Add them to the matrix of influence/power and stance/interest.
- Use the results as a guide for ongoing stakeholder engagement.
- Update the stakeholder matrix.

Explore whether and how likely spoilers may change their stance and have your arguments ready. In a mangrove re-forestation project in Vietnam, for instance, shrimp farmers who contributed to the earlier removal of mangroves were shown to have the highest proportional protective gains from mangrove protection (due to the high relative value of their assets).

Identify the strategies you will use to engage with stakeholders and what their roles and contributions could be to the process. Consider using the IFRC's eleven resilience dimensions to categorize and group possible stakeholder roles and contributions. Ultimately, aim to connect stakeholders to the community in a way that supports the envisaged efforts.

As it will be difficult to fully engage with all stakeholders at the same level, consider grouping them by priority.

- **Level 1 stakeholders:** those with the strongest interest and potential influence and impact over planned efforts, including those most affected by them. Engage with these closely and frequently.
- **Level 2 stakeholders:** those with medium influence or impact. Engage with these these regularly.
- **Level 3 stakeholders:** those with limited interest, influence or impact. Inform and invite to main meetings.

Once identified and thus grouped, approach stakeholders by priority and invite them to participate in the process of assessment, planning and implementation. Engaging with them early can reduce the risk of conflicts later on. Ongoing stakeholder analysis is important throughout a project lifecycle as circumstances continually change, so review and update your analysis regularly.[17]

Step 2.4 | Explore technical support

Most of the NbS presented in this guide require some level of **scientific input.** Fortunately, many entities exist with experts who may be willing to contribute specific expertise. If you have not yet identified suitable experts amongst the stakeholders and government departments that you have started engaging with, explore nearby **universities, research centers** and other **departments** (possibly at higher administrative levels). Depending on your context, you may require marine biologists, engineers, ecologists, social scientists and/or hydrologists. Importantly, you will also need to to have **climate expertise** on board to gain insights on regional impact projections of climate change, in particular on the impact on local ecosystems.

Community groups and stakeholders may be able to initially develop rules and regulations on the protection of threatened areas but will need to review these with technical experts to ensure that appropriate protection can be achieved (Gombos et al. 2014:17). For example, while establishing Locally Managed Marine Areas (LMMA) can be a low-cost activity, marine biologists and ecologists who understand the requirements of specific species will ensure that the most ecologically appropriate areas can be selected.

By law, some countries require feasibility studies or **environmental impact studies** (EIS), using established procedures and professional standards before undertaking any medium to large scale project. Connecting with relevant departments will inform you of the processes that may be required.

Universities are often an **exceptional opportunity** to tap expertise, often at minimal to no cost to the project. Partnering with universities can utilize undergraduate and graduate students who may take part in projects as part of their studies. Supervised by technical experts, they can support community activity in designing, implementing and monitoring preservation and restoration projects. Universities have a wealth of knowledge, such as studies and further technical guides. The ARC Centre of Excellence Coral Reef Studies that is associated with three Australian universities has published a number of guides on coral health in the Indo-Pacific and Caribbean.

17. Once you have connected with stakeholders, you may wish to complete a stakeholder matrix that groups stakeholders by influence on the x-axis (level 1 to 3) and by level of interest on the y-axis. Grouping stakeholders in such a matrix can inform your respective strategies for engagement.

Reaching out to local and regional universities can provide additional technical resources for your envisaged efforts.

Conservation agencies can be a further source of technical expertise and, in some cases, of funding for certain activities. Conservation agencies working at the forefront of NbS globally include The Nature Conservancy (TNC), World Wildlife Fund (WWF), Wetlands International, The Wildlife Conservation Society, and Conservation International.

Numerous approaches have been developed that combine local environmental factors, climate change and ecosystem degradation into **standard risk assessments**. Examples include the Risk and Vulnerability Assessment Methodology (RiVAMP), Adaptive Co-management and Cooperative Research, Participatory 3-D Mapping, and other participatory methods. All these methods aim to link bottom-up to top-down actions but need to be contextualized to the specific situation.

Step 2.5 | Form a steering committee

By now, you should have brought the various partners and stakeholders on board. Great!

Before proceeding to the next stage, make sure that the various partners and stakeholders can continue to be meaningfully engaged. Of course, it would be impractical to go through all the steps with hundreds of people.

Instead, you should **form a steering committee** or similar group with around 5-15 members — small enough to enable effective discussions and big enough to have all major stakeholders included. The steering committee should offer a range of perspectives and areas of expertise.

The steering committee will assume the **role** of a board (similar to that of a company or organization). Its role is to steer the overall process as you progress through the next stages.

Initially, the committee will set the course, overseeing the assessment, defining the objectives, identifying the solutions, and making a plan (stages 3-5).

Later, as you move through implementation and learning (stages 6-8), the steering committee may be complemented by a full-time **operational team**. This is strongly recommended for any larger efforts, as the workload associated with implementation will likely exceed the time steering committee members can make available, in addition to their other duties.

At a minimum, the steering committee should include:

a) the local **authority** in charge,
b) the most relevant **government agency**,
c) multiple **community** representatives (that include women and men, marginalized groups and specific interest groups, such as fisherfolk and disaster management teams),
d) technical **experts**, and
e) the most relevant other **stakeholders** (NGOs, National Red Cross/Red Crescent Societies, businesses).

Each member of the committee should have an assigned role, while also liaising with others in his/her organization. The rules and roles should be set out at the start, including anticipated time commitments and meeting schedules.

Though time commitments will vary throughout the process, members should plan to meet and communicate with each other frequently during the initial stages. The workload and time commitments will be reduced during implementation if an operational team is formed to take on the day-to-day tasks.

In addition to forming a steering committee, you should also ensure that the **wider community and stakeholder group remains engaged and informed**. See the community engagement hub for a list of tools and resources to effectively engage communities.

WATCH: RESILIENT ISLANDS (1:24)

The video gives a short overview of a coastal resilience project led by the The Nature Conservancy and the International Federation of Red Cross and Red Crescent Societies (IFRC) in Jamaica, Grenada and the Dominican Republic. Find out more about the project here.

STAGE 3 ASSESS CONTEXT

Learn how to assess community risk, ecosystems, the external context and how to set your objectives.

Your journey started with the identification of a problem and a an idea as to what could be done about it. By now, you have consulted with government agencies, communities, and other stakeholders. Through these discussions, you have likely gathered a lot of important information that has deepened your understanding of the problem and what can be done about it. Great job!

Now, let's use a systematic approach to gain an even better understanding of the problem(s) so we can identify solutions (stage 4) and make a detailed plan to address it/them (stage 5).

Here, we'll assess the local risks (hazards, exposure, vulnerability), nearby coastal ecosystems, and other factors beyond communities and ecosystems that can may influence the possible way forward.

Let's go!

Principles & tips

- Keep the **steering committee** engaged in the process.
- Get deeper insights into **community risk and capacity** through one of the available tools. Ensure that the right **technical expertise** is on board for the assessment of local marine ecosystems and the risks they themselves face under climate change projections.
- Include a **wide range of departments** in the assessment of external factors to get a broad view of frameworks and plans
- Ensure that you **communicate the results** of the overall assessment with the wider community and request feedback.
- Conclude this stage with a **broad agreement** on the high-level objectives of your proposed efforts.
- Make sure that you **document processes and results** as a basis and reference for planning.

Step 3.1 | Assess community risk

You have an informed idea of the problem, but there may be more to the story. Different community members may have alternative perceptions, be affected by hazards and other stressors in different ways, see additional — and to them, possibly more important — problems, and may have insights as to how different problems relate to each other.

What's more, communities may have a range of solutions in mind, and already have reasonable coping strategies in place that could be built upon.

Especially if you are from outside the community, your understanding will be inevitably limited — so **don't assume, ask**! The inclusive engagement of the wider community in the assessment is critical both for the ensuing process and the eventual outcomes. Robust assessments will help you identify the most feasible and effective needs-based solutions and sustainable, community-driven outcomes.

The **sustainability** aspect is arguably even more important when nature-based solutions are part of the suite, as the need for ongoing community stewardship will extend beyond the time of external support (where this is available).

Numerous manuals for the assessment of risk and capacities exist, and all of them feature as range of tools. These include historical timelines, seasonal calendars, focus group discussions and many more. The time requirements of these assessments vary, so carefully choose what your best option is in terms of available resources and the need for detail. Options include:

- **Climate Vulnerability and Capacity Assessment (CVCA).** Prepared by CARE, this manual offers a wide range of tools and has particular strengths in terms of aspects related to climate change and inclusion. The application of the overall process can take numerous sessions (usually spread over

several weeks). CVCA results are commonly used to inform community action plans. Note that in the context of coastal resilience, such plans defined by individual communities may need to be linked and aligned to wider plans (if ecosystems stretch over many communities and solutions require concerted actions by a wider range of stakeholders).

- **Enhanced Vulnerability and Capacity Assessment (IFRC)** This suite of tools is similar to the CVCA and based on a previous version that has been applied around the world for more than two decades. It is commonly used by Red Cross and Red Crescent Societies but can be used others too, including NGOs and non-humanitarian organizations. The new (enhanced) version has a stronger focus on the overall process and can be used in support of broader processes to reinforce resilience (the 'Road Map to Community Resilience'). A summary tool helps automatically calculate risk and resilience.

- **Resilience star.** For initial assessments — especially if there are time or resource constraints — you may choose this tool. Part of the EVCA toolbox, it can be applied as a half-day focus group discussion, which you can later follow up with a fully-fledged process.

No matter which tool or manual you choose, be sure to read and understand the respective guidance, and test the tools before using them with the community. Each tool has its strengths and limitations, which should be understood at the outset. Strong facilitation skills are needed for all of them — and the better the facilitation, the better the results.

Community risk can be best understood as a function of the overall exposure to hazards and stressors multiplied by vulnerability/capacity (read more about these terms in the glossary).

All these concepts are therefore integral to the assessment of community risk. Solutions based on coastal ecosystems can reduce exposure, though the hazard itself — let's think of a severe storm combined with a tidal surge — will still hit coastal waters. Intact reefs or mangroves and other trees however break the waves and reduce wind speeds — thus reducing a community's comparative **exposure** to the storm and its most damaging effects.

Vulnerability is the propensity or predisposition to be affected (IPCC 2018:560) by adverse forces, and it is linked to a range of socio-economic factors. To take the storm example, a family living in a poorly constructed house will be more vulnerable than one in a solid home.

Capacity refers to the abilities of communities and individuals to anticipate, adapt to, absorb, and transform the effects of shocks and stressors (CARE 2019:12). It is based on the strength of social, physical, human, economic and natural capitals.

Typical questions used in a community risk assessment may include:

- What have been the biggest hazards that have occurred, and what have they affected? When did they happen?
- How has the level of damages and losses changed over recent years?
- To what extent are key assets protected from hazards?
- How have hazards affected different parts of the community? Are there systemic vulnerabilities?
- How have hazards affected the financial status of the community both individually and collectively?
- What are individual/communal capacities in terms of natural resource management, risk management, economic opportunities, and connectedness.
- How do people cope and collaborate after hazard events?

HOW STAGE 3 LINKS TO...

The Road Map to Community Resilience (IFRC 2020)
The Blue Guide's stage 3 broadly links to the Road Map's stage 2 ('understand risk and resilience').

However, the Blue Guide has an extended scope: whereas the Road Map focuses on the community (as does the Blue Guide's step 3.1), the Blue Guide also extends the assessment to ecosystems (step 3.2) and external factors (3.3).

You can follow the Road Map guidance to complete step 3.1 (or alternatively CARE's CVCA Guide), then proceed with the Blue Guide's steps 3.2 to step 3.4.

The Flood Management Green Guide (WWF 2016)
The Blue Guide's stage 3 broadly links to the Green Guide's

- Chapter 3: foundation concepts, key cross-cutting issues; and
- Chapter 4: assessing flood risk: data, methods and analysis.

CLIMATE CHANGE, UNCERTAIN TIMES

When assessing community risk and ecosystems, try to gather insights on projections of regional climate change impact. How will community risk change over time? To what extent will marine ecosystems themselves be affected by manifestations such as ocean acidification and sea-level rise? What can be done about it? Past patterns of community risk and the health status of ecosystems may change significantly, so seek climate expertise and embed it into your overall assessment.

Contact local climate science bodies and see these sources:

- Intergovernmental Panel on Climate Change (IPCC)
- Potsdam Institute for Climate Impact Research
- Red Cross/Red Crescent Climate Centre

Step 3.2 | Assess ecosystems

While initial discussions with stakeholders and insights from the community risk assessment may give you a rough estimate of the status of local ecosystems, a more detailed scientific assessment should be added when considering nature-based solutions.

The health status and conditions (soil, water quality, nutrients etc) of an ecosystem (or often multiple and interrelated ecosystems) will inform what exactly is possible and suitable. For instance, if a mangrove forest has suffered from relatively minor degradation, the less costly option of natural regeneration may be preferable to the more resource-intensive option of artificial reforestation.

MEASURED APPROACH A marine biologist conducts an assessment of a coral reef to explore restoration options. Photo: Carlton Ward Jr, The Nature Conservancy

Engage experts in this process, such as marine biologists experienced in assessments of your local ecosystems. Your steering committee should facilitate this process and for some aspects (e.g. assessing use of ecosystems for livelihoods), the community should be involved. The assessment process may differ for variable contexts, but generally tends to follow the outline described below.

The setting

One of the first aspects to be assessed are the conditions of the ecosystem. This can include the relative height of the ecosystem to the sea-level, tidal movements and wave conditions, water quality and temperature, and soil and substrate conditions.

The flora and fauna

This covers the analysis of current plant and marine species as well as critical interactions between them. Where data is available, this may include a trend in terms of biodiversity and the populations of species.

Current health status

This includes an assessment of plant height, growth and current ability to regenerate and deal with stressors.

Stressors and causes

The list of current stressors that plants and marine species are exposed to (unfavourable soil, substrate and water conditions) leads to the investigation of causes: are they due to environmental/global factors, to local practices by nearby communities (e.g. fertilizer run-off, coral mining), or a combination of both? The future viability of ecosystems should be also assessed in view of current and projected climate change impact.

Strategies

Based on the findings, ecosystem assessments conclude with recommendations for action. Among others, the set of options depends on whether causes for degradation can be halted.

Depending on the scope, ecosystem assessments may also include an analysis of potential gains from rehabilitation (e.g. what is the likely protective effect?)

Step 3.3 | Assess the external context

Furthermore, extend your existing knowledge of policies and plans that are relevant to your envisaged effort. You gathered initial insights (step 1.4) and learned more from the consultations with government agencies (step 2.1) and stakeholders (step 2.3).

Spend some time compiling all relevant plans, policies and regulations that may have an effect (positive or negative) on your planned effort.

Are there any plans for future land use or development in the area and are they in line with regulations? How will they potentially impact the planned activity? To what extent will they be complementary or competing?

You would not want to spend a lot of time, money and effort into restoring a reef area only to find out later that a marina had long been planned at that site.

You should also explore whether funding may be available for managing ecosystems, disaster risk reduction or other aspects of your plan. Are there stakeholders or possible partners who could contribute financially to the proposed activity? Review the results of the stakeholder analysis and consider further or broader consultations.

Step 3.4 | Define your high-level objective

At the conclusion of stage 3, connect the dots: what does the information from the assessments of community risk, ecosystems, and external context tell you?

BIRD'S EYE VIEW of San Roque on the Philippine island of Leyte. The assessment of community risk assessment as well as its wider context (e.g. legal and planning frameworks) is critical for DRR planning and NbS.
Photo: Patrick Bolte, Banyaneer

You now have a lot more information than you had when you formed the initial idea. Review and discuss the results of the assessments with your committee — and don't forget to share the results with a broader group (communities, stakeholders).

Through a process of collaboration, you should define your high-level objective or objectives: what is it that you ultimately want to reach?

Having clarity about that general goal is an important precursor to the next stage: identifying the most suitable solutions to reach it.

STAGE 4 IDENTIFY SOLUTIONS

Learn how to identify the most effective options for your context.

With the results of your assessment, you now have the information to identify solutions and decide on the most promising combinations to reach your objective. Take your time and work through the steps with your steering committee. Gather more data if you identify gaps. Identify the most sustainable and effective solution by following the nine steps in the path laid out in this chapter.

Before starting off, let's clarify four terms:

- **Measure**: refers to an individual action item, for example, the afforestation of mangroves or the rehabilitation of reefs.
- **Option**: the combination of different measures in a package. This may include green and gray structural measures as well as non-structural ones (e.g. improved evacuation systems).
- **Scenario**: a projection of future conditions over a given timeframe. These will be used to test the effectiveness of options under different assumptions.
- **Solution**: the eventual option you decide on. The solution should ideally be based on the best performance in terms of sustainability and effectiveness.

Principles & tips

- Keep the **steering committee** at the heart of the process and ensure that suggested solutions are reviewed and agreed upon by the wider community and group of stakeholders. Keep everyone on board!
- Explore and understand the various **measures** well. You may want to read the step-by-step guides in appendix A.
- Focus on **non-structural measures** first, then add green and/or gray structural measures.
- Use the interactive **solution finder** as your virtual assistant, but make sure that **technical experts** review the ranking of solutions and support decision-making.
- Ensure that the eventual suite of solutions can be reasonably expected to reach your objective.
- If there are limitations (e.g. funding), consider a **phased approach**. Focus on what you can do now and add more aspects later on.

Primer: Understand available measures

There is an abundance of measures to enhance the resilience of coastal communities, and it is beyond the scope of the Blue Guide to provide a full catalogue. Figure 4 (opposite) offers a typology, distinguishing primarily between non-structural and structural measures.

As a DRR practitioner, you may be familiar with many of the non-structural measures listed as examples. This overview focusses on the measures that may be less familiar, the ones related to ecosystems. These include certain governance-oriented measures, as well as all green structural measures. (For the latter, have a look at the overview table on pages 30-31, as well as the various specific step-by-step-guides in appendix A).

Following this overview, this chapter will guide you through the process of identifying and combining the most effective measures to sustainable nature-based solutions.

ECOSYSTEM CONSERVATION

As outlined earlier, ecosystems have numerous benefits for coastal populations. Where they remain intact, the most cost-effective measure is to ensure that they can prosper into the future, fulfilling their multiple roles for communities.

Where ecosystems are degraded in some way, it is imperative to first try to address the causes before venturing out to rehabilitate or restore ecosystems. To illustrate this point, it would make little sense to spend energy and resources on reef restoration if the cause for degradation continues to exist (e.g. coral mining, overfishing, boats anchoring on reefs). Such efforts would likely lead to failures or short-lived successes. It should be noted that it will not always be possible to fully address all factors behind ecosystem degradation through local/regional action, as climate change and other non-local factors put many ecosystems under severe stress.

Figure 4 | **Measures to enhance coastal resilience**

Non-structural measures		**Structural** measures	
Governance-oriented	**Practice-oriented**	**Green structural** measures	**Gray structural** measures
Measures to generate governance change. This includes the efforts to modify or introduce laws, regulations or organizational procedures to induce practices (at different levels) that contribute to greater coastal resilience. **Examples**: • Regulations on the protection or sustainable use of ecosystems, such as **Marine Protected Areas** • Regional or land use planning • Building regulations • Disaster management and early warning frameworks	**Measures to generate direct change of practices among communities and households**, promoting those that contribute to greater coastal resilience.**Examples**: • Community preparedness: Early warning and evacuation systems, disaster management teams • Household preparedness: promoting risk awareness, emergency bags and stock, reinforcements, trimming of trees • Adaptation: promoting income diversification, insurance, cropping/land use change, waste management, regenerative farming	**Measures that directly strengthen ecosystems and reinforce their functions (protective, economic, environmental, food security and social benefits) to address societal challenges for the good of the community.** These measures stand at the core of the Blue Guide. Whether you can apply a specific measure as part of your nature-based solution depends on ecological conditions, which must be assessed. The Blue Guide features the following measures: • **Coral reefs:** CR1 natural reef restoration; CR2 artificial reef restoration • **Shellfish reefs:** OR1 natural reef restoration; OR2 artificial reef restoration • **Mangroves**: MG1 natural regeneration, MG2 replanting • **Seagrass**: SG1 planting rhizomes, SG2 seeding seagrass • **Marshlands & swamps**: MS1 rehabilitation, MS2 restoration • **Dunes**: DU1 rehabilitation, DU2 reconstruction • **Tree shelter belts**: SB1 Rehabilitation, SB2 Planting shelter belts	**Hard engineered measures to reduce exposure or sensitivity, or to improve the preparedness of coastal communities**. Gray measures may complement green measures; green and gray can be combined in hybrid solutions. This makes sense if the anticipated combined effects of green and non-structural measures are insufficient to reach a set objective. **Examples**: • **Measures that help reduce hazard exposure**: Artificial breakwaters, seawalls, levees, floodgates, dams, flood canals • **Measures that help reduce sensitivity**: waterproofing and reinforcement of roofs of schools, health centers, homes; retrofitting of critical infrastructure (power grids, water supply, sewerage, phone networks) • **Measures that help improve preparedness**: evacuation or multi-purpose buildings, boat & equipment shelters

Conservation arrangements are by far the cheapest measure to help protect intact ecosystems, and should be considered a precursor or complementary measure for any green structural measure.

Three main types of arrangements exist:
Marine protected areas (MPA) are clearly defined geographical areas that are designated by governments. Activities in these areas are restricted to achieve long-term conservation of ecosystems, and mostly enforced by governments. Adequately enforced MPAs are seen as the most effective means of marine conservation (Chavanich 2015:132).

They are even more effective if integrated into broader frameworks such as coastal zone management, which also address threats originating outside the MPA boundary (such as land-based pollution). See MPA design principles.

Marine conservation agreements (MCA) are voluntary agreements between local parties and right-holders, who commit to taking or refraining from certain actions to achieve conservation goals. They can be formal or informal and often include economic incentives.

For more information, see the Reef Resilience Network's Field Guide for Marine Conservation Agreements.

Locally Managed Marine Areas (LMMA) are based on another co-management approach to conservation. They are coastal areas managed by local communities, groups, partners and/or governments and can be considered the bottom-up pendant to the rather top-down and government-led model of MPAs. They are characterized by local use, control and, in some parts of the world, local ownership and can help perpetuate traditional conservation management knowledge and practices.

Explore more information on LMMAs via these links:
https://lmmanetwork.org
http://www.pimpac.org

The MPA, MCA and LMMA models are not mutually exclusive, but can be combined in mutually reinforcing arrangements. The most suitable initial approach will depend on your context, for instance, the willingness of communities, land owners/rights holders, local governments and the ability to integrate potential spoilers to conservation efforts.

Read more about conservation arrangements in step-by-step guide A.1.

HOW STAGE 4 LINKS TO…

The Road Map to Community Resilience (IFRC 2020)
The Blue Guide's stage 4 broadly links to the Road Map's stage 3 ('taking action for resilience').

This Blue Guide's stage 4 should be used for the Road Map's step 4.1 (go deeper).

The Flood Management Green Guide (WWF 2016)
The Blue Guide's stage 4 broadly links to the Green Guide's

- Chapter 5: structural and non-structural methods;
- Chapter 6: urban issues, specifically 6.5 - 6.7; and
- Appendix D: resource and cost planning guidance

18. Bleaching occurs under certain conditions (e.g. the water becoming too warm). Corals expel the algae living in their tissues and turn the coral white. Corals can survive bleaching events but are under increased stress.

REEFS

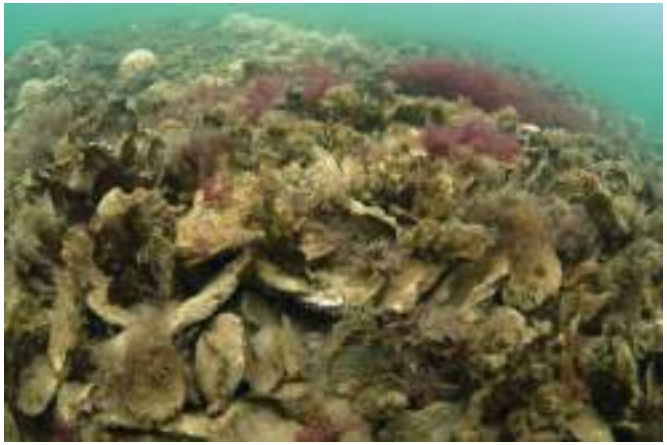
Reefs are underwater ecosystems whose protective benefit for coastlines is derived from the absorption of wave energy. Two distinctive types exist — **coral reefs** and **shellfish reefs**.

Coral reefs are formed by coral polyps and grow best in warm, shallow, clear, sunny and agitated water. While spread over less than 0.1% of the world's ocean expanse, they are home to 25% of all marine species. They flourish in nutrient-poor waters and are fragile due to their sensitivity to water conditions.

As such, they are under threat from climate change (oceanic acidification and rising ocean temperatures) as well as local factors (nutrient runoff from fertilization, overfishing and harmful development practices, such as coral mining).

These 'rainforests of the sea' have numerous other benefits — including their value for tourism, fishing, and biodiversity. Despite their enormous value, coral reefs are being lost and are often degraded, which can easily observed by 'bleaching'.[18]

Shellfish reefs are made of bivalve shellfish (such as oysters or mussels) that attach to existing shells, creating large reefs made of thousands of generations of shellfish.



Shellfish feed on plankton and other organic matter, and thus assume an important water filtering function. These reefs also stabilize shorelines by promoting sediment deposition and buffering wave energy, thereby allowing other habitats, such as sea grass beds and marsh areas, to form, while simultaneously decreasing erosion of the shoreline. Many shellfish reefs have been lost over past decades or are under threat.

Conservation (see above) of reefs is by far the best and least costly option, compared to natural reef **rehabilitation** or artificial **restoration**. These two measures are expensive and technically challenging, requiring expert scientific advice and guidance.

Climate change adversely affects coral reefs through warmer oceans, altered water conditions and more intense weather events. These factors need to be accounted for when preserving, restoring or rehabilitating reefs.

Coral reefs have the ability to naturally recover if degraded. At 60-70%, coral reef restoration survival rates are relatively high when specific methods are tailored to local conditions (Boström-Einarssen et al, 2018:2).

SEAGRASS

Seagrass grows in shallow, sheltered, and soft-bottomed coastal waters and estuaries. More than 60 species of seagrasses exist worldwide and play important roles in shallow marine ecosystems (Björk et al. 2018:16).

Their main protective benefits are wave attenuation and sediment trapping, thus reducing the risk of soil and coastal erosion, particularly after heavy rainfall. Seagrass meadows are nurseries for young fish, who feed in the nutrient-rich waters while hiding from predators.

In terms of environmental benefits, seagrass is a powerful carbon sink and important habitat (home to 40 times more species than bare sand). Seagrass is also a food source (seeds) and used as material for roofing, mattresses and traditional medicine (ibid:17).

Seagrass restoration and rehabilitation requires scientific and technical advice. Specific actions may include efforts to improve water quality and light exposure, planting of seedlings or seeding areas for restoration, eliminating the causes of seagrass decline, raising awareness of the value of seagrass and inclusion in coastal management plans (ibid, 26-34).

MANGROVES

Mangrove forests consist of salt-tolerant shrubs and trees that grow along tropical and sub-tropical coastlines. Fringing mangroves along gentle coastlines inundated by daily tides are most common, though mangroves are also found along river estuaries, basins, and other settings (UNEP 2020: 3).

Mangrove forests consist of numerous species, with dominant types altering based on their relative position to the sea. Globally, the expanse of mangrove forests shrank between 1997 and 2016 from 18.3 to 8.3 million hectares, largely due to land use conversion, pollution, over-exploitation and climate change (ibid:5).

Where mangroves have been lost, previously protected areas are faced with substantially greater hazard exposure (mangroves attenuate waves, retain soil and act as wind breaks). The loss also robs the critical function of mangroves as a carbon sink and reduces local biodiversity.

Two options for NbS — natural regeneration or artificial restoration. Both are inexpensive (in particular if applied at scale), but require technical expertise and suitable nurseries. The choice of options depends mainly on the current status.

Artificial restoration has been applied widely, often with community volunteer input. This process stretches over several years and includes nursery development, fencing/protection, replanting (initial plant survival rates are often below 50%) and sustained monitoring and community engagement.

MARSHLANDS & SWAMPS

Coastal salt-marshes and swamps form a buffer between the sea and riverine systems. They are most common in temperate regions and also occur in higher latitudes of tropical regions. Salt-marshes form a mosaic of coastal wetlands that occupy areas of low energy tidal inundation, typically in bays, inlets and estuaries. Salt-marshes are dependent on fresh water coming from rain, rivers and groundwater and on tidal flows (Creighton 2015). This mixing of fresh and salt water is vital for their health. Their protective benefits lie in wave energy absorption and the stabilization of shorelines through sediment trapping. They also reduce the risk of flooding (ibid:13). Salt-marshes are an important habitat for a large range of species.

As salt-mashes in particular are facing ongoing threats from urban development and agricultural practices, **conservation** of existing marshlands is the best and most cost-effective option.

In areas where **rehabilitation** is possible, fencing off these wetlands to prevent access by livestock, removing of feral fauna and flora, and replanting of appropriate species can support the **natural recovery** of the ecosystem. Furthermore, general access should be restricted (vehicles, collection and disruption of sediments) and agricultural levees and artificial drainages removed, allowing free flow of water within the system. In fact, restoring the natural hydrology of the area is the paramount element to successfully restore salt-marshes.

For **restoration**, expert technical advice must be obtained. Such efforts may also require engineering support and the use of heavy machinery to remove landfill and restore natural water flows.

DUNES

Coastal dunes act as a barrier against incoming waves and deflect wind and salt spray. The presence of a stable dune system provides a natural defense mechanism against wave inundation and erosion. However, dunes are dynamic ecosystems, with natural changes occurring during storm events.

In its natural state, a beach is backed by a frontal dune as well as hind dunes. Vegetation cover is an important part of the dune system, reducing wind velocity and encouraging windblown sand deposition. The frontal dune is usually more established and persistent despite being naturally impacted by storm waves.

Their stability, shape and size are controlled by the **vegetation cover**. Woody shrubs tend to be present in the seaward side, while trees are present landward (O'Connell, 2008).

Specific options include **protection**, **rehabilitation** (assisted natural recovery) and **restoration**. The engagement of communities and technical experts is critical for any of these options.

SHELTER BELTS

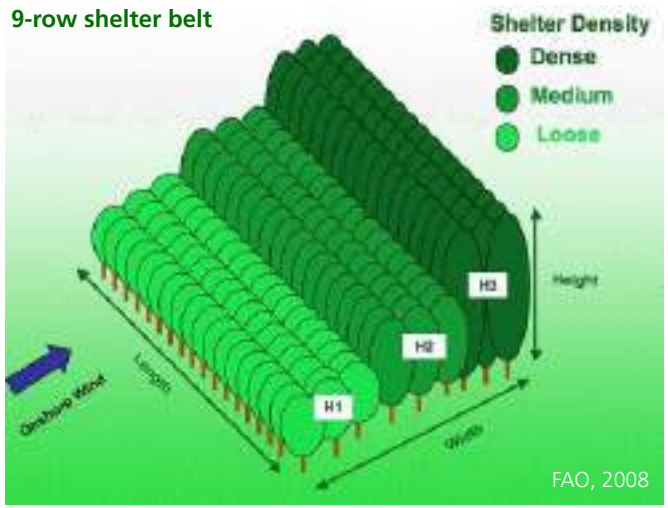
Further landward, the distribution, typology and composition, and relative position of trees to homes, productive assets and fields can make an enormous difference to hazard exposure.

Many coastlines have naturally occurring belts of trees that absorb and redirect oncoming wind. These benefits have long been recognized by farmers and communities in coastal and other windswept areas, who have also been planting rows of trees for many centuries.

Science has helped design coastal shelter belts that consist of multiple rows of trees, with the seaward (outer) rows consisting of bush and shrubs, the central rows of trees with a medium height, and the landward (inner) rows of trees with the greatest height. The protective benefit mainly stems from the redirection of air flows, reducing effective downwind speeds over an area 30-40 times the height of the tallest trees (Zhu 2008).

A 20-meter high shelter belt thus helps protect an area 600 meters in width, with the protection being greatest close to the shelter belt (where wind speed is up to 60% lower than the initial speed).

One of the strengths of shelter belts is that a multitude of local tree species can be used. Shelter belts can thus be planted in most settings, provided that land is available. They can add protection where marine ecosystems cannot offer sufficient protective function. Depending on the design, shelter belts can also offer numerous economic benefits (e.g. increase of yields) and are therefore often used in agroforestry.



FAO, 2008

See further information on coastal shelter belts in FAO 2008 here.

Figure 5: **Overview of nature-based solutions**

Ecosystem	Reefs (coral or shellfish reefs)	Mangroves	Seagrass
Specific solutions	A. Natural recovery B. Restoration: addition of coral colonies, enhancement of coral larvae, addition of cultch for shellfish recruitment, C. Artificial reef: artificial reef substrate creation	A. Natural mangrove regeneration B. Artificial mangrove restoration	A. Natural recovery B. Planting rhizomes C. Seeding seagrass D. Combining B & C
Key benefits	**Protective:** wave attenuation and increased friction **Economic:** fish production, tourism, nutrient mitigation, facilitation of seagrass, mangroves, salt marshes. **Environmental:** biodiversity habitat	**Protective**: wave attenuation, soil retention, windspeed reduction. Specific benefits: savings due to reduced damages after storms, lower costs for adjacent coastal structures **Economic**: increase of fish, shells, molluscs, tourism **Environmental**: carbon sequestration, biodiversity habitat	**Protective**: wave attenuation, current reduction, seabed stabilization, prevention of coastal erosion **Economic**: fish, crab nurseries, shelter and food for marine species **Environmental**: carbon sequestration, biodiversity habitat
Restoration costs median USD/m2 (range) based on Narayan et al 2016	Coral reef restoration: very high — USD 115.62 (2.00 - 7,490) Shellfish reef restoration: very high — USD 135.63 (1,207 - 316) Restoring one kilometer of coastline with a 10m-wide reef may cost around USD 1,200,000. Natural recovery is far cheaper.	Inexpensive — USD 0.1 (0.05 - 6.43). Costs mainly depend on local labor costs; larger projects benefit from economies of scale. Restoring one kilometer of coastline with a 100m-wide belt may cost around USD 10,000 with volunteer-based labor.	A. Planting rhizomes — expensive B. Seeding — inexpensive
Indications When to use	Presence of reef (current or historical) Proximity of healthy resilient reef (healthy coral areas, herbivore species present, limited coral disease or predators and high biodiversity	Type A: limited level of degradation Type B: Complete loss of pre-existing mangrove forests or severe degradation (beyond self-repair)	Type A: presence or past history of seagrass meadows Type B: rhizome planting when small areas require restoration Type C: seeding for large scale restoration Type D: combinations of B & C
Counter-indications When not to use	Coral or shellfish reef restoration should not be attempted until there are protections around the proposed areas, causes of degradation are addressed and where there is limited coral recruitment opportunities (proximity of health corals for cross fertilization and considering recruitment —proximity to broodstock)	Mangrove reforestation should not be attempted if the mangrove loss is due to extreme changes in site conditions, such as soil factors (especially salinity), hydrology (water movement), and sedimentation	Excessive runoff from urban waste, effluents and agricultural lands Frequent flooding from rivers, including proximity to river mouths leading to turbidity and poor water quality. High levels of water traffic, dredging, use of seabed net dragging
Prerequisites Things that must be in place	Protection agreements Technical expertise to ensure correct methods and species types Coral reefs: sufficient coral colonies or larvae collection for spawning Suitable water quality and temperatures	Suitable ecological conditions (organic muddy soil, salinity, tidal zone and range) Availability of land/coastline, seedlings, technical expertise for assessment and implementation guidance	Suitable ecological conditions (low levels of organic matter in the seabed, high water quality and adequate light) Water movement and undisturbed root environments Access to other seagrass beds for increased genetic variability
Success factors Things that should be in place	Enforced regulations and long-term protective arrangements Strong community stewardship Sheltered sites for coral nurseries Long term monitoring programs	Enforced regulations and long-term protective arrangements Strong community stewardship Designs that include direct economic benefits — income-generating activities	Enforced regulations and long-term protective arrangements Strong community stewardship Plans and funding for re-seeding following hazard events Long term monitoring programs
Process overview How it works: specific steps that are in addition to the general one listed under stages 1-3	Assess reef vulnerability and resilience Set targets and objectives Identify reef restoration options Implement actions Conduct biophysical and socio-economic monitoring	Specific site assessment and preparation Establishment of nurseries Out-planting Growth monitoring and adjustments (e.g. re-planting, thinning)	Assess seagrass vulnerability and resilience Set targets and objectives Identify seagrass restoration options Implement actions Conduct biophysical and socio-economic monitoring
Link to step-by-step guide	**Appendix A.2**	**Appendix A.3**	**Appendix A.4**

Marshlands & swamps	Dunes	Shelter belts	Ecosystem
Preservation of existing marshlands and swamps Rehabilitation of saltmarshes Restoration of reclaimed marshlands and swamps (saltmarshes)	Preservation of stable undamaged dunes Rehabilitation and regeneration of denuded or damaged dunes Reconstruction of severely damaged dunes	Extension of exisiting rows of coastal trees Bio-engineered planting of shelter belts	**Specific solutions**
Protective: wave attenuation 72%, hold flood waters, wind speed reduction, sediment retention **Economic:** recreational space, fish, crab and prawn nurseries, shellfish, tourism **Environmental:** carbon sequestration, wildlife habitat, fish and prawn nurseries, diversity of vegetation, nutrient recycling	**Protective:** wave and storm surge attenuation, absorbs winds, traps sand, reduces erosion, buffer for landward structures **Economic:** protective to beach areas — tourism **Environmental:** wildlife habitat, diversity of vegetation, protection of natural landward areas	**Protective**: wind speed reduction to reduce storm load on buildings in adjacent communities as well as landward erosion **Economic**: can be used to incorporate fruit trees **Environmental**: carbon sequestration, biodiversity habitat	**Key benefits**
Saltmarshes: inexpensive — USD 1.11 (0.01 - 33.00)	Low if it only entails weeding and some replanting USD 22-30 per meter High if it includes earthmoving equipment and sand replenishment — up to USD 3,500/m^2 (IGCI, 2018)	Low (provided that land is made available at no cost)	**Cost range**
Existing degraded, intact or partially intact marshlands or swamps Where there are unused previously reclaimed marshlands or swamps	Existing dune system in need of preservation Existing dune system in need of rehabilitation Dune system damaged by storms or human actions	Storms as major hazards Absence or insufficient protection from other ecosystems that offer wind breaks, such as dunes and mangrove forests.	**Indications** When to use
If areas less than 2 hectare are proposed If small area and there are no adjacent marshlands or swamps	When development is planned and will destroy the dune	None	**Counter-indications** When not to use
Technical support — multidisciplinary teams of engineers, wetland ecologists, hydrologists Access to equipment and vegetation species	Technical support Access to vegetative species and water Community engagement and participation In large scale projects access to heavy equipment	Contiguous stretch of land is available for planting (15 - 30 meters in width) — designated no-build zones can be used for this purpose Basic understanding of benefits and willingness to act as stewards among communities	**Prerequisites** Things that must be in place
Protection of areas Restoration of hydrology Replanting of local vegetation	Protection of areas Replanting of local vegetation, access to water Strong community stewardship	Designs that incorporate direct benefits (food sources) Strength of community stewardship Conservation arrangements Demonstrated success of reduced storm damages	**Success factors** Things that should be in place
Ensure solution-specific technical support is consulted Assess marshland and swamp vulnerability and resilience Set targets and objectives Identify restoration options Implement actions Conduct biophysical and socio-economic monitoring	Ensure solution-specific technical support is consulted Assess vulnerability and resilience Set targets and objectives Identify restoration options Implement actions Conduct biophysical and socio-economic monitoring	Ensure land is available (government, land owners) Ensure solution-specific technical support is consulted Explore soil conditions and suitable trees (including heights) Prepare shelter belt design Plant and monitor (biophysical and socio-economic)	**Process overview** How it works: specific steps that are in addition to the general one listed under stages 1-3
Appendix A.5	**Appendix A.6**	**Appendix A.7**	**Link to step-by-step guide**

TOOL: TNC SOLUTION FINDER

Use the **TNC solution finder** as your assistant for this stage. In appendix F.4, you will find these files:

- The user manual, which is an animated PowerPoint file. It contains decision flowcharts and explains how to fill out the solution finder (appendix F.4a)
- The solution finder itself, which is an Excel file. Complete the sheets to identify your solution. (appendix F.4b)
- An example of a completed solution finder. See appendix F.4c.

Now that you have had a glance at the available measures, let us start identifying those that are feasible and suitable to your context, and then combine them to the most effective and sustainable solution.

We suggest that you read through steps 4.1 - 4.9 first to understand the overall process in stage 4, then use the Excel-based TNC solution finder and its associated user manual to identify appropriate solutions.

Step 4.1 | Confirm & classify objectives

4.1 — 4.2 — 4.3 — 4.4 — 4.5 — 4.6 — 4.7 — 4.8 — 4.9

By now, you have engaged all key parties (stage 2) and completed the assessments (stage 3). If you find that there are **any gaps, address them first** before proceeding. This is because adequate and inclusive stakeholder engagement and robust assessments are **decisive success factors.** Not spending enough time on stages 2 and 3 may save you time now, but could lead to less sustainable and effective results later on (or even complete failures).

You also defined your high-level objective (step 3.4). Let's look at that in greater detail: **what is it that you are trying to achieve?**

In one or more ways, your objective is about addressing the problems you identified in step 1.1 and that you gained further information on through the assessment of community risk (3.1), ecosystems (3.2), and external context (3.3). Broadly speaking, your objective should aim to enhance the resilience of coastal communities. How that translates into practice depends primarily on the hazard profile. You may have different priorities for areas frequently exposed to fast-onset hazards than for areas that are mainly exposed to long-term stressors.

In the **TNC solution finder's sheet 4.1,** enter and classify your objectives: what is the primary goal, what are secondary goals?

Note that all categories are generally suitable to enhance resilience. However, they act in different ways. You can think of them as different lines of defense (see fig. 6).

Reducing exposure: Exposure to hazards can be reduced by putting something in the way between the oncoming force and the target area, thereby reducing the energy with which it hits a community.

For instance, a coral reef or breakwater absorbs some of the energy of a storm surge, so that less energy effectively hits the coastline (and communities). Similarly, a mangrove forest can help reduce exposure to groundwater salinity that may otherwise affect water usability and agricultural yields.

Decreasing sensitivity is about lowering the possible effect a hazard or stressor can have on communities. Measures to decrease sensitivity can include:

- Reinforcing homes, buildings and critical infrastructure so they are more robust and can resist storm and flood loads.
- Diversifying livelihoods (income and food): if one source fails, there are others to rely on. Think of 'not having all the eggs in one basket'.
- Adjusting crop types and agricultural practices so that produce is less susceptible to hazards or stressors. Examples include the adoption of more flood-resilient crops or the creation of irrigation systems.

Improving preparedness is largely about non-structural measures such as response systems (e.g. local response teams, disaster management agencies), the strengthening of evacuation systems (routes, drills, emergency shelters), as well as the promotion of preparedness among households (e.g. go bags, life vests, provision of emergency supplies) and schools.

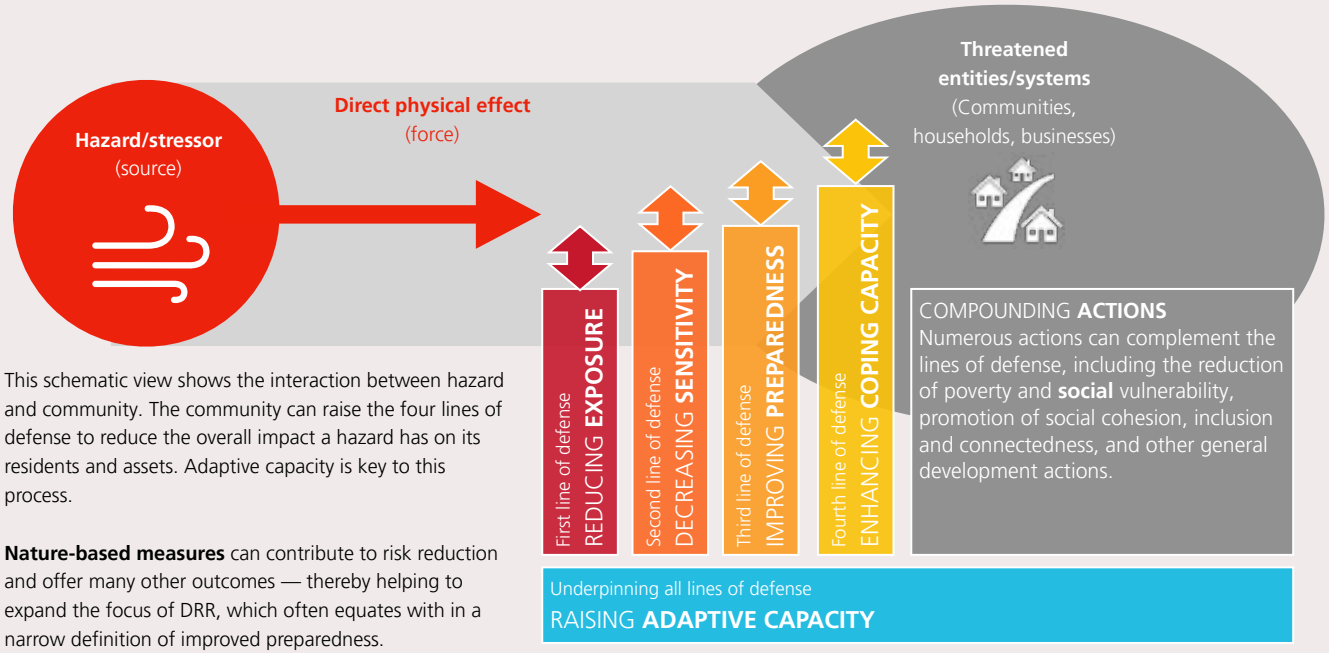
Enhancing coping capacity is about strengthening the ability to deal with residual risk. Even the most resilient communities will occasionally be hit by hazards and stressors. Measures include risk transfer (promotion of insurance, calamity funds), the creation of buffers (savings, food reserves), the use of alternative food and income sources (collecting non-timber forest products, labour migration) and efforts to strengthen social capital (mutual support groups, collective action).

Raising adaptive capacity is critical to timely adjustment to emerging and predicted long-terms stressors. In most cases, early and anticipatory adaptation is more effective than reactive adaptation. Adaptive capacity is based on the timeliness, scope and scale of adjustments made in light of emerging information (anticipated sea-level rise, more frequent and intense storms).[19]

At this stage, it is useful to be clear about your primary objective — and good practice to combine measures that support various categories.

As described earlier, ecosystems offer benefits in terms of protection (reducing exposure) and economic, food and environmental security, as well as social gains (decreasing sensitivity, enhancing coping capacity).

Figure 6 | **Objective categories - the lines of defense**



This schematic view shows the interaction between hazard and community. The community can raise the four lines of defense to reduce the overall impact a hazard has on its residents and assets. Adaptive capacity is key to this process.

Nature-based measures can contribute to risk reduction and offer many other outcomes — thereby helping to expand the focus of DRR, which often equates with in a narrow definition of improved preparedness.

As a DRR practitioner, you may wonder how **vulnerability** fits into this chart. Vulnerability is a broad concept (the propensity to be adversely affected, see glossary) — in fact, it relates to all lines of defense and many compounding actions. The chart disaggregates vulnerability (exposure for instance is a physical aspect of vulnerability) and turns its components into lines of defense, along which actions can be designed. While this disaggregation makes sense from a programmatic point of view, it should be noted that physical and social aspects are inter-related.

Step 4.2 | Explore feasible measures

4.1 — **4.2** — 4.3 — 4.4 — 4.5 — 4.6 — 4.7 — 4.8 — 4.9

Being clear about your objectives, let us move to the next step: what measures could be principally available? Have the information from the assessments of community risk, ecosystems and context at hand and conduct this step with the members of your steering committee.

For this step, use the **decision flow-chart screens** in the solution finder user manual, and enter the results in the solution finder's **sheet 4.2**.

Start with the general screen. This determines which ecosystem-specific screens you will need to complete. This general screen eliminates any ecosystems that have never existed in your target area from further analysis. If an ecosystem never existed in the area, it is highly unlikely that it can be established. An exception to this rule concerns shelter belts, which can be established without a history of these belts in the area.

19. Adaptive capacity consists of a) access to information on trends and stressors, b) swift, effective and inclusive decision-making processes, c) access to resources and techniques to adapt, and d) the actions of adaptation. Thus, you can raise adaptive capacity of communities by strengthening these four components. For instance, this may include a) providing channels to obtain long-term climate projections and seasonal forecasts, b) cross-cutting efforts to strengthen decision-making, c) the creation of adaptation funds and formation of partnerships with technical institutes, and d) guidance for the implementation on specific actions of adaptation.

Next, complete all specific screens as directed by the general screen. For instance, if you have a previously or currently existing coral reef and mangroves in your area, complete the screens A (coral reefs), C (mangroves) and G (shelter belts).

On each of these specific screens, answer the questions and follow the path until you come to a result for the specific measures. If a measure is deemed feasible on this process, change its status to 'feasible' in sheet 4.2.

Note that in sheet 4.2, all measures are set to 'not feasible' by default.

Step 4.3 | Screen for suitability

So far, we have only looked at green structural measures. In sheet 4.3 of the solution finder, you will find all feasible green structural measures you previously identified.

In this step, you will add possible **non-structural** and **gray structural measures.** You can only add up to five from each category, so focus on those that you deem feasible and most important. We now have a broad menu of non-structural, green and gray measures. Congratulations!

Next, we'll narrow down the menu by running two checks. Narrowing down the menu helps us reduce complexity and makes it easier to proceed through the subsequent steps.

For each item on the menu, you should first check the **expected effectiveness** of the measure, then check the prevalence of **specific success factors**. Add the following information on each measure.

What is the expected effect?
How far can the measure be reasonably expected to

- reduce exposure?
- decrease sensitivity?
- improve preparedness?
- enhance coping capacity?
- raise adaptive capacity?

Use the drop-down menu (major, medium, minor, no effect) and add narrative information based on the data you have obtained so far.

To what extent do specific success factors exist?
Each of the measures has a specific set of factors, which you can find at the end of the solution finder user manual. To what extent do these factors exist in your context? Use the drop-down menu (strong, medium, weak, none) and add narrative information, using the data you have gathered so far.

Pre-select measures.
On the basis of the expected effectiveness and prevailing success factors, select those that have the greatest potential towards reaching your objectives.

It is a good idea to have multiple measures listed for each of the five objective categories (reducing exposure, decreasing sensitivity, improving preparedness, raising adaptive capacity, enhancing coping capacity).

Review all feasible measures and their scores, then make your pre-selection. These are the building blocks of the options you will develop in step 4.4.

Congratulations! You have now completed the menu of measures — which may be quite long at this point. Not to worry, as we will narrow down the menu to the most suitable ones.

Step 4.4 | Develop options

4.1 — 4.2 — 4.3 — **4.4** — 4.5 — 4.6 — 4.7 — 4.8 — 4.9

Sheet 4.4 of the solution finder shows all pre-selected measures on the left. Now, combine these measures to identify options (an option is some combination of measures). Sheet 4.4 lets you build up to five different options (numbered 1-5).

Develop option 1 as the smallest intervention (in terms of scope and scale) and option 5 as the most comprehensive option. Now, try inserting alternative measures that have the same purpose (e. g. reef crest rehabilitation and artificial breakwaters as alternative measures to absorb wave energy).

Step 4.5 | Develop scenarios

4.1 — 4.2 — 4.3 — 4.4 — **4.5** — 4.6 — 4.7 — 4.8 — 4.9

While we cannot predict the future, we can develop a set of informed guesses in terms of expected patterns of hazards and climatic stressors. In order to compare the options we have just created, you'll develop three scenarios in sheet 4.5 of the solution finder. Each scenario is a prediction of the future, using different assumptions. It is important to understand that all three scenarios are based on the premise that no actions are taken to reduce disaster risk.

The scenarios are about the **cost of inaction.** The timeframes of all scenarios are set to 20 years. You can change the time-frame but must apply it to all three scenarios to keep them comparable.

All scenarios are based on the history of damages and losses over the past ten years. You will need to enter hazard and loss data first (see the user manual for the detailed process), then all scenarios will be automatically calculated.

REFLECTIONS Homes near the fish port in the town of San Sebastian stand damaged after Typhoon Ruby hit the Philippine island of Samar in 2014.

Gathering data on past damages and losses from hazards is an important element to develop scenarios and gain insights on the value of disaster risk reduction and NbS: what future damage can be spared under various scenarios? Photo: IFRC

Scenario A is an extrapolation from the recent history of hazard events and climatic stressors. It assumes that hazards and stressors will continue to emerge with the same frequency and strength as they did in the past ten years.

You may have already completed a historical timeline as part of the community risk assessment. Use this information and fill the gaps as needed.

In particular, you should gather and complete these data:

- What hazards and stressors have occurred and when?
- What was their strength?
- Who and what was affected and how?

- What damages were caused (in monetary value)?
- What losses (direct and indirect) were caused (in monetary value)?

Try to be accurate with monetary values. If no data exist, use informed guesses on the basis of available information. For example, if several houses were destroyed and you do not know their value, find out the average building cost and multiply it by the number of destroyed houses.

Ensure that necessary expertise is involved in this process. If your steering committee does not have the right expertise, ask others! Getting accurate values in scenario A is important because the calculation of overall cost effectiveness depends on it. The solution finder automatically calculates some important values, including the annual probability rate, average and annualised hazard losses.

Scenarios B and C are variations of scenario A. The **basic approach** assumes that the level of damages and losses will progressively increase by 10% (scenario B) and 20% (scenario C), primarily as a result of increasing climate change impact. You may change these percentages to other values if you can obtain relevant local projections on expected climate change impact over coming decades.

Congratulations - you now have calculated the cost of inaction under different scenarios. You have completed half of the steps in stage 4!

Step 4.6 | Estimate costs and benefits

4.1 — 4.2 — 4.3 — 4.4 — 4.5 — **4.6** — 4.7 — 4.8 — 4.9

Next, let us bring together the options we have created in step 4.4 with the scenarios developed in step 4.5. The solution finder's sheet 4.6 will help you through this process.

Define budget lines
Each of your options includes a range of measures. We now need to identify the budget lines (main cost items) for green, gray, and non-structural measures, as well as for other costs that cannot be attributed to specific measures.

Estimate costs
Now, add the costs for each budget line. Try to gather information on costs from similar efforts and ask experts for estimates. Be diligent in compiling this information. The total direct cost of your respective options is calculated automatically.

In addition to these **direct costs** of the initial effort, there may also be long-term **indirect costs** to monitor and maintain your outcomes. Think, for instance, of costs for replanting, for external advice, and for activities that help to uphold skills and awareness (e.g. refresher trainings). For the time being, it does not matter who bears these costs (it could be the government, the community, or be derived from other funding arrangements).

The total cost of each option is automatically calculated and includes the direct cost plus the annual indirect cost multiplied by the number of years of our analytical timeframe (set to 20 years by default).

Estimate benefits

For each option, calculate the benefits on the basis of all available information. Note that not all benefits can always be quantified or monetized (expressed in money values). If you cannot monetize certain benefits, add these at the bottom of sheet 4.6. However, be aware that the more benefits you can monetize, the higher the eventual benefit-cost ratio will be.

Consider the following types of benefits for each of the option under scenarios A, B and C:

- Protective benefits
- Economic co-benefits
- Environmental benefits

Note that there is a fundamental difference between protective benefits and all other benefits. Whereas the latter materialize in an ongoing fashion (e.g. increased income from fishing, improved water quality), the former materialize only in a hazard event, in the form of avoided damages and losses (see the text in the box on the side if you'd like to learn more).

Understand that in sheet 4.7, you need to enter the expected damages and losses for all your options - under each of the three different scenarios. The formulas are set up to then calculate the difference between the damages and losses under your options and inaction. This difference is equal to the avoided damages and losses; they are your protective benefit of your various options.

The benefit-cost ratio

At the bottom of sheet 4.6, the solution finder presents all your options with their respective benefit-cost ratio (BCR) under scenarios A, B and C. The BCR is the total amount of benefits divided by the total amount of costs over the projected timeframe.

A BCR above 1.0 is 'positive' (the costs paid off). A BCR of 4.0 would mean that for every dollar spent, 4 dollars are expected to be generated in benefits.

Step 4.7 | Compare options

Because the previous steps were rather technical, it was useful to restrict the engagement to the members of your steering committee and additional experts as needed.

Having now identified the BCRs for all your options under different scenarios, we recommend sharing and discussing the results with your stakeholders. Present and explain the results to the **wider community** and make sure that the underlying logic is understood, in particular:

- what the different options entail;
- the scenarios;
- the benefit-cost logic;
- assumptions you made in the calculation; and
- benefits that were not included in the calculation.

Have a look at the results: which option offers the greatest benefit-cost ratios under the three scenarios? You may explore the details: who benefits and how?

What are the disbenefits (negative side-effects)? When comparing the options, make sure that you don't focus exclusively on the BCR.

Keep those benefits not included in the BCR in mind, and also think of the extent to which each option is aligned with your objectives.

Looking at the results from such a broad angle, pre-select the two most promising options. Give time for adequate deliberation so that all voices can be heard. Consider voting or a ranking exercise on these two preferred options.

Step 4.8 | Check for sustainability

Sustaining the results of an intervention always matters. After all, you want to make sure that the initial investments continue to bring benefits for many years. There are three specific challenges to sustainability.

First, the success of DRR is usually **invisible**. Ideally, it leads to non-events — to hazards not turning into disasters. People may not appreciate the value of avoided losses because they remain abstract.

Second, if efforts focus exclusively on DRR and protective benefits, there may be a **long interval** between the investment and the gain (avoided losses). If cyclones happen every year, there is no problem.

But if they occur only every eight years, people may forget and lose interest in caring for a protective measure.

Third, ecosystems are **dynamic by nature**. Their health needs to be nurtured and monitored. To maintain their desired function, continuous care is needed long after the conclusion of the initial effort (likely an NGO-supported project).

Sustainability can be translated to the **willingness** and **capacity** of local owners as well as the strength of the **enabling** environment. It must not be an afterthought.

You should keep sustainability concerns integral to your decision-making early on: to what extent will communities and stakeholders be able and willing to commit to and deliver the stewardship of reefs, mangroves, or other measures included in your options?

Consider asking the following questions:

- how can the required resources (funds, equipment) be continuously secured for the long term?
- to what extent can technical expertise and skills be maintained and secured?
- what drives the community to sustain the outcomes?
- in how far are external enablers likely to endure (e.g. rules, laws, budget support)?

By having communities and stakeholders already engaged, you already have a head start: the sense of process ownership favours sustainability. If you can identify options and ways that combine long-term protective benefits (avoided losses) with near-term, tangible benefits (such as an increase in fishing income), you have a smart duet of continuous benefits that acts as an incentive to uphold community stewardship.

In sheet 4.8 of the solution finder, add your analysis of the sustainability for the two pre-selected options.

Step 4.9 | Decide on and refine your solution

4.1 — 4.2 — 4.3 — 4.4 — 4.5 — 4.6 — 4.7 — 4.8 — **4.9**

Through the assessment of feasibility, suitability, effectiveness and sustainability, you can now make a well-informed selection and decide on your solution. **Congratulations!**

In the final sheet of the solution finder (sheet 4.9), document your decision and summarise your reasons as well as the overall process (who was involved, main discussion points and concerns).

Save the solution finder — it will be an important resource for the detailed elaboration of a plan at the next stage, and could be shared with agencies offering funds for your planned efforts.

On a final note, we should end with a **caveat**: don't think of your solution as something that is 'set in stone'. Over time, you should explore how you can adjust it to become even more effective and/or sustainable.

One particular aspect concerns **integration**. The options were assembled out of measures like building blocks. Explore how you can integrate these measures in such a way that their effects mutually reinforce each other.

Examples include:

- the practical involvement of school and youth groups in afforestation activities that are coupled with education in risk management, conservation and science
- the integration of ecosystem care activities with livelihood activities, focussing on the most vulnerable. See case studies B.1 and B.3.

STAGE 5 MAKE A PLAN

Learn how to set your project on track through a concise plan.

By now, you have engaged the community and stakeholders, completed the assessment, and developed the solution to reach your objective. At this stage, you will need to operationalize your solution. While your solution is a combination of building blocks, you now need to determine when each block will be laid and by whom.

Principles & tips

- Keep the **steering committee** engaged in the process.
- Be **ambitious** but **realistic** in setting objectives and timelines.
- Ensure that your logframe indicators are **SMART**, and that your logframe is logically **coherent**.
- Retain **flexibility**: your plan should resemble a framework that still allows communities to have variable pathways to reach objectives.
- Be specific on **responsibilities**: who should do what and by when?

Step 5.1 | Build your logframe

Logframes are planning tools that show how various activities are linked to different layers of goals. They have a logical hierarchy:

- **Impact** refers to the final results on your target area. These may often emerge only in full after the conclusion of a project. Impact is expressed as the overall objective in logframes and may be reached if all underlying outcomes are achieved. For instance, the reduction of hazard-induced damages and losses (compared to the long-term trajectory on the basis of no action) could be a suitable overall objective.
- **Outcome**: The outcome level refers to **indirect** results of your actions that can be measured by the end of your project. It is useful to have multiple outcomes (or 'specific objectives') that support the overall objective at the impact level. The objective categories listed earlier (reduced exposure, decreased sensitivity, improved preparedness, enhanced coping capacity) may serve as a template for possible outcomes.
- **Outputs** are the direct results of your actions. If you run a training course for instance, the expected output would be the knowledge gains among course participants.
- **Inputs** are your activities, such as training courses and planting activities.

Complete the logframe by following a path that starts at the top (impact) and then progressively works downwards.

Rather than filling out the logframe table, develop a **theory of change** first. Write the components on cards and attach these cards to a flipchart. This has two advantages. You can visualise the connections and, if any do not seem logical, you can shift the cards around until you are content with the structure.

Start by asking: what impact do we want to achieve? Then ask: to reach that impact, what outcomes do need to be attained? Initially, focus on impact, outcomes and outputs only (don't worry about activities yet).

Although you may have many activities in mind (based on the results from the solution finder), the initial elaboration of the top level makes it easier to focus on the objectives. In other words, don't ask "what can we do?" but "what is needed?"

Start with narratives

Use the available information from the solution finder and assessments (communities may already have ideas expressed in community action plans) to develop your logframe. Formulate statements for impact, outcomes, outputs, and inputs. When you are happy with the structure, fill out the 'narrative' cells in the logframe. Use the planning tool (appendix F.5) for your logframe (this Excel-based tool also includes sheets for the work plan and budget).

Add indicators
For impact, outcomes and outputs, now add the indicators that you will use to measure progress. An example for an output indicator is "number of hectares with replanted mangroves". Avoid the common mistake of mixing targets into the indicators — indicators are simply your 'measuring tapes' or your 'thermometers'.

Set targets
Now add the targets for each of your indicators: what amount or percentage do you aim for? Targets can either be expressed in **absolute** terms ("40 hectares replanted") or in **relative** terms that refer to a baseline ("increase by 25% over baseline value).

If you use relative terms but do not yet have baseline values, you can establish the formula and add the baseline values later on when you have gathered baseline data.

Add assumptions
In principle, logframes should be coherent in the sense that if all goals on level X are reached, the goal on level X+1 is also reached. In other words, if all output targets underpinning an outcome are reached, that outcome target should be reached more or less automatically.

Assumptions, such as "as long as…", act as qualifiers: As long as assumptions X, Y and Z are met, outcome 1 will be attained when outputs 1.1, 1.2, 1.N are reached. Assumptions should only include aspects that you have no direct control over.

Review your logframe
Before proceeding further with the insertion of activities, review your logframe by running two checks. The **coherence check** asks whether the result chain is thorough and logical. Double-check the different elements of your logframe as visualized in your theory of change.

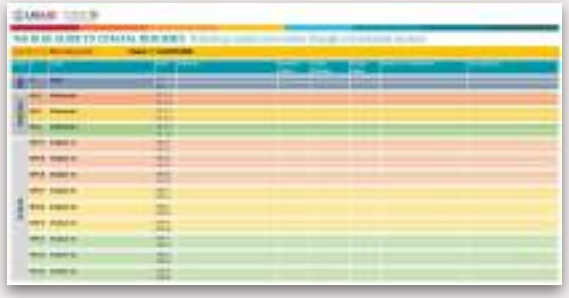
HOW STAGE 5 LINKS TO…

The Road Map to Community Resilience (IFRC 2020)
The Blue Guide's stage 5 broadly links to the Road Map's stage 3 ('taking action for resilience') — in particular, its step 4 (define actions and resources) and the related milestone 'Community Resilience Plan of Action'.

The Flood Management Green Guide (WWF 2016)
The Blue Guide's stage 5 links to the Green Guide's:
- Chapter 5, specifically 5.8: resource and cost planning in selection and implementation of structural methods;
- Appendix D: resource and cost planning guidance.

This Blue Guide's stage 5 adds more detail on how to develop the plan, and can be broader in focus (noting that the plan may transcend the boundaries of one community).

PLANNING TOOL: LOGFRAME, WORK PLAN, BUDGET



Use the Excel-based **planning tool** (appendix F.5) to:
- Create your logframe (sheet 1)
- Prepare your work plan (sheet 2)
- Develop your budget (sheet 3)

FISHING FLEET Boats resting on a beach in the Philippines. Fish is a critical source of protein and income for coastal communities around the world. Keeping marine habitats clean and healthy and using sustainable fishing practices are imperative from the food security perspective, among others. Photo: Patrick Bolte, Banyaneer

Will outcome X be reached if all its underpinning outputs are reached (and the assumptions are met)? Great if you can answer the question with a resounding 'yes!'. If that is not the case, either re-formulate your outcome or add further outputs until the coherence can be ascertained.

The **SMARTness check** is about your indicators and targets: are all of these sufficiently specific, measurable, achievable, relevant and time-bound? If not, tweak and improve them.

Add activities

Now add the activities that are required to achieve your outputs. Specify each activity and quantify the targets (e.g. delivery of 10 training courses on sustainable use of mangroves to 200 community members). Complete the list and conclude with a review as to whether the activities are sufficient to reach the output targets they support.

Step 5.2 | Build your work plan

Whereas the logframe is a list of objectives and activities, it does not include information as to who does what by when. That information is added in the work plan. The work plan combines schedule (showing the timeline on the x-axis) and activity list (on the y-axis).

Try building the work plan in sheet 2 of appendix F.5. This template allows you to create links between the three components (logframe, work plan, budget), in turn making it easier to update your plan.

Consider the following tips:

- **Group** the activities by output and list the activities under each output in more or less **chronological** order.
- Mark **dependencies** (e.g. activity Y can only be launched upon completion of activity X)
- Set **milestones** — major achievements that should be met at certain points of time.
- Assign **responsibilities** (who is in charge of each activities) Consider who will be responsible, accountable, consulted, and informed.
- Be **realistic** as to how much can be achieved in the set timeframes.
- **Share and review the plan** among steering committee members, and improve it as needed.

Step 5.3 | Develop the budget

Once you are confident that the logframe and work plan are effective and realistic, add the budget. This will need to include costs specific to activities (e.g. material, labour) as well as cross-cutting overhead costs that cannot be directly attributed to specific activities (e.g. the costs for a core project team).

List the items needed for your activities, indicating unit, number of units, unit cost, and sub-total (number of units multiplied by unit cost). The template in appendix F.5 automatically calculates the sub-totals and totals.

Step 5.4 | Secure funding

Depending on your context, your budget (as well as the work plan and logframe) may need to be revised.

- **If you already have a donor** and a defined funding amount that is lower than the total in your budget, reduce the scope of your plan, search for additional sources of funding, or do both. It's a good idea to stagger implementation if initial funding is insufficient. Implement an initial set of activities first, then add follow-up activities later as additional funding becomes available.
- **If there is no funding yet**, you will need to explore possible sources of funding first. Consider breaking up your plan to parcels, where each parcel is funded by different donors. Most donors appreciate synergies between different projects (parcels).

Step 5.5 | Search for long-term support

We have already highlighted the need to think of sustainability concerns under step 4.8. These concerns should now be operationalized. While a donor may fund an intervention over a defined period of time (e.g. a three-year project), there are usually indirect costs that will need to be carried by some sources after the conclusion of a project.

These indirect (post-project) costs may include expenses for monitoring, maintenance, refreshers and replanting. Explore ways to secure long-term financial support. It may not yet be possible to secure such funding (e.g. inclusion of such items in government budgets may take considerable time). Laying out a set of possible pathways — demonstrating that you have worked on long-term sustainability plans — is a formidable practice that will be viewed favourably by potential donors.

SIGNS OF STRESS Healthy coral reefs absorb wave energy and help protect communities. The combined effects of climate change and local pollution put them under stress, which often leads to coral bleaching, as can be seen in the case of this reef in the Maldives. Photo: Ishan @seefromthesky on Unsplash

STAGE 6

IMPLEMENT & MONITOR

Learn how to remain agile to keep implementation effective & efficient.

You now have your plan and should have acquired at least some of the funding to allow for your activities to take off. Excellent! The steps for implementation are outlined in your work plan. The Blue Guide provides **seven principles** that you should keep in mind throughout implementation. These principles reflect success factors.

Principle 1 | **Invest in your team.**

One of the most critical success factors of projects is the strength of the project team. Strong technical and communication skills are essential.

So far, you have mainly worked with the steering committee, who should remain central throughout implementation. However, one can rarely expect for volunteers to work full-time on major efforts. Especially if there are fixed project timelines (as is the case with all donor-funded projects), you need to recruit a management team.

Don't under-invest. Ensure that the size of your team is proportionate to the scale of the project and that your team has the right mix of skills. For typical community-based efforts, your team should have these skills:

- Project management & leadership
- Stakeholder liaison & advocacy
- Community facilitation
- Technical expertise in risk management
- Technical expertise in ecosystem management
- Protection, gender & inclusion
- Monitoring & data analysis
- Financial management & administration

Four of these skills should be highlighted for projects focussing on coastal resilience, because many projects tend to under-invest in them. First, you should have expertise within your team on **ecosystem management**, in particular expertise specific to the ecosystems that are part of your solution. There may be lots of technical questions for which adequate guidance is needed. Having the right expertise on your team will thus be immensely useful. If that is not possible, ensure that you have strong arrangements with relevant partners you can frequently draw on.

Second, **stakeholder liaison & advocacy**: keeping all stakeholders engaged is always important. With the added complexity of multiple sectors and themes (ecosystem management and disaster risk management, among others), it is critical.

The team should have a robust understanding of government structures, mandates, policies, planning and budgeting mechanisms, as well as laws and regulations pertaining to the intended effort. Such understanding will help align efforts with government and others and prevent the creation of parallel systems. In **urban settings** with more complex and dynamic contexts, the need is especially pronounced.

Third, **community facilitation**: engaging the community early and involving them in the planning process is essential. Effective facilitation will help you build and maintain the trust that is required, by listening, asking, summarizing, explaining, convincing (refer to principles 4 & 5). Many projects underfund facilitation and/or assign the least senior team members to this role. Avoid making this mistake.

Finally, **monitoring & data analysis**: monitoring often fails to be as central as it needs to be, and is sometimes seen as the inevitable task needed for reporting to donors. What's more, monitoring often tends to put too much focus on documenting inputs and outputs, but not enough on the analysis of progress towards outcomes and impact. Have well-trained members on your team who understand both qualitative and quantitative modes of analysis, as well as at least some basic statistics (see also principle 2).

Invest in the team-building and skills development to ensure that all team members are pulling on one rope.

Principle 2 | **Monitor to manage.**

Imagine you cook a soup. You probably wouldn't want to wait until it's ready, only to find out that it tastes terrible. You'd taste every now and then to fine-tune ingredients and come up with the best-tasting soup, right? Good monitoring creates short feedback loops, similar to the way you cook a soup.

Timely identification of success factors (why did the newly planted mangroves have such a high survival rate?) allows you to strengthen the role of those success factors in remaining programming. The flipside: the sooner you can identify problems and causes, the sooner you can rectify them. **Good monitoring enables adaptive management**.

Note that when you engage NbS, you should monitor both the performance and health of the ecosystems as well as other outcomes amongst the community. Your ecosystems experts should thus work closely with the monitoring team on socio-ecological monitoring — looking at the ecological impacts/performance, the extent to which they benefit the people, and the extent to which stewardship is taken up.

Principle 3 | **Use tangibles as mobilizers.**

In step 4.8, we already raised two common dilemmas of DRR projects: first, actual protective benefits tend to be invisible (hazards not leading to disasters).

Second, in areas with low-frequency hazards, the interval between the initial (project) investment and the materialization of protective benefits (avoided losses after a hazard) tends to be long. Over time, people may feel little incentive to maintain an exposure-reducing measure if the only benefit is a vague and abstract reward at some time in the future. To avoid these dilemmas, ensure that community members perceive and receive direct rewards — ideally, benefits that are tangible. There is much more incentive to maintain an outcome if community members receive ongoing direct livelihood benefits from it, as well as eventual hazard protection later on.

Throughout implementation, maintain this linkage and make it explicit. As presented in the introduction of this guide, NbS with their multiple benefits are a formidable fit to this end!

REEF RANGER A marine conservation ranger records notes after monitoring underwater coral reefs off Lamu island in Kenya. Photo: Mike Pflanz

Principle 4 | **Build & maintain trust.**

A strong relationship of trust between your project team and the community is absolutely essential. But trust needs to be earned and can be lost quickly. It is good to visit frequently and maintain a constructive relationship with the wider community.

HOW STAGE 6 LINKS TO…

The Road Map to Community Resilience (IFRC 2020)
The Blue Guide's stage 6 covers an aspect that is not directly covered in the Road Map — guidance for implementation is addressed in other IFRC materials. Implementation and monitoring should go hand in hand to ensure short feedback loops and to enable adaptive management. In terms of monitoring, this stage converges with the Road Map's stage 4 ('learning for resilience').

The Flood Management Green Guide (WWF 2016)
The Blue Guide's stage 6 links to the Green Guide's

- Chapter 5: structural and non-structural methods;
- Appendix E: monitoring and evaluation requirements for different methods.

CLEAN UP School children clean up the beach in Indonesia
Photo: The Nature Conservancy

You have already engaged the community in the planning process — and through the assessment, you should have gained insights on community structures and dynamics. Build on this capital. Listen. Ask. Explain. Convince.

Be humble. Be honest. Be respectful.

Don't promise what you may not be able to deliver. Avoid taking sides in local conflicts. Make sure you include all groups of the community. Men and women. The old and the young. The rich and the poor. The marginalised and the influential.

Good facilitation requires strong social skills and a sound understanding of culture and context. Ensure that your team has the right set of facilitators who have and maintain the trust of the people.

Principle 5 | **Nurture stewardship & cohesion.**

Trust is an essential pre-requisite if you want to nurture a strong sense of community stewardship of ecosystems and other measures. And that is exactly what you need to do, as a strong sense of stewardship is your best bet to sustainable results.

For NbS, this is even more important than for many other structural measures. Ecosystems are dynamic by nature. If adjacent communities do not sufficiently care and protect them — or continue practices that led to them being harmed in the first place — then prospects for success are not good. If you fail to win the community, you're very likely to fail the project. Therefore, continue **deep engagement**. Visit often. See what people think and do. Run surveys and focus group discussions, convince charismatic leaders and innovate to reach the wider community in an ongoing fashion.

See whether you can work with existing groups in the community or help form new groups. Train and equip groups, so that they are able to be strong stewards. Develop ways to render these groups sustainable and resilient themselves. For instance, provide training on technical skills, fundraising, financial and volunteer management. Help them establish routines. Make sure that their drive does not solely come from just one person.

Stay focused on reaching your objectives, but don't forget to look around. **Look for new opportunities** that may emerge over the course of implementation.

Fostering **social cohesion** and **collective action** often emerges as a by-product of project efforts. By facilitating equitable engagement and promoting a common vision, you can play a direct role in helping communities become more cohesive and proactive. Continuously seek input and be responsive to new ideas from community members — and be flexible enough to incorporate new measures if they support previously agreed objectives.

Principle 6 | **Ensure high technical quality.**

It almost goes without saying: any measure that is implemented should be of high technical quality to ensure that it can endure over time.

A seawall that has been built out of concrete without the right share of cement may quickly crack and break under lower loads than anticipated. Poor-quality measures like this can be more than ineffective: they can be deadly. They may give a false sense of security, leading the community to believe that they do not need to evacuate ahead of an upcoming cyclone.

So whatever measure you implement, ensure that it is carried out at the highest possible standards. Having the technical expertise on board is crucial. Let's take mangrove afforestation as an example. It may sound simple, but it is not. Selecting the wrong seedlings, outplanting at the wrong time of the year, or not sufficiently protecting the young plants from grazing livestock may lead to low plant survival rates. Although you need to brace for occasional setbacks, ensure that you reduce the risk by operating with high technical standards.

Following the step-by-step guides, using the additional set of external resources, and investing in the right skills (see principle 1) will help you in the process.

Principle 7 | **Adapt to remain agile.**

The final principle may be counterintuitive, but it is paramount: don't stick to your plan.

A plan is a pathway to reach your objectives. With a robust monitoring system, new information emerges all the time on what works and what does not. With good stakeholder networking, you may get new insights on government plans or policies that affect your current plan. With an open mind to new opportunities, you may be able to explore different and possibly better pathways. Think. Explore. Test. Then adapt and change your pathway. Communicate and explain changes to all parties involved. As long as you can argue your case for change, most donors will approve changes and in fact welcome your initiative.

There is an innate tendency among many project teams to push through a set pathway at all costs — partly due to insufficient monitoring capacity, partly because they see mid-project changes as a weakness or because these adjustments may simply require more work.

Sticking to plans that do not work is one of the most severe mistakes one can make. So, continuously **reflect and revise** to make sure that your efforts will lead to the most effective and sustainable results. At the next stage, we'll give more guidance to achieve exactly that.

NURSING MANGROVES

Julia Wati cares for tree saplings in a nursery in Aceh Jaya, Indonesia.

American Red Cross provided relief in the immediate aftermath of the 2004 Indian Ocean Tsunami, but also invested in long-term projects to ensure that towns build back stronger, healthier and better prepared for future disasters that may come their way.

By planting mangroves, casuarinas, and other trees, the Red Cross restored an ecosystem that had been severely damaged by the tsunami. The local Red Cross office hosts tree nurseries on their premises so they can grow species with certain characteristics, like mangroves that absorb the most heavy metals in water and soil.

The nursery also helps keep the local Red Cross office sustainable: by selling the saplings to local people and businesses, they are able to supplement their disaster services budget. Photo: Jenelle Eli, American Red Cross

STAGE 7 ANALYZE & LEARN

Learn how to reflect and adjust in order to maximise impact.

You have already learned about the importance of short feedback loops as a key to remain agile. Beyond continuous monitoring, invest in deep learning and analysis at regular intervals. Bring in external experts to facilitate learning amongst everybody involved in your effort.

Step 7.1 | Systematically analyze outcomes

Regular monitoring should aim to analyze the progress towards achieving outcomes, as we have argued above. (It must also analyze outputs and document inputs.) For instance, seasonal surveys of a small sample of the community can be used to analyze seasonal variation of food security and other parameters.

However, a **systematic and robust analysis of outcomes** requires a larger effort: representative surveys with sufficiently high levels of precision to detect statistically significant changes (such as those deployed as baseline, midline and endline) require many person-days to prepare, conduct, and analyze. Similarly, comprehensive and detailed reviews of the health status of ecosystems and their likely protective function and growth require substantial time.

Therefore, plan for these important reviews. As a rule of thumb, conduct at least one mid-term review for projects with a 3-4-year implementation period, and at least one such review every two years for longer projects.

Carry out additional **ad hoc reviews** if your project encounters substantial roadblocks and problems. Early action may save your project and set it back on track!

Furthermore, consider commissioning **thematic studies** of key aspects that are crucial to your project. Examples include the analysis of institutional or legal options for conservation arrangements such as Marine Protected Areas (MPA), analysis of behavior change communication (BCC) strategies, or of market conditions for alternative livelihoods. Such thematic studies are very valuable if a) there is an evident information gap (scan for existing studies first!), b) your team and steering committee does not have the required skills or knowledge and c) the study can benefit multiple projects.

Step 7.2 | Conduct hazard event reviews

The two dilemmas of DRR (the invisible success and the fact that 'avoided losses' are abstract) have been highlighted earlier. If your target area encounters a hazard event during or after implementation, conduct a post-hazard review.

These can be extremely useful to a) illustrate and analyze the protective benefit, b) reveal lessons as to how the overall solution can be further enhanced and c) to identify damages to ecosystems and other structural measures. Ultimately, these reviews can lead to more or renewed community engagement and to more effective arrangements. In many cases, they may make an invisible success visible.

These reviews should be carried out with the steering committee, as well as with the wider community. Prepare the exercise well and be mindful of appropriate timing: don't overwhelm a community if members are too busy rebuilding, however, try to complete the review within six months after the hazard event.

The **hazard event review tool** in appendix F.6 may be used for this purpose. It includes sections on the hazard strength, the damages and losses, the performance of ecosystems and other structural and non-structural measures, a comparative section (with past hazards and no-action counterfactual as reference points), as well as on lessons learned and actions for improvements.

Step 7.3 | Learn & adjust to maximise impact

Systematic reviews of outcomes and performance during hazards are only as powerful as the extent to which their findings are used. Don't do them if you don't plan to act on them.

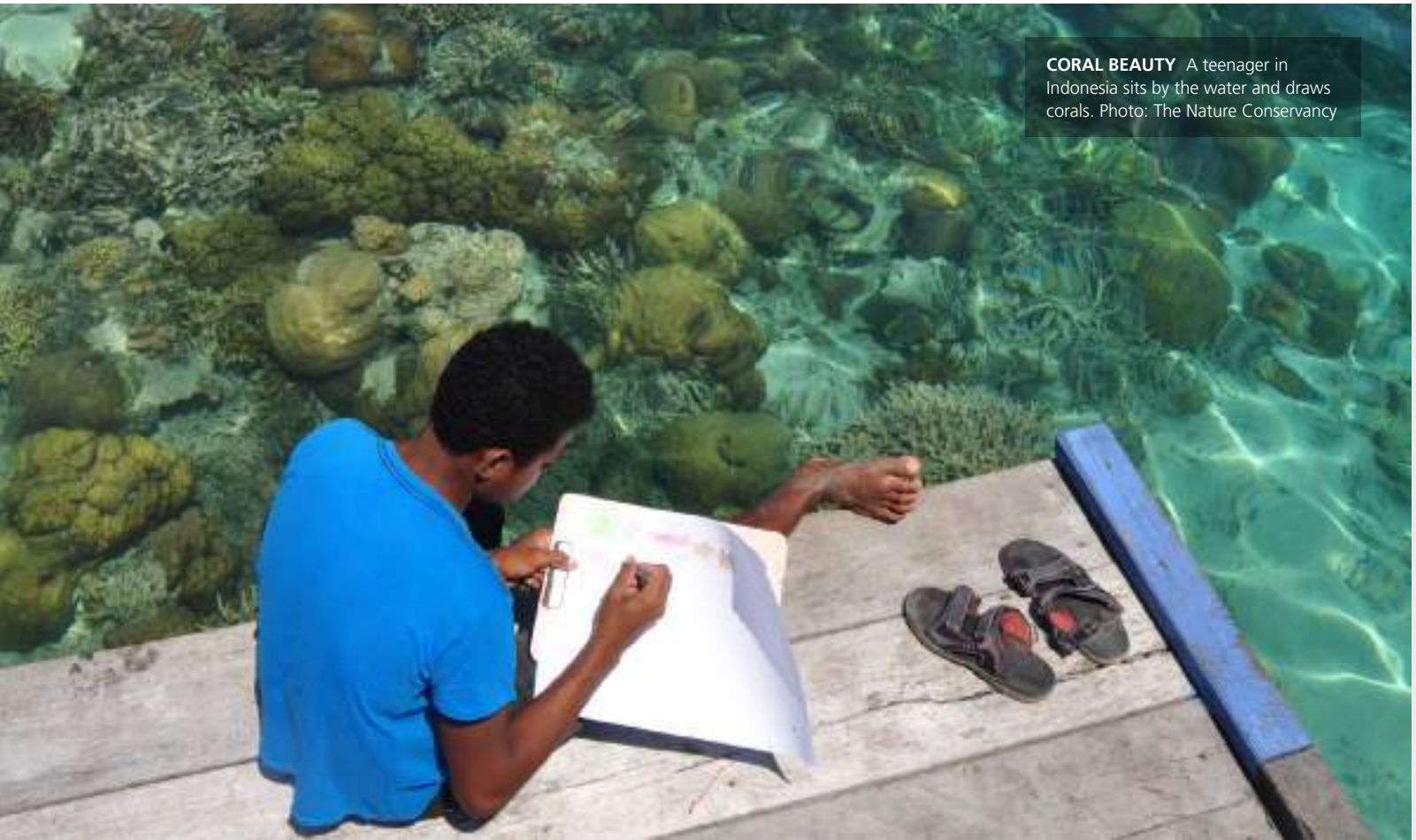
Numerous examples exist in which mid-term reviews, thematic studies and hazard event reviews led to substantial improvements — in turn, helping to achieve greater impact.

So be open to learn, to inquire, to adjust and to plan again.

It is a great practice if members of your team, steering committee and the community are closely involved in such studies. Don't simply outsource the study and wait for the report.

Make sure that the findings are communicated and widely understood by all. This allows everyone to get involved and to contribute to adjustments.

Just as you did in the initial planning, make sure that community, government and stakeholders remain engaged. Much like the initial plan, any adjustments should be locally owned!



CORAL BEAUTY A teenager in Indonesia sits by the water and draws corals. Photo: The Nature Conservancy

HOW STAGE 7 LINKS TO…

The Road Map to Community Resilience (IFRC 2020)
The Blue Guide's stage 7 has no exact equivalent in the Road Map - the systematic analysis described here goes beyond the regular monitoring. If you follow the Road Map, you can see stage 7 as a logical extension.

The Flood Management Green Guide (WWF 2016)
The Blue Guide's stage 7 has no exact equivalent in the Green Guide. However, the Green Guide discusses the value of documenting lessons learned.

TOOL: HAZARD EVENT REVIEW

Use the Word-based **hazard event review** (appendix F.6) to systematically analyze the difference that your DRR measures made in the hazard event. The tool is also useful to identify needs for improvements to these measures. Share the results of your review widely.

STAGE 8 SHARE & EXPAND

Learn how to best inspire others to adopt nature-based solutions

WATCH: STORM WATCHERS (12:27)

SHARING WIDELY 'Storm watchers' is an inspiring example of a film about a project by Malteser International in Myanmar's Rakhine State that included mangrove afforestation as part of disaster risk reduction efforts.

The challenges that climate change poses for coastal communities around the world are enormous. Yet the scale of communities supported by projects like yours is dwarfed by those not receiving similar support. Replicating and upscaling such efforts is therefore in dire need. By sharing your experiences and analyses openly, you may inspire and guide others.

Step 8.1 | Document your experiences well

Although there is no lack of practical case studies, most of them lack a thorough analysis of lessons, factors of success and failure, and eventual impacts (e.g. to what extent did a project help reduce damages and losses). While such case studies may inspire others to some extent, they offer limited guidance. Without adequate analysis of impact and cost effectiveness, they also have limited value for advocacy

Use the **case study templates** in appendix F.7 (see Word file, PowerPoint file, writing guide) to develop convincing case studies, invite scientists to conduct research related to your efforts, and consider externally produced case studies (e.g. as a spin-off from an evaluation or mid-term review).

Step 8.2 | Share openly and widely

Share your case studies and other experiences widely — within and beyond your target country, in online communities of practice, at conferences, webinars and workshops. Importantly, allocate some funding for conference participation, workshops and regional exchanges.

Also consider organizing national and regional exchanges among practitioners. To ensure that not only the highest-ranking officers take part — who may often be removed from direct action on the ground — ask potential participants to submit abstracts on a particular insight or experience. Then, select participants based on their submissions and invite them to present their case study or innovation at the meeting. Field visits can also be extremely insightful if they are well-designed. For instance, you may ask participants to complete specific tasks that help distill lessons for your and similar projects (e.g. 'investigate how the local team at the field site worked and compare their approach with yours').

Step 8.3 | Advocate for & support replication

Although NbS have moved from a niche role to greater acceptance and the case for using NbS as part of efforts to enhance coastal resilience is strong, much untapped potential remains.

You have already worked with governments and other stakeholders — now spread the word beyond your immediate target area.

Take the initiative and approach government agencies, stakeholders and communities in other areas. Invite them to see and hear about your solution and its impacts from your community members. Not only can this reinforce the pride of your community over their achievement, it can also be a powerful trigger, inspiring similar action elsewhere. If you can, support partnerships and exchanges between communities, and support replication and expansion where possible.

In addition to expansion to adjacent areas, explore opportunities to advocate for changes in regional or national policies and plans. Bring strong evidence along (to what extent were damages and losses reduced? What other benefits were created?). Utilize your understanding of government structures, policies, and budgeting mechanisms. Partner with other organisations and make advocacy a concerted effort.

Convince. The road to greater coastal resilience around the world remains long.

APPENDIX

WHY TWO TOOLBOXES?

- The application toolbox contains all tools for the regular use of the Blue Guide.
- The training toolbox is intended for those who plan to facilitate a training course

A. Step-by-step guides

A.1 Conservation arrangements

A.2 Reefs

A.3 Mangroves

A.4 Seagrass

A.5 Marshlands and swamps

A.6 Dunes

A.7 Shelter belts

B. Case studies

B.1 Vietnam: Mangroves' multiple benefits

B.2 Micronesia: Recovered reefs, raised resilience

B.3 Papua New Guinea: Conservation & empowerment

B.4 Belize: Young stewards with a passion

B.5 Grenada: Reducing coastal erosion

B.6 Philippines: With seaweed to win-win outcomes

B.7 Kenya: Blue carbon. Financing mangroves

B.8 Practical inspirations

C. Literature

D. Glossary

E. Key resources

TOOLBOXES (available online)

F. Application toolbox (click here)

F.1 Idea scrapbook

F.2 Problem tree template

F.3 Stakeholder mapping template

F.4 Solution finder

F.4a Solution finder user manual

F.4b Solution finder tool

F.5 Planning tool

F.6 Hazard event review tool

F.7 Case study template

F.8 Writing effective case studies

G. Training toolbox (click here)

G.1 Facilitation manual

G.2 Presentations (PowerPoint)

G.3 Teamwork material

G.4 Forms and templates

APPENDIX A.1 Conservation arrangements

Where ecosystems remain **intact**, the most cost-effective measure is to ensure they can prosper into the future, fulfilling their multiple roles for communities.

Where ecosystems are **degraded** in some way, it is imperative to first try to address the causes before venturing out to rehabilitate or restore ecosystems. To illustrate this point, it would make little sense to spend energy and resources on reef restoration if the cause for degradation continues to exist (e.g. the coral mining, overfishing, boats anchoring at reefs). Such efforts would likely lead to failures or short-lived successes.

It should be noted that it will not always be possible to fully address all factors behind ecosystem degradation through local/regional action, since climate change and other non-local factors put many ecosystems under added stress. In settings of **severe degradation**, additional remedial actions (as those outlined in appendices A.2-7) may need to be pursued. But even then, some form of conservation arrangement should accompany the actions.

The success of ecosystem preservation is inevitably bound in the level of commitment by government, communities and key stakeholders, as well as by the availability of staffing, resources, enforcement and resource monitoring.

While marine protected areas (MPA) are usually designated through a top-down government approach and legislated, locally managed marine areas (LMMA) may be designated and managed at the local level by communities, land owning groups, partnerships and/or collaborative governments based in the same area. LMMA will usually include some or most of the key recommendations outlined below but may also include revival or continuity of traditional practices that have sustained the area over generations. While the participatory nature of LMMA may require more investment at a local level, the ownership and commitment can be a major strength.

Marine Conservation Agreements (MCA) have been increasingly used by NGOs when working with coastal communities and are defined as "any formal or informal contractual arrangement that aims to achieve ocean or coastal conservation goals in which one or more parties (usually rights-holders) voluntarily commit to taking certain actions, refraining from certain actions, or transferring certain rights and responsibilities in exchange for one or more other parties (usually conservation-oriented entities) voluntarily committing to deliver explicit (direct or indirect) economic incentives".

Supporting and promoting ecosystem preservation areas plays an important role in DRR and coastal resilience. Not only can they provide a protective effect from storm surges, waves and reduction of erosion, coastal ecosystems also provide opportunities for community and stakeholder engagement and learning about coastal resilience practices. Regardless as to whether MPA, LMMA or MCA approaches are selected, basic principles should be applied across all areas and adapted to fit the local conditions.

Step 1: Manage MPA effectively

No-take areas (no fishing, collecting, harvesting) need to be in place for the long term (20-40 years) or permanently. Action must be taken to minimize and reduce stressors to the environment. Aim to embed MPAs in a broader management framework, for example through integration with coastal management regimes, to effectively control threats coming from outside the MPA and in network of multiple MPAs that are ecologically connected.

Step 2: Represent and replicate

Represent the full suite of marine habitat types to help preserve all key elements of biodiversity (species, communities and physical/oceanographic factors). Designate multiple representative habitats to reduce risk in the event of an adverse event in one location. This method spreads the risk and

increases the likelihood that surviving habitats will help seed affected habitats and encourage natural recovery. It also increases the diversity of habitats.

Step 3: Critical areas

Ensure that 'no take' areas include critical habitats, including spawning, feeding, breeding grounds, juvenile fish habitats and larval sources. Include special or unique sites (e.g. turtle nesting sites, rare or threatened habitats) and resilient sites in the MPA network.

Step 4: Connect protected areas

Apply minimal sizing to protected areas in the network with a variety of spacing distances between protected areas them. For instance, space marine reserves 1 - 15 kilometers apart and smaller reserves closer to each other. With LMMAs and MCAs, this may not be possible or feasible. Locate MPAs in habitats that are important to focal species. Use square or circular shapes for MPAs subject to considerations of compliance (e.g. including using landmarks).

Step 5: Consider social, cultural, economic and governance aspects of coastal communities in design and management.

Community acceptance and involvement is critical for the preservation of sites. Thus, it is important to address current patterns of use by coastal communities (recreation, education, cultural practices and economic benefits). Explore whether conflicts of interest are present, how resources can be managed, and what cost-sharing arrangements are feasible. Community groups and stakeholders must be involved in decision-making, management and monitoring of all conservation arrangements.

Step 6: Adaptive management

Make well-informed decisions about what actions are the best for a conservation project. Measure and test the effectiveness of strategies used and learn and adapt in order to improve strategies. Use adaptive management cycles to continually improve.

ON PATROL A team of rangers patrols a marine protected area in Raja Ampat, Indonesia. Photo: The Nature Conservancy

Step 7: Measure effectiveness

Identify effective practices. This helps determine which activities a manager should continue and build upon. Some practices might be modified and replicated for other programs or initiatives based on the results. Explore whether local regulations allow for options of expansion.

Identify practices that need to be improved. Some activities may need to be changed in order to improve the effectiveness of a management program. Provide value to existing and potential funders: funders are acutely aware of the need to document the success of programs. Future funding opportunities will often depend on the managers' ability to demonstrate that the program and activity is effective.

FURTHER RESOURCES

- Introduction to Marine Conservation Agreements
- Practitioner's Field Guide for Marine Conservation Agreements
- MCA Field Guide Checklist
- Advanced Studies in Coral Reef Resilience: Module 5

APPENDIX A.2

REEFS

Reefs are underwater ecosystems whose protective benefit for coastlines is derived from the absorption of wave energy. As a home to many sea creatures, these reefs provide nutrients, food and protection for a multitude of residents. Reefs differ in their composition and how they nurture nature. There are two main and distinct types of biogenic reefs - **coral reefs** and **shellfish reefs**.

UNDERSTANDING CORAL REEFS

Coral reefs are formed by coral polyps and grow best in warm, shallow, clear, sunny, and agitated water. While they are spread over less than 0.1% of the world's ocean expanse, they are home to 25% of all marine species. They flourish in nutrient-poor waters and are fragile due to their sensitivity to water conditions. Healthy coral reefs absorb wave energy and help protect communities. These 'rainforests of the sea' have numerous other benefits - including their value for tourism, fishing, and biodiversity.

A meta-analysis of coral reefs in the Indian, Pacific, and Atlantic Oceans revealed that on average, reefs dissipate 97% of wave energy that would otherwise impact shorelines.

In their meta-analysis of 27 studies on coral reefs and wave attenuation in the Indian, Pacific, and Atlantic Oceans, Ferrario et al. (2014) compared the wave energy and height reduction by reef crests (the seaward barrier of the reef), the reef flat (the expanse of the reef), and the whole reef.

Most of the energy is absorbed by reef crests (86%), although the width of the reef flat also makes a difference in wave energy and wave height reduction (for reef flats less than 1,000 meters wide). A study estimates that 100 million people receive protective benefits from existing coral reefs (Ferrario et al. 2014:6), although it did not quantify the benefit.

In the Caribbean, the value of local biodiversity protection from coral reefs has been estimated at USD 251 million per year (Heck et al. 2019:5). For its fisheries and aquacultures alone, the overall value has been estimated at USD 110 million for coral reefs. These reefs attract foreign and domestic visitors and generate revenues, including foreign exchange earnings, in over 100 countries and territories. The gains from coral reef tourism in the Caribbean has been estimated at USD 5.7 billion annually (ibid). Globally, the benefits are estimated to be worth USD 35.8 billion per year, with the highest shares in Egypt, Indonesia, Mexico, and Thailand (Spalding et al. 2017:109).

Despite their enormous value, they are under threat from climate change through oceanic acidification, altered water conditions, rising temperatures, and more intense weather events, as well as local factors such as nutrient run-off from fertilization, over-fishing, and harmful development practices such as coral mining. The combined effects of climate change and local pollution put them under stress, which often leads to coral bleaching, as can be seen in the case of reefs in the Maldives on page 43. Bleaching occurs under certain conditions (e.g. the water becoming too warm), where corals expel the algae living in their tissues and turn the coral white. They can survive bleaching events but are under increased stress.

Coral reefs have the ability to naturally recover if degraded. At 60-70%, coral reef restoration survival rates are relatively high when specific methods are tailored to local conditions (Boström-Einarssen et al, 2018:2). However, the vast majority of studies only monitor restored coral colonies for one to two years, after which coral survival decreases.

UNDERSTANDING SHELLFISH REEFS

Shellfish reefs are made of bivalve shellfish (such as oysters or mussels) that attach to the existing shells and can create large reefs made of thousands of generations of shellfish. Shellfish

feed on plankton and other organic matter, and thus assume an important water filtering function. The biodeposits from the shellfish encapsulate the particulate matter from the water column, making the contained nutrients available to the invertebrates that live in the reef, increasing biodiversity and biomass, increasing fish production and increasing the supply of nutrient available for bacterial denitrification.

These reefs also stabilize shorelines by promoting sediment deposition and buffering wave energy, thereby allowing other habitats such as seagrass beds and marsh areas to form while simultaneously decreasing erosion of the shoreline.

Many shellfish reefs have been lost over the past decades, mainly due to overfishing, or are under threat.

Shellfish reefs play important roles in ecosystem services, including:

- Water filtration that improves water clarity and can help support seagrass growth;
- Provision of food and habitat for many species, birds, fish, and crabs,
- Nutrient mitigation through increased denitrification; and
- Coastal protection, as they absorb wave energy, stabilize the seabed, and reduce erosion from storms and sea-level rise.

Globally, over 85% of shellfish reefs have been lost. Though action to restore and preserve these important ecosystems remains limited, large-scale restoration efforts in the United States and Australia have demonstrated that the ecological function can be repaired and ecosystem services restored.

Shellfish reefs can provide both short and long-term employment opportunities, and established reefs can provide long-term disaster risk reduction, economic and environmental gains for coastal communities, particularly in fishing, tourism, and coastal protection.

REEF RECOVERY

Considering the enormous protective benefit of coral and shellfish reefs as well as several other benefits (e.g. value for food security and tourism), the economic case for investing in healthy reefs is strong in most contexts (even if the environmental benefit of preserving biodiversity is discounted).

Conservation of reefs (e.g. protection and effective management) is by far the best and least costly option, compared with coral reef restoration interventions including biological and physical (artificial) restoration. These measures are expensive and technically challenging - requiring expert scientific advice and guidance.

A study focusing on the Caribbean concludes that coral reef and mangrove restoration projects in that region are ten to one hundred times cheaper than artificial coastal defenses (Narrayan et al. 2019: 1). For instance, the study concludes that the median costs for coral reef restoration in the Caribbean are USD 1 million per linear kilometer (assuming a width of ten meters), compared to USD 19 million for artificial breakwaters and levees.

If you are interested in pursuing **coral reef** restoration, there is guidance supplied in A Manager's Guide to Coral Reef Restoration Planning and Design, developed by The Nature Conservancy and others. The Manager's Guide includes a six-step, adaptive management planning process to help users develop a restoration action plan in their location, with the assistance of several tools and tutorials.

Similar resources are available for **shellfish reefs** (Fitzsimons et al. 2019) with an adaptation for the European native oyster available here. Note that restoration in any habitat should not be attempted until there are protections around the proposed areas and the causes of degradation are addressed (whenever possible).

THE CORAL REEF RESTORATION FRAMEWORK

Step 1 | Set the goal and geographic focus

To start, you should identify priority restoration goals for the region in which you work. This step is intended to help managers develop a realistic and achievable vision for their restoration work and help avoid "trial and error" projects.

In conservation, a goal is a formal statement that details the desired impact you hope to achieve by conducting interventions - here, restoration interventions. Goals should be thought of as being achieved over the medium-to-long term– such as over 10 to 20 years - and reached through more concerted objectives that occur over shorter time intervals (in step 4 of the Reef Restoration Guide).

The suggested process for completing this step is to brainstorm and prioritize restoration goals. You can then craft SMART goal statements using the attributes of Specific, Measurable, Achievable, Relevant, and Timebound.

Spending time to make sure goals go from being broad to including as many details as possible will allow you to be able to assess whether your restoration work has indeed been successful and that your goals have been met.

You will then identify geographic focus areas of interest for each of these goals. These are broad areas where conducting restoration interventions would be most appropriate or relevant to achieving your goal. From this, you can narrow down to selecting specific sites for restoration in the next step.

Figure A2.1 | **Coral reef restoration framework**

Step 2 | Identify, prioritize, and select sites

In this step, you will identify sites where restoration could be conducted to reach your goal. To do this, the restoration guide suggests starting with a brainstorm to list all potential restoration sites in the geographic focus areas designated in step 1.

To narrow down and finalize your list of sites, the restoration guide provides a framework to help prioritize which sites are high, medium, or low priority for restoration.

The framework provides a rigorous process for site selection and is designed to help ensure:

- That sites where restoration is conducted will help achieve your restoration goal
- That restoration interventions have the ability to improve conditions at the site, and
- That corals have the potential to survive there in the short and long term. Coral survival depends on future exposure of reefs to stressors, the ecological resilience of reef sites, and the level of human impacts experienced on reefs. This may require conducting a reef resilience assessment (find more information about the Reef Resilience Network's 10-step process here).

The framework can be used in a semi-quantitative or a fully quantitative approach. For both approaches, the end result is a ranking or classification of the potential restoration sites as high, medium, or low relative priority. Deciding on which approach to use requires collecting available data on those sites and assessing gaps in the data.

After gathering relevant data and synthesizing results, the final step is to work with key partners, stakeholders, and decision-makers to decide on a list of sites where restoration will be conducted or piloted.

Step 3 | Identify, design, and select interventions

This step starts with considering all possible interventions that could be used to support the restoration goal. After developing this initial broad list, it is suggested to design these interventions including details of how they will be implemented. This includes applying general design questions as well as climate-specific questions, to determine how climate change could impact the interventions.

General design questions include:

- What coral species will be used?
- Where will corals be obtained?
- What coral propagation and/or outplanting methods will be used?
- What biological control techniques will be used?
- What physical or engineered techniques will be used?

Climate-smart design considerations include:

- How will climate change and its interaction with local stressors of concern impact the biological resilience of the restoration intervention?
- How will climate change affect the physical functionality of the restoration intervention through direct impacts on structural components?

You can use the Adaptation Design Tool to more thoroughly consider climate change in your design.

The final process is to develop and conduct an evaluation process where partners and stakeholders provide input on which interventions (as designed above) to implement. The restoration guide suggests using evaluation criteria of effectiveness, feasibility, flexibility, urgency, and externalities, and provides an excel tool to visualize results of the evaluation process for discussion.

Step 4 | Develop a restoration action plan

In this the final planning step, it is suggested to decide on the final details needed to develop a restoration action plan. This includes identifying performance metrics and developing SMART objectives (that can be measured using the performance metrics). Performance metrics are used to quantify the results of interventions and monitor progress in order to determine if they have been successful. Objectives are descriptions of shorter outcomes over 1 to 10 years that can be used as benchmarks towards reaching your restoration goal.

More information on performance metrics and how they can be monitored for coral reef restoration can be found in the Coral reef restoration monitoring guide: Methods to evaluate restoration success from local to ecosystem scales (Goergen et al. 2020).

Information gathered throughout the planning process can then be culminated into a summary Restoration Action Plan. A template is provided here.

Step 5 | Implement restoration

Implementation of a restoration project will occur over many years, during which interventions are piloted, scaled up, and monitored to determine if and when the restoration goal has been achieved.

Control sites similar to restoration sites should be identified in order to assess and attribute changes in the reef state to restoration interventions rather than natural recovery.

A common method for this is called a BACI (Before-After-Control-Impact) experiment (Smith 2014). As natural recovery of reef ecosystems can take years to decades, implementation and monitoring should also occur over this timeframe.

Consider incorporating local stakeholders and community members in restoration. These partners can be critical players in successful implementation of restoration activities and for ensuring the long-term sustainability of the project. At the least, providing updates on the progress of the restoration project allows involved stakeholder groups to remain up-to-date, may lead to solutions to problems, or help to set and keep reasonable expectations.

Step 6 | Monitor and evaluate progress

It is important to develop a detailed, long-term monitoring plan that assesses how reefs recover at restoration sites. A monitoring plan will need to include details on information needs, targets for performance metrics, the methods you will use to measure the metrics, spatial scale and locations, timeframe, and project personnel roles and responsibilities for collecting data.

To develop a monitoring program, we recommend using the Coral Reef Restoration Monitoring Guide: Methods to Evaluate Success from Local to Ecosystem Scales (Goergen et al. 2020).

In addition to monitoring progress towards your objectives and goals, regular status assessments of the project should be conducted to identify needs for maintenance. Checking the status of the project will likely need to be done more regularly than data collection.

Monitoring should be done simultaneously with monitoring rather than sequentially and be used to adaptively manage a restoration project. For more on coral reef monitoring, see resources on the Reef Resilience Network.

Common methods for coral reef restoration

Coral gardening

Coral gardening (also called asexual coral propagation) involves a number of methods to generate new coral colonies and add them to a natural reef. This includes intermediate propagation and a growth phase in a coral nursery.

Coral grown in this way are genetically identical and are grown by fragmentation, where a colony breaks and fragments grow into individual colonies that are genetic clones. Coral gardening is best suited to restoration projects that aim to increase coral cover or to assist a struggling coral population that cannot recover naturally.

The benefits of coral gardening are that it allows the generation of large amounts of coral colonies while minimizing the damage to existing populations. The disadvantage is that fragmentation does not increase genetic diversity.

Coral nurseries are critical to this process and can be set up at field-based or land-based locations, where large quantities of corals can be propagated and grown.

Usually established close to the reef restoration site, field-based nurseries require less cost and technology. However, they can also be more susceptible to environmental extremes, such as severe weather conditions. See here for more details on nursery site identification, nursery structures, nursery types, and nursery monitoring and maintenance.

Land-based nurseries are more sheltered and protected from extreme environmental events, and conditions can be managed adapted, as needed, to promote increased growth. However, these nurseries can be expensive to establish and operate and they require trained staff with technical expertise in aquarium husbandry.

See here for further details on land-based nursery design and considerations, water quality conditions, coral fragments, and disease management.

Larval propagation

Larval propagation is technique of assisting in the creation of new coral colonies by using the natural sexual reproduction process of corals. As corals produce millions of larvae each year with new and diverse genetic traits, this technique allows practitioners to promote coral reproduction.

Larval propagation can scale up restoration efforts, improve the genetic diversity of coral populations, and work across diverse coral species. However, challenges include working with microscopic coral, rearing larvae in culture, having the right equipment and conditions, and night diving.

It is important to consult with regulatory authorities and scientific experts before commencing this type of work.

Coral produce larvae by two methods — broadcast spawning and brooding. Broadcast spawning involves the release of eggs and sperm into the water column. Brooders undergo internal fertilization and release larvae. While both can be collected for larval propagation, broadcast spawning provides the largest volumes of gametes for larval propagation.

For more detail on the biology of coral reproduction, predicting spawning, collecting spawn, propagating recruits through fertilization, rearing larvae, settlement, monitoring coral recruits, and outplanting, follow the link to Lesson 3: Restoring Coral Populations with Larval Propagation.

RESTORING SHELLFISH REEFS

The restoration guidelines for shellfish reefs (Fitzsimons et al. 2019) include a useful practitioners' checklist that is presented below.

Know the system you are working in

Become familiar with the ecosystem in its local setting (e.g. consider its historical distribution), causes for decline, current threats (including diseases), bivalve lifecycle and reproduction methods and associated community assemblages. Gather evidence of recruitment strength and timing from previous research, observation, aquaculture operators and settlement plates.

Develop a restoration concept and socialise with potential project stakeholders and supporters

Consider developing a short document that outlines project aspirations and potential approaches. Use this to receive feedback and support for establishing a more detailed feasibility plan and funding proposals. Include regulators in the outreach.

Establish a feasibility plan

Consider including the following in a feasibility plan:

- Identification of reference ecosystems or reference models and derived targets
- Clearly defined SMART objectives
- Identification of project stakeholders and supporters
- Likely funding streams
- Different restoration approaches
- Availability and disease tolerance of broodstock and source of seed (if larvae limited)

Identify funding sources and secure funding

Consider linking ecosystem service outcomes to beneficiaries and targeting funding opportunities linked to ecosystem service outcomes. Explore opportunities to leverage and match initial support.

Establish project management systems

Establish detailed project and implementation plans, communication plans, volunteer management, legal framework and contracts, detailed risk assessments, site management plans, tenders and quotes, etc.

Know biosecurity risks and permitting requirements

Identify biosecurity and disease risks to wild populations and to aquaculture and fishing industries. Understand requirements and development times to secure permits. Understand/address the potential threat of the harvest of shellfish from the restored reef.

Undertake habitat suitability assessments and pilot studies

Identify optimal places for restoration with the system using suitability assessments, history of the most recent shellfish reefs, and pilot studies.

Confirm technical approach(es) required to support recovery including reef designs

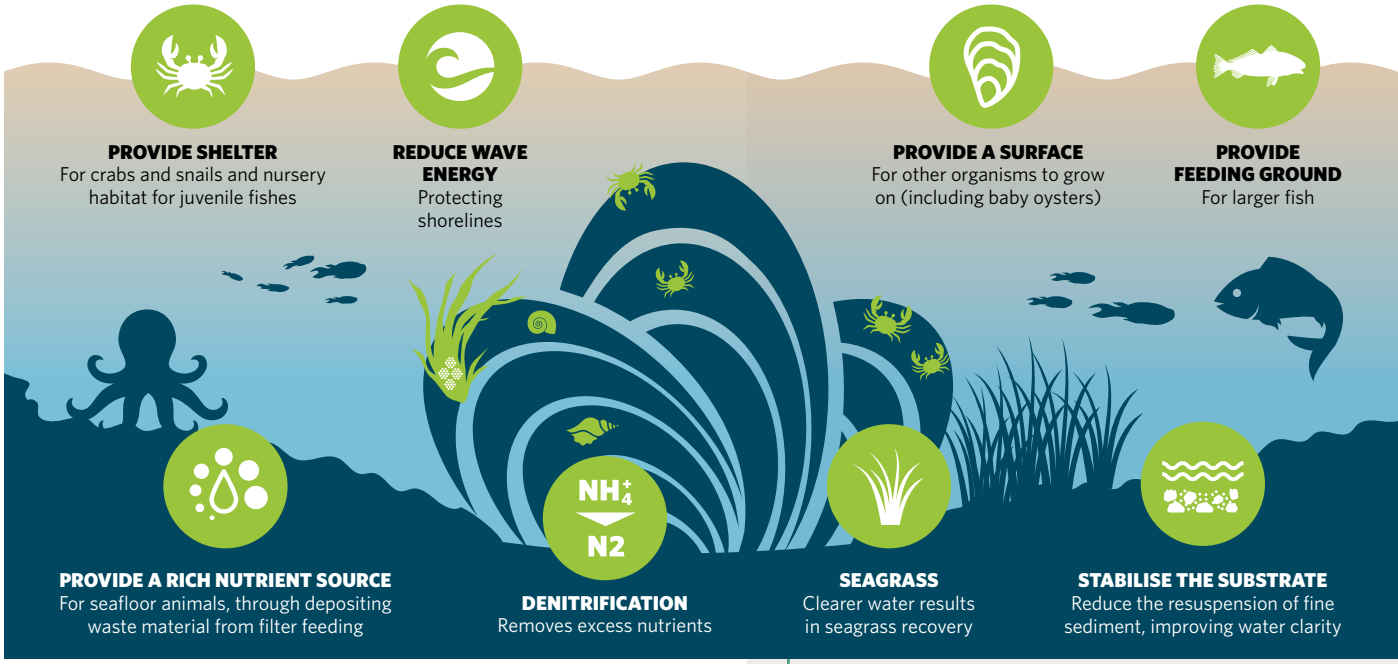
Does the ecosystem require reconstruction (e.g. addition of substrate and shellfish), assisted regeneration (e.g. addition of substrate or shellfish) or management to limit threats (e.g. sediment, disease or predation). What reef designs will be used to support these technical approaches?

Undertake restoration

Work with community volunteers, contractors and third parties to mobilise and deploy substrate, shellfish and reduce/remove threats.

Undertake monitoring, evaluation and reporting

Measure progress against predefined restoration targets and reference ecosystems and models. Measure universal indicators.



ECOSYSTEM SERVICES OF SHELLFISH REEFS

From: Restoration guidelines for shellfish reefs

Effectively communicate outcomes of your project to stakeholders, practitioners and the research community

Plan for communication, do the basics and target visual mediums and social media.

For more on monitoring of shellfish reefs, see here and here. For case studies on shellfish restoration projects, see here.

FURTHER RESOURCES

- A manager's guide to coral reef restoration. Planning and design (2020)
- Restoration guidelines for shellfish reefs (2019)
- Reef rehabilitation manual (2010)
- A step-by-step guide to reef rehabilitation (2008)

APPENDIX A.3
Mangroves

This appendix is primarily based on the **Guidelines on Mangrove Ecosystem Restoration for the Western Indian Ocean Region (UNEP 2020).**

Access the full guide here.

UNDERSTANDING MANGROVES

Mangroves grow along tropical and sub-tropical coastlines within latitudes of 32° North and 38° South. There are two distinct groups — the **western group** ranging from the eastern Pacific to the African west coast, and the **eastern group** ranging from Africa's east coast to the central Pacific. The eastern group is much more diverse, having five times as many species as the western group. Only three genera of species exist in both groups (Acrostichum, Avicennia, Rhizophora).

Most mangrove forests are **structured in zones** that run parallel to the shoreline. Each of these zones usually has dominant (sometimes just one) mangrove species. This distribution of mangrove species is caused by varying levels of environmental factors across the intertidal area. This includes salinity, level and frequency of inundation, tidal flow and nutrient availability, amongst others (see fig. A3.1 below).

Mangroves play important roles as **habitats** and nursery grounds for fish, birds and other wildlife, and **support associated ecosystems** such as seagrass meadows and coral reefs. Mangroves are formidable carbon sequesters that store much more carbon than land-based forests — particularly underground. Despite their substantial environmental, protective, economic and cultural significance, the global expanse of mangrove forests has seen a stark decline.

Like all ecosystems, mangroves are dynamic and regenerate, shrink, expand or shift over time, in response to environmental conditions. Their propagules (seeds) fall off into the water when ripe and develop into new plants, provided they end up in fertile soil.

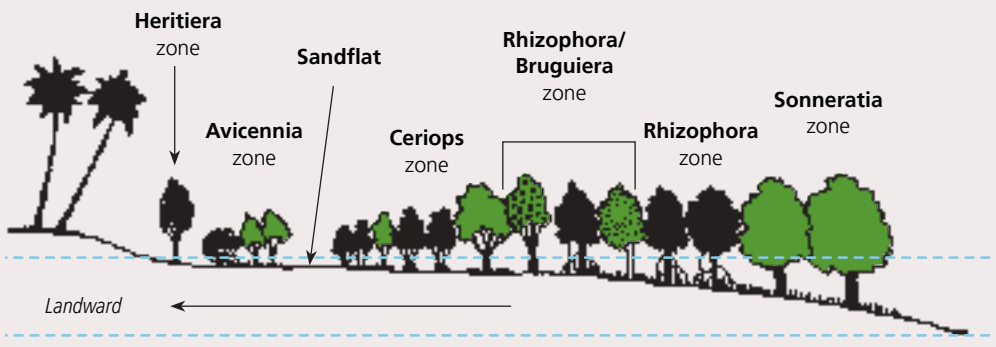
PRINCIPLES & PITFALLS IN REGENERATION

Mangrove reforestation has been integrated into numerous development projects, mostly at small scales (though some large-scale applications have been pursued in Bangladesh and Vietnam, see case study B.1). But many initiatives have focussed on planting itself, rather than on pursuing a comprehensive management approach.

Three main pitfalls have been identified that led to failures in mangrove reforestation projects:

- **Extreme changes in site conditions**, including soil factors (especially salinity), hydrology (water movement) and sedimentation;
- **Inappropriate restoration techniques**, as species-site mismatch, low-quality seeds/propagules, poor nursery establishment, poor site preparation and inappropriate transplantation; and
- **Failure to involve all stakeholders**, especially local communities and government agencies.

Figure A3.1 | **Mangrove species zones**



Most mangrove forests consist of various zones. Each zone is inhabited by species that are adapted to the varying conditions in terms of water level, salinity, and soil. The illustration shows a zonation that is typical for the Western Indian Ocean.
Source: UNEP 2020:4.

Deciding to plant mangroves at the outset is equivalent to having a 'solution' without knowing the problem. In many cases, effective mangrove reforestation does not involve planting at all.

When mangrove forests are degraded or shrunk in size, the first question is: what caused the degradation? Why do propagules no longer grow into flourishing trees? Identifying these problems underlying degradation has to be part of the ecosystem assessment (step 3.2). It is also critical to understand what role the community plays: did altered use of the mangroves cause the degradation?

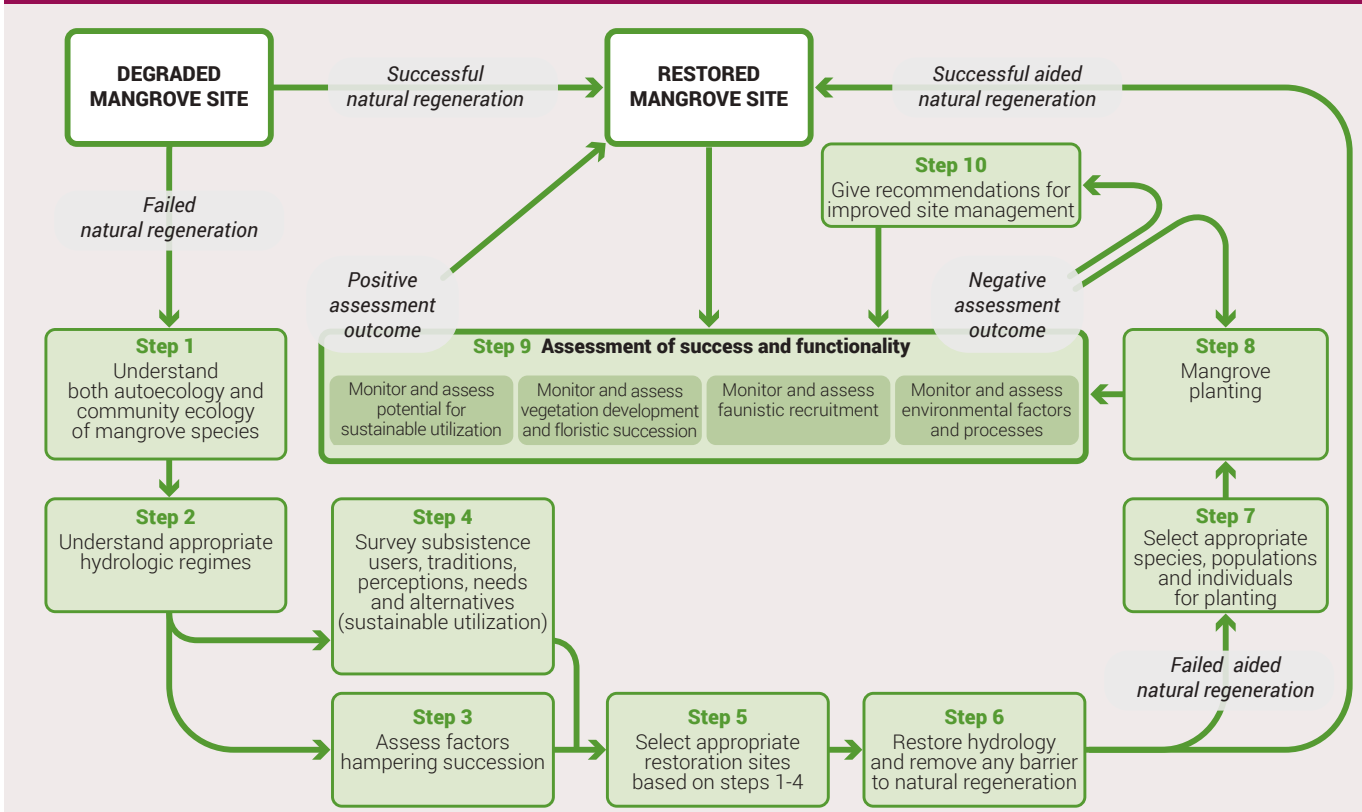
DECIDING WHAT TO DO

In principle, there are two ways to make mangrove forests prosper again — **natural** and **artificial restoration**. Use the flowchart in fig. A3.2 to determine the most appropriate technique.

Natural restoration (also called natural aided regeneration) addresses the external causes. This removes any barriers that currently prevent natural regeneration. For instance, this may include efforts to restore hydrology (e.g. the removal of dams) or to reduce harmful community practices, such as over-exploitation of mangrove trees for cooking fuel.

If these efforts fail to succeed, **artificial restoration** — the planting of suitable mangrove species in the various zones of the intertidal area — may be considered. However, technical expertise is required both to judge the chances of success (if site conditions have seen extreme changes and cannot be rectified, newly planted trees may not survive after all) and to guide the planting process. Whenever possible, integrate alternative livelihood opportunities for coastal communities to create tangible and ongoing benefits, for instance through beekeeping, ecotourism and aquacultures. Eco-efficient cookstoves could be promoted to reduce the demand on mangrove forests.

Figure A3.2 | **To plant or not to plant? Ten steps for decision-making**



Source: Bosire et. al 2008, as cited and illustrated in UNEP 2020:48.

IMPLEMENTATION

The decision flowchart in fig. A3.2 illustrates the steps in assessments (steps 1-4) and natural restoration (natural aided regeneration, steps 5-6). Let us look more closely at the steps you need to take if natural restoration has failed and you want to consider **planting mangroves** (steps 7-10).

Note that the steps listed here primarily correspond with the Blue Guide's **stages 5** (make a plan) **and 6** (implement and monitor). There is an important caveat that needs to be noted.

Golden rules of mangrove restoration

- **Understand why natural regeneration is not occurring** or is not sufficient and then make adjustments to the site or find solutions to social issues.
- **Plant close to where** the species naturally occur, as this follows nature. Try planting two or three propagules or seedlings close together in clumps or groups.
- **Do not plant mangroves** too densely (covering the entire area), as this will restrict the opportunity for natural regeneration and higher biodiversity. Plant as many species as are naturally occurring on your site, if possible.
- **Small-scale test planting** is a wise way to assess your site, as mass planting could be setting you up for a big failure.
- **Do not plant** in any water channels, seagrass beds, mudflats, or on the raised sand flats.
- **Make sure the local community members are fully involved** from the planning stage and that they take on the ownership of the project.
- **Ensure the site is protected** from people, boats and livestock, fenced if necessary. Install signs at the site with a phone number so outsiders know it is a restoration site.
- **Plant seedlings, propagules, or wildlings collected as close as possible** to the restoration site. If wildings are used, replant them immediately, preferably in the late afternoon
- **Monitor your site long-term** (usually five years) and learn from both successes and failures and make necessary corrections and adjustments.

Source: Enright and Wodehouse (2019), as cited in UNEP 2020: 20.

Unless there have been prior unsuccessful efforts in natural restoration, it may not be known yet as to whether the a project will need to include artificial restoration. **You must not go straight into planting activities without having understood and addressed the factors of degradation first.**

Identifying appropriate species for the mangrove zones: with the mangrove zones and species in those zones identified, select the various species that you will need to plant in each of the zones in the designated reforestation area. Aim to use existing species in each zone and try to replicate the naturally occurring mix of species.

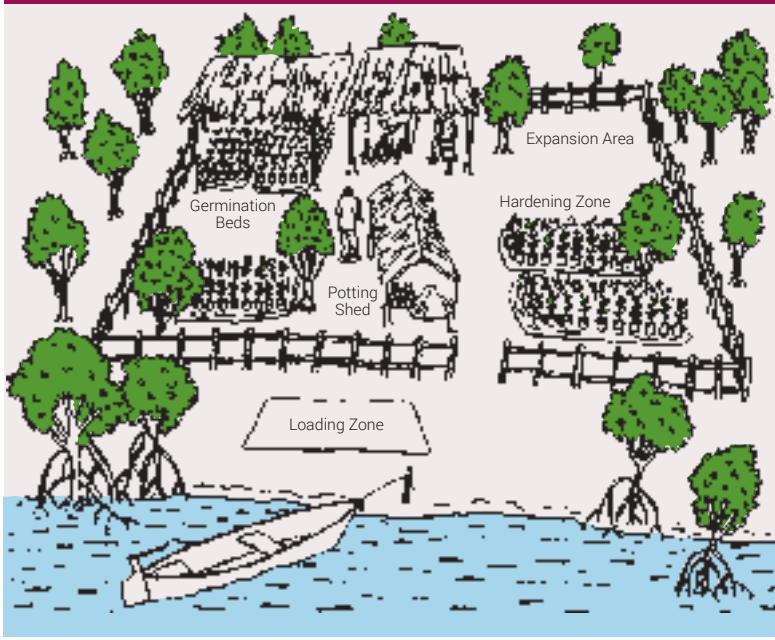
Establishing nurseries: nurseries should be established in close proximity to the reforestation site, allowing ease of transport during out-planting later on (see fig. A3.3 for a typical nursery layout). Nurseries should have the following elements:

- Seed germination beds: this is where the young propagules, once collected, will germinate and see their initial growth period. To ensure that the plastic potting bags do not topple over, construct a sunken bed (either a dug-out trough or a wooden frame). This will also help with moisture control. Construct a thatched roof to provide shade or locate this area under trees.
- Potting shed: Construct a covered shed to protect nursery workers from rain and heat on sunny days. This is where the potting bags will be filled with soil.
- Hardening beds: one month before out-planting, the plants will need to be transferred to an area exposed to direct sunlight — allot space for this phase or allow for the removal of cover from the germination beds.

Filling pots: Plastic potting bags should be 20 - 30 cm wide depending on species and filled with muddy and clayey soil. The soil should be collected from mud flats during low tide.

Collection and sorting of propagules: As most mangrove species have specific fruiting peak seasons, propagule/seed

Figure A3.3 | **Typical nursery layout**



production may not be available throughout the year. Ensure that you take this timing into account when devising your plan. Mature propagules should be collected from mangrove forests that are close to the designated planting site or, if these are not available, from forests with similar conditions. Seek local technical expertise and ask local experts to guide your team in selecting the highest quality propagules for use in the nursery.

Sowing of propagules: Mangrove propagules have different sowing methods, depending on the species. Strictly follow the advice of your local experts when sowing, as this can make a major difference on success rates (germination).

Out-planting: Once the planted propagule has germinated and been hardened in the sun (appropriate times vary between species), the saplings are transported to the site and planted. It is crucial to take care not to damage the roots during the process. Saplings should be planted at the same density as

found in nearby mangrove forests. Avoid planting the saplings too close to each other, as this will restrict biodiversity and natural regeneration. Obtain guidance from your local mangrove experts and follow the prescribed distances between saplings. Try to imitate the naturally occurring diversity of species in the different zones.

Wildlings versus nursery-raised saplings: For some mangrove species (especially Rhizophora), you do not need nurseries — you simply collect ripe propagules and directly plant in the designated site. Using these 'wildlings' is cheaper and associated with higher survival rates than those of nursery-raised saplings of the same species. However, given that you should have a mix of species in your reforestation site and that the technique is not feasible for most species, you should incorporate nurseries into your overall design.

Monitoring of mangrove development: mangroves are dynamic ecosystems, and monitoring the growth of plants and their ecosystems services is essential. A monitoring plan will:

- include the assessment of survival and growth performance, thus enabling the replacement of dead seedlings;
- identify challenges (such as disease attacks, algal growth, solid debris brought in by tides, destruction of young plants by storms) in a timely fashion, allowing for remedial action;
- identify success factors that can inform future mangrove reforestation; and
- assess whether restoration objectives are being reached.

Many restoration projects have failed due to the lack of monitoring and follow-up. Consider a monitoring timeframe of at least five years and assess the following aspects: germination and plant survival rates at sample sites,

- germination and plant survival rates at sample sites,
- needs for gap filling or thinning/pruning,
- pest and disease surveillance,
- soil and salinity conditions,
- existence of fish and other marine species, insects and birds in reforestation sites,
- pollutants and debris, and
- community use of mangroves.

See a typical monitoring schedule at UNEP 2020:33 for general guidance, but ensure that a locally appropriate plan is developed with technical experts and the community.

Restoring mangrove forests can bring multiple benefits and be extremely cost-effective, in particular when applied at scale. From a DRR perspective, aim for wide mangrove belts to reduce exposure. Though relatively narrow belts can reduce surface swell and coastal erosion, wider belts are required to substantially absorb wave energy and lower the impact from storm surges.

Have technical expertise at hand, assess causes of degradation, explore natural regeneration, add artificial regeneration if needed, and make sure you monitor the growth over an extended time of at least five years.

GROWING GREEN
Kandelia candel plants grow to a height of three meters, are mature after about five years and live for about 35 years. In the Vietnam project (see case study B.1), they were planted with distances of 50 - 70 cm between them. Photo: IFRC

USEFUL TIPS

- **Engage community members** in the work at nurseries, as well as in out-planting and monitoring activities, while ensuring that they are adequately trained and guided by mangrove experts.
- **Get the timing right** as your reforestation activity should be in sync with natural cycles. Keep in mind a) the peak fruiting times at which the propagules can be collected, b) the duration of young mangroves growing in nurseries, and c) the cyclone season. The more mature a plant is during the first cyclone, the higher its chance of survival.
- **Protect young mangroves** at nurseries and reforestation sites from livestock and other predators. Use fencing if needed.

APPENDIX A.4
SEAGRASS

UNDERSTANDING SEAGRASS

Seagrass meadows are rated the third-most valuable ecosystem on a per-hectare basis, preceded only by estuaries and wetlands. They have undergone a worldwide decline, primarily as a result of local pollution along coastlines.

The plants grow best in clear and gently moving water. They require light and nutrients for growth. Runoff of wastewater and sediments reduces the light, often as a side effect of excessive algae growth (which steal the light).

Protecting seagrass meadows by reducing runoff, pollution and direct physical disturbances by human activity is therefore the starting point — and usually the single most cost-effective measure.

If there is — or has been — seagrass in your area, follow the guidance below.

PROCESS

Step 1 | Scope context, needs and options

To start, map the various locations of seagrass. Together with local communities, analyze whether and how the health of seagrass meadows has changed over the recent past. If seagrass meadows are considered stable, you may not need to invest in assisted natural recovery. However, consider options to preserve existing seagrass, such as regulating and reducing pollution and direct human activities within and close to seagrass areas.

Survey and select sites to explore whether prevailing environmental conditions favor seagrass restoration. Develop baseline maps to allow for monitoring of changes in distribution and abundance.

Improve management to reduce human impacts and to maintain seagrasses in as healthy a condition as possible. This will enable the plants to better cope with and recover from stresses, including climate change. There is no substitute for effective management and good water quality to enhance seagrass resilience.

Identify and protect seagrass areas that are healthy and strong and at low risk to human and natural event threats. These will serve as future seeding/transplanting recovery areas. Aim to do this across a wide geographic and seagrass species range.

Identify interdependencies with other habitats like mangroves and reefs and seek to improve overall management through marine protected area networks. If seagrass meadows have been degraded, work with coastal communities as described in step 1 of appendix A.2 (reefs).

Step 2 | Find further facts

Following the initial scoping, conduct a review of the 'enabling environment'. Explore the following aspects:

- Stakeholders. Who may be affected and who may affect the project? List all stakeholders and list possible roles they may play (positive and/or negative). Engage multiple sources to identify and review the list regularly.
- Who may be your allies? These can include donors, community and industry volunteers, technical and logistical support entities and seagrass and climate science experts. Select the experts who can provide technical advice.
- Identify local regulations. What regulations exist, and which authorities are responsible for enforcing them? Ensure you look at local disaster risk reduction policies and regulations. Make sure these authorities are included in the stakeholder list.
- Site-specific contexts. Are there other ecosystems and environmental issues that need to be addressed to ensure success?

Step 3 | Assess seagrass vulnerability and resilience

If the overall enabling environment is deemed strong enough, conduct a technical assessment of the seagrass status (in terms of current health, vulnerability and resilience).

Complete a resilience and vulnerability assessment to ensure potential impacts on seagrass meadows are considered. Resilience assessments should include exploration of the ecological resilience — the health and function of the ecosystems habitats, organisms and processes, including reproductive cycles, population connectivity and recruitment (connection to healthy populations), species, soils and water quality. Consider using the Adaptation Design Tool to explicitly consider climate change in your design.

Step 4 | Set targets and objectives

Now, set your objectives for restoration. Ideally, aim for a model that returns the seagrass to its original (non-degraded) status.

Align these objectives with your overall project objectives and timeframe. Use SMART indicators to define how you will measure progress and revise your objectives as needed.

Identify initial monitoring measures - these may be refined later. See the 'favourable conditions' box overleaf to develop seagrass-specific indicators.

Step 5 | Identify restoration options

At this stage, you have defined what you want to achieve. Now, let's have a look at how to achieve your objectives.

Where to focus: once your vulnerability and resilience assessment has been completed, select sites for restoration on the basis of the information you have collected. List the sites or areas with the best combination of low vulnerability to climate change and human impacts and the highest resilience. Consider how the restored seagrass will support DRR.

What actions to choose: review potential adaptation actions. Ensure you have appropriate technical and scientific advice when deciding on actions. Use common evaluation criteria to decide what actions to take — including effectiveness, feasibility, urgency, flexibility and externalities. Ensure that all key stakeholders are engaged in the process.

IN THE LIMELIGHT

Seagrass needs light for photosynthesis. Light availability is the most dominant overriding factor in seagrass growth. The most widespread and pervasive cause of seagrass decline is a reduction in available light — for instance due to nutrient and pollution runoff.

Favourable conditions for the survival of seagrass Source: Björk et al 2008:31

High water quality
Sufficient light is a key factor for healthy seagrass meadows. Water must not be too cloudy from suspended matter or plankton. Excessive algae growth (due to of high levels of minerals and nutrients, e.g. due to fertilizer runoff) may absorb too much light. At least 10% of the light at water surface should reach the seagrass leaves. Proximity to developed areas and rivers may threaten seagrass unless sediment, nutrient and wastewater runoff is contained.

Mellow water movement
Some water movement is important for the supply of nutrients and inorganic carbon to enable photosynthesis. Yet, the currents must not be too strong so as to uproot plants or stir up sediment.

Good sediment conditions
The root environment should be undisturbed, and the organic content of the sediment should be under 5%. Human activities such as dredging, heavy boating and fishing (especially bottom trawling) should be prevented.

Genetic variability and connectivity
Genetic variability between plants is important for seagrass resilience to temperature stress. Meadows with high genetic diversity should be prioritized for protection.

Effective management
Potential threats to seagrass meadows from human activities need to be managed (e.g. by limiting or preventing pollutant run-off) to sustain seagrass meadows.

Restoration of seagrass occurs through improved environmental conditions, for instance through improved water quality. This can encourage natural regeneration. It may involve seeding or transplanting of seedlings or mature plants from a variety of widely distributed seagrass donor beds (thereby preserving genetic diversity).

In some cases, combinations of all methods can be used to aid recovery. Restoration objectives, local conditions, seagrass species and project budgets will determine which planting approach is most appropriate for a given site.

Restoration planning guidelines include identifying project goals regarding seagrass coverage, species composition and ecological function of restored seagrass beds. If no restoration appears feasible, consider whether other actions could be conducted (see figure A4.1 opposite).

Step 6 | Implement actions

Expert advice is required when planning and implementing seagrass restoration. See material for planning and monitoring seagrass restoration here.

A. Natural recolonization

Natural recolonization involves the process of improving the environment of the seagrass, usually through a combination of improving water quality and optimizing light access to promote photosynthesis.

Water quality is most often affected by drain discharge, stormwater runoff and effluent disposal. Dredging, shipping and boat activity, as well as trawling of the seabed also acts to reduce the water quality around seagrass areas.

Management of these impacts must be addressed prior to any attempts at recolonization. Transplantation of healthy rhizomes and seeding (of species found in the area) can then be used to support natural recolonization.

B. Transplanting seedlings

Seedlings, either collected from nearby donor sites or raised in nurseries, can be transplanted directly to areas for restoration. This is a labour-intense method — however, it can have faster results in terms of re-establishing seagrass meadows.

or seedlings are fixed in grid systems to the ocean floor using a number of different methods, including

- laying sandbag snakes across the tide movement and planting seedlings behind them, using small metal u-shaped stakes to hold seedlings in place;
- locking frames into place on the seabed to provide a base on which seagrass can be planted;
- placing special (hessian) bags on the sea floor to hold seagrass seedlings in place until they are sufficiently established (the bags eventually decompose).

See a selection of videos with examples of these methods here, here and here.

C. Seeding

Seeding, while a cheaper and slightly less labor-intensive method, requires access to healthy fruiting seagrass.

Seeding densities appear to be critical to success, and recurrent seeding on an annual basis is required to create sufficient cover and build seagrass density. Partnerships between recreational and commercial fisherfolk, landcare, indigenous organisations and government agencies are engaged in large-scale seeding programs in Australia.

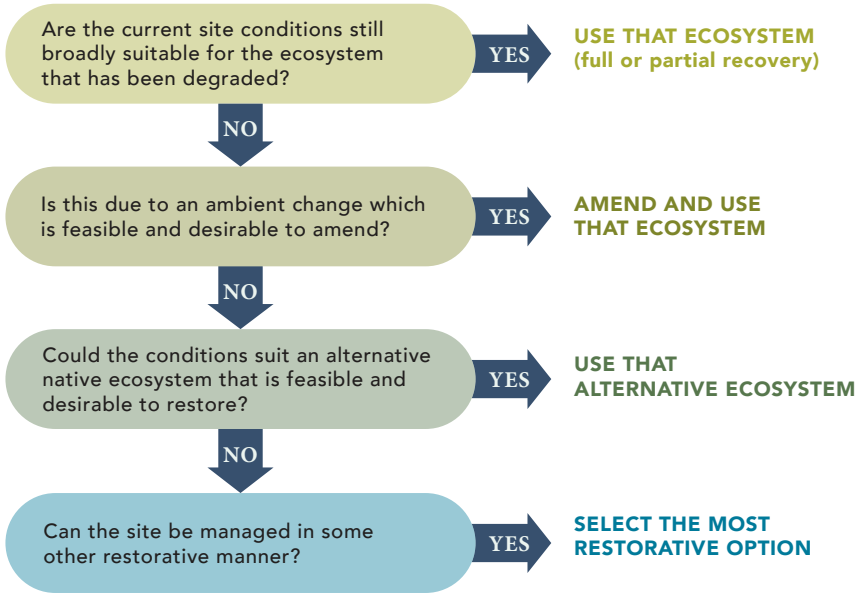
Fisherfolk were provided with collected seeds that they carefully placed into sand-filled hessian bags. They then took them out to sea in fishing boats to be 'sown' at low tide.

D. Seagrass monitoring

Once transplantation has occurred, the sites should be monitored to determine survival rates, shoot density and area coverage of the transplants. Implement monitoring programs and adapt coastal management strategies to address challenges.

For more resources on seagrass monitoring, see here.

Figure A4.1 | **Decision tree for restoration** (Source: Gann et al. 2019:30)



FURTHER RESOURCES

- Managing seagrasses for resilience to climate change (2008)
- Seagrass Watch for additional resources and monitoring tools.

APPENDIX A.5 Marshlands and swamps

UNDERSTANDING MARSHLANDS & SWAMPS

Coastal wetlands can preserve lives and property by abating the impacts of tropical storms, cyclones and large storm surges. Wetlands at the margin of the water bodies such as rivers, lakes, and oceans protect the lands from erosion, as plants within the wetlands hold the soil and reduce the strength of waves or the speed of the water flow. Wetlands trap sediments, filter runoff, metabolize excess nutrients and reduce flooding by slowing and absorbing rainwater. They have proven to reduce flooding far better than hard infrastructure like seawalls and levees — and at lower cost. In one recent study, researchers found that wetland restoration provided USD 8 in flood reduction benefits for every USD 1 invested (Reguero et al. 2018).

Salt marshes are intertidal communities of plants that grow on the foreshores of coastal lakes and estuaries. Occupying the high tide zone, they contain plants such as sedges, rushes, reeds, grasses, succulent herbs and shrubs that are able to tolerate high salinity and sea water inundation. The vegetation is generally low, although the more landward reaches often have buffers of larger tree species. There are bare patches within them and sometimes salt pans or sandy areas (Dpt. E&E, 2016). They are also home to a large variety of fauna, including water birds, fish and crustaceans.

Step 1 | Scope context, needs and options

To start, map current and previously existing locations of salt marshes. Identify the connections with other habitats like mangroves, as you may need to work on multiple ecosystems simultaneously.

With the local communities, analyse as to whether and how the health status of the salt marshes has changed. If salt marsh areas are stable, you may not need to invest in assisted natural recovery. Instead, focus on preservation as your main action.

Conduct site surveys to map vegetation types, fauna, tidal access and tide levels (high and low). Develop baseline maps to allow for monitoring changes in distribution and abundance.

Identify whether the sites should be rehabilitated, restored or reconstructed (very expensive). While you may be able to make this judgement from initial scoping, you will need expert technical advice to decide if this is feasible and likely to be successful.

Step 2 | Find further facts

Following the initial scoping, conduct a review of the 'enabling environment'. Explore the following aspects:

- Stakeholders. Who may be affected and who may affect the project? List all stakeholders and list possible roles they may play (positive and/or negative). Engage multiple sources to identify and review the list regularly.
- Who may be your allies? These can include donors, community and industry volunteers, technical and logistical support entities, as well as ecologists and climate science experts. Select the experts who can provide technical advice.
- Identify local regulations. What regulations exist, and which authorities are responsible for enforcing them? Look at local DRR policies and regulations. Make sure these authorities are included in the stakeholder list.
- Site-specific contexts. Are there other ecosystems and environmental issues that need to be addressed to ensure success?

Step 3 | Assess vulnerability and resilience

If the overall enabling environment is deemed strong enough, conduct a technical assessment of the salt marsh status (in terms of current health, vulnerability and resilience). Complete an ecosystem resilience assessment to ensure potential impacts on the salt marsh are considered. These assessments explore

ecological resilience — the health and functions of the ecosystem habitats, the organisms and processes. This includes the reproductive cycles, population connectivity and recruitment of flora and fauna (connection to healthy populations), species, soils, and water quality. Consider using the Adaptation Design Tool to explicitly consider climate change in your design.

Step 4 | Set targets and objectives

Align objectives with your overall project objectives and the timeframe. Use SMART indicators to define how you will measure progress

Step 5 | Identify restoration options

At this stage, you have defined what you want to achieve. Now, let's have a look at how to achieve your objectives.

Where to focus: Once your vulnerability and resilience assessment has been completed, select sites for restoration on the basis of the information collected. List the sites or areas with the best combination of low vulnerability to climate change and human impacts and the highest resilience. Consider how a restored salt marsh will support DRR.

What actions to choose: review potential adaptation actions. Ensure you have specific technical and scientific advice when deciding on actions. Use common evaluation criteria to decide what actions to take including effectiveness, feasibility, urgency, flexibility and externalities. Ensure that all key stakeholders are engaged in the process.

Step 6 | Implement actions

For all of the actions below, seek expert technical advice to ensure your solutions will not create or exacerbate other problems.

A. Rehabilitation

Rehabilitate salt marshes if they remain relatively strong and if tidal flows remain intact or can be restored through removal of hard structures or artificial barriers. Consider: a) fencing off the area from livestock; b) reducing the impact of vehicles and foot traffic; c) weeding of invasive species; and d) reducing access to feral animals. In some cases, you may also want to replant appropriate species to aid the natural recolonization of flora. This can be done by transplantation from donor sites nearby or with appropriate nursery-raised plants. Salt marsh plants tend to be slow-growing and have specific requirements in terms of salinity and water conditions, so ensure you have specialized support if nursery work is being undertaken. Start nursery-related work early to allow time for seedlings to establish.

B. Restoration and reconstruction

Restoration usually refers to the process of reconstructing a salt marsh area that has been either very damaged or completely filled in for some other use. Restoration or reconstruction in these cases is often costly, requiring heavy machinery (to remove landfill and restore tidal access) and large-scale replanting to achieve positive results.

Restoration tends to be most effective when the right conditions for water flows are re-established, thereby enabling natural regeneration. These sorts of projects are commonly undertaken by government departments or industry (e.g. as part of agreements following extractive practices, such as mining). See examples of large-scale salt marsh reconstructions here and here.

C. Salt marsh monitoring

As part of your efforts, you should monitor water levels and changes, tidal inundation levels, survival rates and coverage area of any plantings, the presence of flora and fauna species (including fish, invertebrates and crustaceans), soil composition and resilience to hazard events. Monitoring should continue for several years to ensure adaptive management can be implemented as required.

APPENDIX A.6
Dunes

UNDERSTANDING DUNES

Coastal dunes often represent the last line of defense from ocean erosion. Dunes act as a barrier against inundation and deflect wind and salt spray. The presence of a stable dune system provides a natural defense mechanism against wave attack and erosion. However, dunes are also a dynamic system with natural changes occurring, usually during storm events when extensive movement of sand leads to beach erosion, exposure of substrates and inundation. These events can be quite extreme but need to be recognized as naturally occurring. Intact frontal dunes can mitigate the impact in terms of erosion-initiated losses.

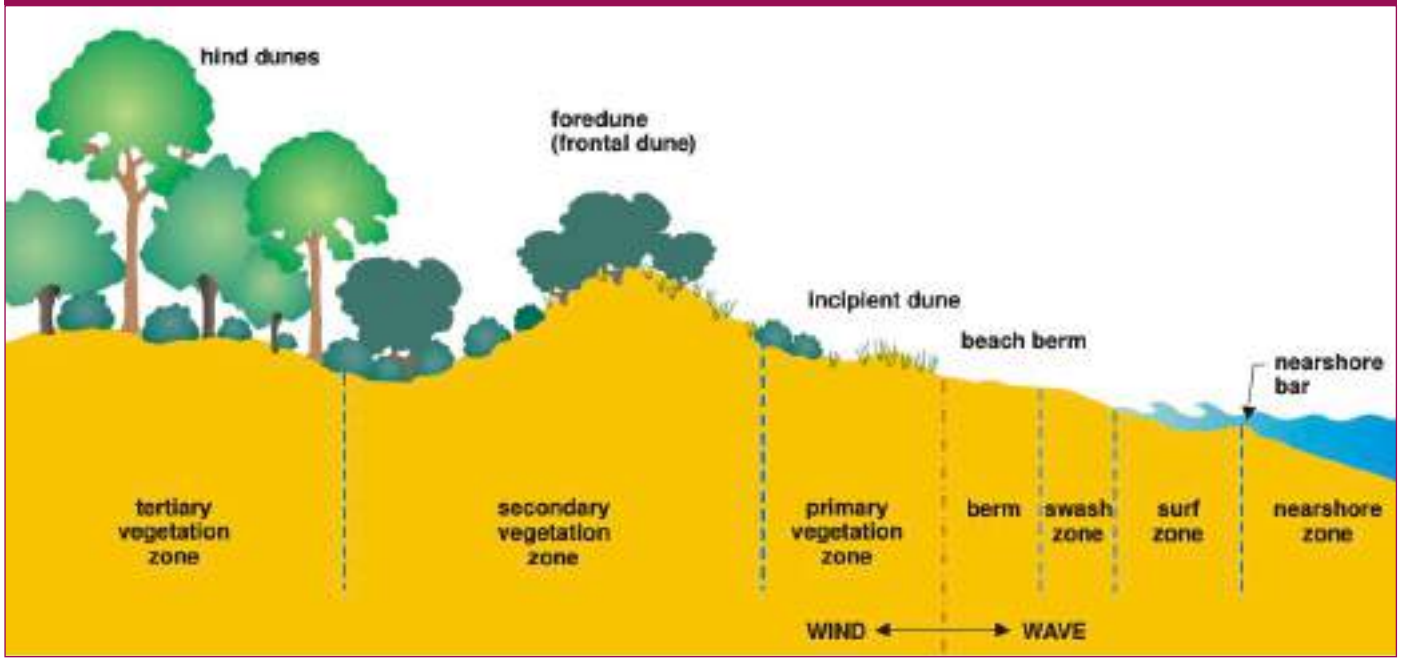
In their natural state, many beaches include a foredune (nearest to the sea) and hind dunes (inland of the foredune). In many places, there is also an incident foredune that is formed by windblown sand and colonized by grasses and creepers.

Vegetation cover is an important part of the dune system, reducing wind velocity and encouraging windblown sand deposition (see figure A6.1 below).

Although the foredunes tend to be the most established and persistent components of the dune system. Their stability, shape and size are controlled by the vegetation cover. Woody shrubs are common on the seaward side, while larger trees are common landward. Vegetation species vary depending on location and context.

Without the stabilising effect of vegetation, and through several adverse factors (introduction of weeds, human activity, storm waves, drought and even lightning-induced fires), sand drift can progressively cover natural and built environments. Many dunes are impacted by development, which inhibits the natural flows of the sand and the dune system.

Figure A6.1 | **A typical dune system**



Where buildings are constructed on top of the foredune, there is great risk that storm and wave action will undermine the area. Where seawalls have been constructed seaward of the frontal dune, sand behind the hind dune is separated from the system. This can lead to significant erosion, up to the complete loss of sand on the beach (Chan, H.T. & Baba, S., 2009: 5).

THE PROCESS

Step 1 | Scope context, needs and options

To start, map the dunes and identify their connections with other habitats like tree belts and mangroves, as you may need to work on multiple areas simultaneously. Conduct site surveys to map vegetation types, fauna, soil types, tide levels (high and low), erosion, water flows, presence of weeds and other possible hazards. Understanding wind patterns in the area will also help in planning activities. Create baseline maps to monitor changes over time.

With the local communities, analyze whether and how the health status of the dunes has changed. If dunes are stable and intact, you may not need to invest in assisted natural recovery. Instead, work on preservation as your main action.

If you seek to rehabilitate the dune system, explore anticipated uses and needs with the community. It would be futile to restore a dune system, only to have it destroyed or continually damaged through human activity. You should consider asking these questions:

- Is there a need to ensure beach access through or near the dunes?
- Is any development planned close to the dune system that may have an adverse impact on it?
- What sort of signage or communication will be used to inform people of the repair work and ongoing maintenance?

Decide whether the dune system should be (merely) preserved, rehabilitated, or reconstructed.

While you may make a tentative judgement based on scoping results, consult expert technical advice to assess whether the proposed measure is feasible and likely to be successful.

Step 2 | Find further facts

Following the initial scoping, conduct a review of the 'enabling environment' - explore the following aspects:

- Stakeholders. Who may be affected and who may affect the project? List all stakeholders and list possible roles they may play (positive and/or negative). Use multiple sources and review the list regularly.
- Who may be your allies? These can include donors, community and industry volunteers, technical and logistical support entities and ecologists and climate science experts. Select the experts who can provide technical advice.
- Identify local regulations. What regulations exist and which authorities are responsible for enforcing them? Ensure you look at local DRR policies and regulations. Make sure these authorities are included in the stakeholder list.
- Site-specific contexts. Are there other ecosystems and environmental issues that need to be addressed to ensure success?

Step 3 | Assess vulnerability and resilience

If the overall enabling environment is deemed strong enough, conduct a technical assessment of the dune status (in terms of current health, vulnerability and resilience).

Complete an ecosystem resilience assessment to ensure potential impacts on the dune are considered. These assessments explore ecological resilience, including the health and functions of ecosystem habitats, organisms and processes. This includes the reproductive cycles, population connectivity and recruitment of flora and fauna (connection to healthy populations), species and soils.

Consider using the Adaptation Design Tool to explicitly consider climate change in your design.

Step 4 | Set targets and objectives

Align objectives with your overall project objectives and timeframe. Use SMART indicators to define how you will measure progress.

Step 5 | Identify measures

At this stage, you have defined what you want to achieve. Now, let's have a look at how to achieve your objectives.

Where to focus: Once your resilience assessment has been completed, select the most suitable restoration sites based on the information collected. List the sites with the best combination of low vulnerability to climate change and human impacts and the highest resilience. Consider how a restored dune will support disaster risk reduction.

What actions to choose: review potential adaptation actions. Ensure you have specific technical and scientific advice when deciding on actions. Use common selection criteria to decide, including effectiveness, feasibility, urgency, flexibility and externalities. Ensure that all key stakeholders are engaged in this process.

Step 6 | Implement actions

A. Leave it alone

Dune areas that have not been subject to human degradation may be cycling through natural periods of instability, thus demonstrating bare areas and changing patterns of windblown sand. These areas should be left alone, as the ecological cycle will maintain the balance within these systems. Any interventions may do more harm than good.

Expert advice should be sought before making any decisions on actions in dunes. In these situations, focus your actions on raising community awareness and monitoring the dune system.

B. Rehabilitation

Simple rehabilitation and protection actions can help maintain and preserve dunes that are physically stable but ecologically damaged. Fencing off areas from human access and provision of designated pathways to beach areas is critical to reduce the risk of further degradation.

Signage that informs people of the dune repair actions can help build compliance. Weed control may be initially required to remove any introduced species. Depending on the ecological damage, actions may also include the replanting of indigenous vegetation. Expert advice is needed to ensure that appropriate vegetation is selected.

Where efforts include revegetation, consider:

- seasonal rounds to weed, spray and plant;
- access to water for irrigation of seedlings and young trees;
- the use of tree guards if animal predation on young plants is likely, and for ongoing maintenance and monitoring of revegetated areas.

Overall, aim to restore and maintain biodiversity. Sufficient plant cover is needed to protect the dunes against wind erosion. Nurseries may be used to grow indigenous species for planting. If there are local sites with sufficient species, collect seeds for direct seeding within the dunes or for planting and growing in a nursery.

If areas are significantly denuded of vegetation, you may have to plant in two stages. Initially, use sand-colonizing herbaceous plants such as creeping herbs, sedges and grasses to stabilize the foredune. Once this cover has been restored, add further stabilization with an adequate coverage of woody tree species.

In some contexts, dune-forming fences can be used to reduce wind velocity and to induce the deposits of sand drift around the fence. This method is used mainly in small-scale areas where "blowouts"[20] have occurred, as well as in large-scale dune restoration.

This method can also be useful in environmentally or culturally sensitive areas where access is difficult. A common challenge with these structures is that they are often not made of natural materials, thus leave a long-term hazard in the area. Planting can occur once the fences have filled with sand.

COVERED This dune's restored vegetation cover helps it stabilize its physical shape.

20. Blowouts occur when strong onshore winds push a tongue of sand inland beyond the vegetated foredune. They are usually U-shaped and can become deeper over time and result from the collapse of side walls of the dune.

APPENDIX A.7
Shelter belts

UNDERSTANDING SHELTER BELTS

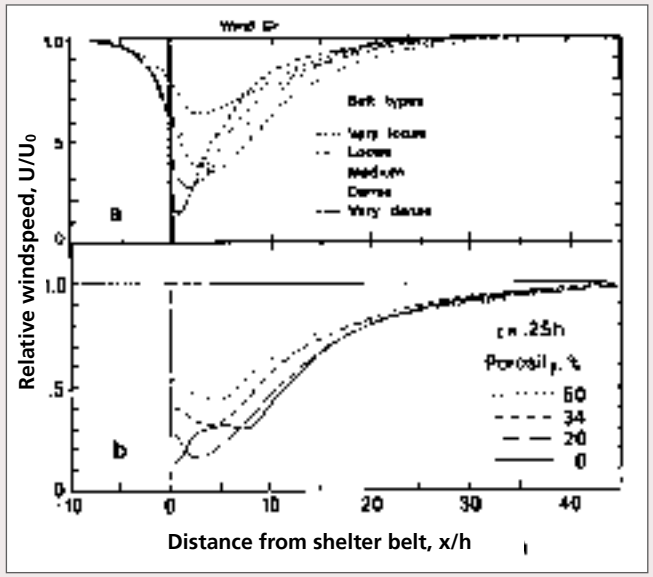
Coastal communities are affected so greatly by tropical storms because out at sea, nothing stands in the way of the storm. Buildings, fields, assets and infrastructure are exposed to the full wind speed and storm surge unless some barrier is in the way. The distribution, typology, composition and relative position of trees to homes, productive assets and fields can make an enormous difference to hazard exposure in terms of the wind load.

Planting of trees as windbreaks is a practice that has been around for centuries and is a common practice in agroforestry to reduce erosion and increase yield. Trees planted in several rows reduce the wind speed on the downwind (leeward) side over a large area — up to 40 times the height of the trees (see figure A7.1).

Analysis of aerial imagery taken in the Philippines after Typhoon Haiyan (2013) indicated that one factor on typhoon damage appeared to be the extent to which villages are protected by surrounding trees. During the recovery phase, new homes were built with a sturdier design, capable of withstanding wind speeds of up to 200 km/h. Yet, these are still likely to be damaged by wind speeds produced by a Haiyan-like typhoon (Haiyan generated speeds of up to 315 km/h). Rather than building even more wind-resistant houses, which is likely to be substantially more expensive, it may be more cost-effective to explore windbreaks as an option to reduce actual storm load on houses.

Shelter belts have been planted for this purpose in Bangladesh (after Cyclone Sidr in 2009), in Myanmar (after Cyclone Nargis in 2008) and in Vietnam (since 1997). An exploration of this matter suggests that there is little information on the impact of these shelter belts and on practical guidance. One paper gives a succinct overview of benefits and design considerations, although this is not specific to the various regional context (Wight/Stuhr 2002).

Figure A7.1 | **Wind speed reduction: shelter in the storm**



Mean horizontal relative windspeed (U/U_0) (a) to the windward and leeward of shelter belts with five different densities based upon measurements at the 1.4m height and (b) leeward of thin artificial barriers of four different porosities in a wind tunnel.
Source: Heisler, Dewalle 1988:46

THE PROCESS

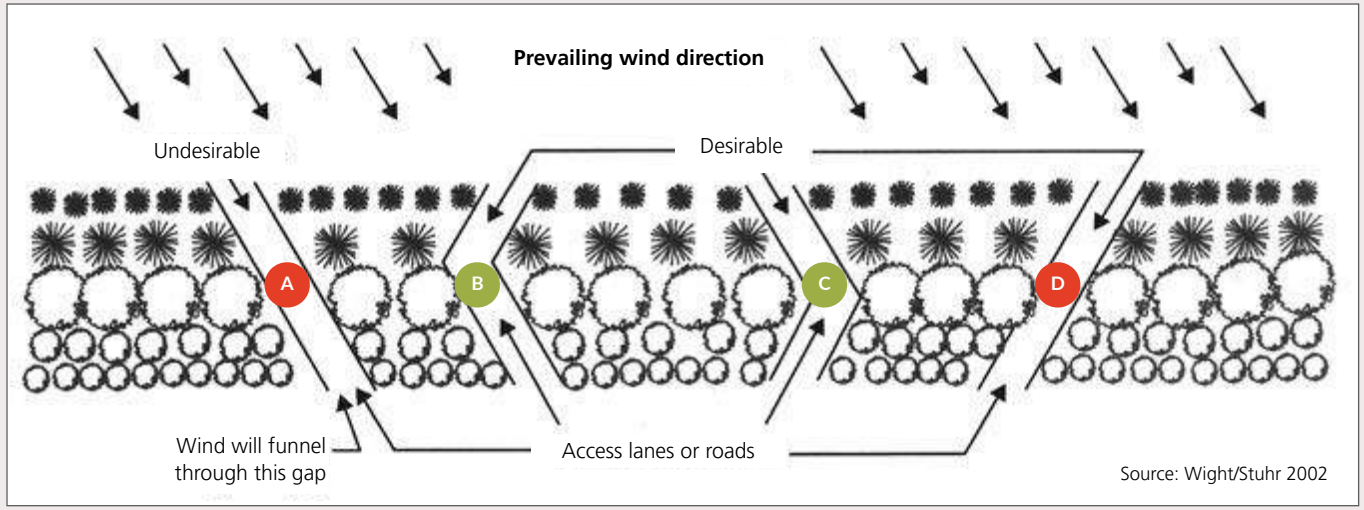
Shelter belts should be considered if land is available along the coastline and if other ecosystems, such as mangroves, provide insufficient wind protection for the community. Follow the guidance in stages 1-3 of the Blue Guide and explore the possible measures in stage 4.

Consider and address the issue of land ownership: are landowners willing to give the land for the purpose? If the coastal stretch is public land, seek the endorsement of the government and seek designation of the land as a shelter belt. If the land is already a declared no-build zone, it may be easier to obtain consent. If the coastline already features tree lines,

ensure that these are protected. You may consider adding further tree rows to reinforce the protective function.

Keep the community at the center of the process and explain the benefits of the shelter belt. Engage them in planting and monitoring of the trees. Ensure that technical expertise is available to provide the most effective design, most suitable trees and to explore possible side effects.

Figure A7.2 | **Design considerations: beware of funnel effects**



Source: Wight/Stuhr 2002

DESIGN CONSIDERATIONS

Consider the following factors when designing a shelter belt:

- **The type of trees**: It is crucial to identify the most suitable trees, considering root structure, suitability to soil and weather conditions, strength, porosity, and potential for direct economic benefits. The combination of various types is likely the most appropriate and effective design.
- **The number of rows**: Generally, one should aim for several rows (5-10), but the width of the shelter belt may be restricted by available land.
- **Shelter belt structure**: From the direction of the coast, the belt should start with low-growing scrubs, then medium-sized trees, and (closest to the village but in safe distance from buildings) high-growing species. This will help redirect the wind upward while not leaving any one row fully exposed to the storm load.
- **Access to the coast**: For many coastal communities, fishing is an important income source. It is therefore crucial that villagers maintain easy access to the shore. The design of these access routes is critical, as a linear path in the wind direction (which is unknown) would induce a jet effect with actually higher than ambient wind speeds. Designs B and C in figure A7.2 are, therefore, preferable.
- **Gap between shelter belt and buildings**: Anticipating that trees within the shelter belt may be unable to withstand storm load, the distance between the shelter belt and any building should at least equal the maximum height of the highest tree rows. Falling trees can cause a lot of damage.
- **Livelihood benefits**: Investments in mitigation tend to be more sustainable when they bring ongoing tangible benefits to a community (the protective benefits will only materialize in the event of a strong typhoon). In the Vietnamese case of mangrove afforestation, the direct economic benefits (more aquacultures to collect in that case) made people appreciate and care for the new vegetation (see case study B.1). The inclusion of fruit trees and other 'productive' species should therefore be considered. Bamboo (fast-growing and flexible) could also bring such benefits while providing construction material after a future storm damage.
- **Possible side effects**: There are possible effects that need to be considered and weighed against benefits. These include increased wind speeds at the edges of the shelter belts and effects on the downwind micro-climate (less circulation and cooling).

FURTHER RESOURCES

- **Tackle**, E., S. Chen, T., Wu, X. (2008). Protective functions of coastal forests and trees against wind and salt spray.
- **Wight**, B., Stuhr, K. (2002). Windbreaks: an agroforestry practice.
- **Zhu**, J-J. (2008). Wind shelterbelts.

Case study B.1: Vietnam

Mangroves' multiple benefits

How Vietnam Red Cross grew an idea into a 9,000 hectare mangrove forest

Location 166 communities across eight provinces in Vietnam's Red River Delta (Quang Ninh, Hai Phong, Thai Binh, Nam Dinh, Ninh Binh, Thanh Hoa, Nghe An and Ha Tinh).

In 1993, the Thai Binh chapter of Vietnam Red Cross (VNRC) identified a problem: as the country was rapidly developing, many of the mangrove forests along the Red River Delta were being cut down at unprecedented rates. Many were replaced by shrimp farms. The chapter noted that the annual cyclones now caused more damages along the coastline than they used to — both to the dikes and the communities nearby.

The chapter took its idea of mangrove reforestation to VNRC headquarters, which in turn gained the support and funding of international partners.

The idea led to a 22-year program, in the course of which more than 9,000 hectares of mangroves were planted across eight provinces. An evaluation in 2011 found substantial protective, economic and environmental benefits from the scheme.

The challenges

Almost 70% of Vietnam's population live in coastal areas, along its elongated coastline of 3,200 kilometres and in low-lying delta areas. With several cyclones hitting the coast each year, the protection of coastal communities and infrastructure is essential. Yet, in the wake of the country's rapid development from the late 1980s, many of the natural barriers — mangroves — were taken down.

At the mouth of the Red River, the rates at which mangroves were being cut were alarming to the local VNRC chapter of Thai Binh. Having noticed greater storm damages, it proposed an idea that few then would have considered a typical Red Cross task: to replant the mangroves.

The actions

Initial reservations were overcome, and with the support of Danish Red Cross (DRC), an initial three-year project was launched in the province in 1994. The expertise of marine biologists at nearby universities was sought, and after some setbacks, the project succeeded in working with communities and government departments.

The mangroves grew and so did the project: over time, it was expanded to eight provinces and extended four times with the support of DRC, Japanese Red Cross, and the IFRC.

The project established many nurseries and planted a range of mangrove species to suit variable conditions, in particular Kandelia, Sonneratia, Rhizophora and Avicennia. As the project extended its coverage to areas unsuitable for mangroves, it added Casuarina trees for sandy conditions (as coastal shelter belts) and bamboo along riverbanks.

VNRC furthermore added school and community-based risk education and preparedness measures to the portfolio.

The results

Seventeen years after the project launch, IFRC commissioned an impact and cost-benefit analysis. By that time in 2011, the VNRC-planted mangrove forests had grown to almost 9,000 hectares along a stretch of 100 kilometers (bamboo and casuarina trees then covered another 500 hectares).

"The project is very good and useful for the community, especially the poor farmers", said Ding Nguyen Dau, chairman of Giao Lac commune. He went on to explain: "The community catch seafood from here because with the mangrove forests, the amount of seafood is very high. The mangroves also protect the dike. With the mangroves, we don't have to use so much effort to protect people from the storms. The project also led to the environment becoming very green and very clean."

Ding's statement coincided with the three main findings of the evaluation: First, the project led to strong **protective benefits**. The cost of post-hazard repairs of dikes was down by USD 199,600 to 676,800 in studied communities, as the dense and wide mangroves absorbed much of the energy from storm surge.

The overall avoided damages and direct losses (to farmland, homes, other property and infrastructure) were far greater (up to USD 37.8 million in one community) and exceeded proportional project costs in all studied communities.

Second, the project yielded substantial direct **economic benefits**. Per hectare yield amongst mangrove forests from the collection of shrimps, crabs, molluscs and other aquacultures was increased by between 209 and 789% compared to bare mudflats.

In Dien Kim commune of Nghe An province, the collection of young crabs has become a new livelihood for around 200

people. Mrs Ha Thi Thanh, a local resident, said: people can make good money from the collection of crabs. They also recognise the value of the mangroves. In the past, there had been some loggers but not now. No one causes harm to mangroves."

Representing values of up to USD 6.7 million in one community over the 20-year timeframe, the economic benefits alone exceeded planting costs in all but one community. Poor farmers benefited disproportionally as they found new income. The majority of survey respondents (60%) identified a positive impact of the mangroves on their income.

Third, the evaluation valued the **environmental benefit** as a function of the mangroves' carbon sequestration. It found that absorbed CO_2 equalled the 2005 emissions of 455,000 Vietnamese people, and put the value of CO_2 emissions that would be absorbed by the project mangroves between 1997 and 2025 (at USD 20/t CO_2) at USD 218.8 million.

With USD 8.88 million total project expenditure and costs of USD 843 per hectare of planted mangrove forest, the study identified high benefit-cost ratios that ranged between 3.06 and 68.92 for studied communities (accounting for protective and direct economic benefits only), and between 28.86 and 104.96 with environmental benefits.

GREEN PROTECTION Giao Lac commune chairman Ding Ngyuen Chau walks along the mangroves that VNRC planted to protect the community. Photo: Thorkell Thorkelsson, Icelandic Red Cross

The lessons

The project experience highlighted the virtues and values of tenacity and technical expertise, local ownership (communities and government), economies of scale and of the integration of NbS into broader DRR efforts.

Initial setbacks (low survival rates of plantings) were addressed after technical experts adjusted the mix of species and enhanced growth monitoring and management (thinning, replanting in expansion zones).

Community engagement and stewardship was vital and reinforced as communities realised direct economic benefits.

Enforcement of protection regulations through community guards and government oversight remained important nevertheless.

The project efforts in tree planting beyond mudflats also showcased the protective effects of shelter belts (casuarina trees) and riverbank stabilization (bamboo).

FURTHER RESOURCES

- Read 'Breaking the waves', the 2011 impact and cost-benefit analysis of the mangrove project (IFRC).
- Watch a video on the project (10:09, in Vietnamese with English subtitles)

Case study B.2: Federated States of Micronesia

Recovered reefs, raised resilience

How two communities joined forces and overcame critical challenges

Location
Kaday and Okaw communities
Weloy Municipality, Yap,
Federated States of Micronesia

"Fishing is part of Yapese life. Our daily life" says James Manguon, the chief of Weloy Municipality. "I listened to the old people talk about fishing in the village, in the community. I also saw a lot of changes compared to before, when I was young going fishing."

"Back then, I rarely saw dead corals. More recently, I saw a lot of dead corals, a lot of places in the water where there are very few fish. It wasn't like it had been before", explains the Chief.

Two villages — Kaday and Okaw — joined forces in a traditional alliance and set up a community-led marine conservation area. The results highlight the potential of economic and ecological benefits.

The challenge

For several years, villagers had been noticing declining fish stock as well as the deterioration of the nearby coral reefs. The protective function of the reef was at stake. The villagers identified overfishing as the primary reason for the decline.

Actions

Creating a traditional alliance in 2005, the two villages discussed how to address overfishing in the Nimpal Channel. Traditional practice meant that it was ultimately the chiefs' decision, and despite some initial resistance from fishermen, the chiefs decided to create the conservation area. With the support of a local NGO, a rapid ecological assessment was conducted in 2006 to identify the status of marine resources. The reef monitoring and assessment team included many of the experienced fishermen from Okaw and Kaday villages, as well as regional scientists and international experts.

The assessment confirmed that ecosystems were under threat from natural causes and overfishing. Prompted by these findings, the villagers agreed to also designate a 'no take' zone. Although marine scientists had proposed different areas for the MCA, the two villages felt that the area they proposed was the appropriate one for their own needs and their ability to manage, as it represented traditional fishing grounds for both groups.
In 2008, the two villages publicly declared the Nimpal Channel as a marine conservation area (MCA).

Results

The MCA was marked by poles and lights to indicate the boundaries and designate the 'no take' zones. Within just two years of the MCA designation, monitoring teams confirmed improved fishery resources - no other waters around Yap island that were in close proximity to communities had more abundant fish stock.

In a bid to better involve **local youth** in the MCA, a surveillance platform was built on its boundary in 2009. Young people stayed overnight on the platform, monitoring any illegal activity in the 'no take' zone and confiscating unattended nets. If violators were detected, they were dealt with in traditional ways: their nets and gear were confiscated, and they were brought to the chiefs (who would decide on their corrective actions). This enforcement helped bring down poaching over a short period of time.

In 2009, a damaging spread of the crown-of-thorns starfish (COTS) was found in coral reefs around Micronesia. In the Nimpal Channel MCA, villagers chose not to remove them in line with the no take policy. Monitoring showed that the Nimpal Channel appeared to be far more resilient to the event

HEALTH CHECK Community members monitor the conditions of seagrass beds. Photo: Nimpal Channel MCA

than other surrounding areas with no starfish present. This was attributed to the intact predator fish population as well as high coral density.

In 2012, a formal scientific assessment identified that the Nimpal reefs' condition was second highest among other MCA in the region, despite its small size of 77 hectares. Nimpal was showing the highest density of fish in the region and was comparable to other areas of more remote reefs with no human interactions. Overall, the MCA had exceeded the expectations of the marine scientists. The strong social acceptance and enforcement proved to be more important than ecological conditions.

As other communities became interested in the results, the Locally Managed Area Network (LMAN) was established to support similar processes across other islands.

Lessons

Land-based development had the potential to negate all the positive gains of the MCA, as sediment was impacting the health of the mangroves, seagrass and reefs.

A **ridge-to-reef approach** was therefore deployed, thus encompassing multiple ecosystems.On land, 92 hectares have since been protected. Land-based nurseries grow nipa palm, coconut and other plants. These are aimed at providing food sources and are also planted along shorelines to provide protection from erosion, waves and wind through coastal plantings. Community acceptance and enforcement led to success in restoration of traditional fishing areas and improved food security.

FURTHER RESOURCES

- Watch the video on how the communities established the MCA and the benefits they yielded (21:41).
- Read the story on the crown-of-thorns starfish and how the reef proved resilient
- Read an article on seascape connectivity.

Case study B.3: Papua New Guinea

Conservation and empowerment

How women combined mangrove conservation with new livelihoods

Location
Milne Bay and Manus Island, Papua New Guinea

Tucking her sleeping baby into the billum over her shoulder, Senita slips out of the canoe into the mangroves. She searches among the roots for her crab pots, hoping she would have a good catch to sell at the market tomorrow. School fees are due for her older child and the family needs cash to pay them.

Meanwhile back at the village, representatives from a conservation NGO meet with the chief and some local men. "Where are the women?" they ask. "They are in the mangroves looking for our dinner" the men reply. As key users of the resources, women need to be empowered to come to the table, engaging in conservation and the economic opportunities that it brings.

The challenge

Women are often disproportionally impacted by disasters and vulnerable to climate change. In Melanesia, they are often underrepresented in political, government and business forums. Women in coastal areas of Papua New Guinea (PNG) work hard collecting seafood to sell and to feed their families, and women's work accounts for 60-80% of all food production in PNG.

The women rely on sea and mangroves to provide for them and in turn value the protection that mangroves give them. Women's involvement in conservation can support improved economic outcomes as well as empowering their decision-making, enabling them to ensure sustained access to resources while also protecting wider communities.

The actions

In an effort to generate employment and income, women in PNG were supported by The Nature Conservancy (TNC) to develop and trial business and conservation ideas, build their leadership skills, strengthen financial literacy and learn conservation management methods.

Nature's Leading Women At the 2017 event, women from across the Pacific and Indigenous Australia gathered for a week-long mentoring process with business leaders. Following mentoring sessions, the women pitched their ideas to a panel of leaders from businesses and donors (USAID, DFAT, Qantas).

The women developed concepts related to mangrove economic opportunities, eco-tourism and blue carbon. Following the Nature Leading Women event, they formed the group Mangoro Maket Meri (Mangrove Market Women, MMM) to sustainably manage the mangroves and draw on the benefits the mangroves can provide.

MMM facilitated a mangrove awareness campaign, produced and delivered by a local female entrepreneur in mangrove communities of Milne Bay Province. PNG's female mangrove specialist Mazzella Maniwavie provided technical support to the awareness training.

MANGROVE GUARDIANS

With mentoring and training, a group of women formed Mangoro Maket Meri (MMM) to pursue new livelihood opportunities, while protecting and raising awareness about the value of mangroves. Photo: The Nature Conservancy

This included material and handbooks for ecology and restoration trainings. Following focus group discussions on mangrove usage, training on mangrove ecology and restoration was provided to 50 women from three villages.

The results

The program resulted in numerous achievements:

- It supported women to use clean cookstoves, reducing their need for wood and exposure to smoke;
- Women acquired nursery skills in mangrove pot planting and transplanting;
- Crab handling and marketing training;
- Formation of a women's micro-bank.

Plans are in place to facilitate biodiversity and conservation training for tourism operators in Milne Bay Province, and TNC continues a partnership with VilLink Tours and Expeditions, a woman-owned company, to promote information and importance of mangrove ecosystems in the province.

The 45 women who participated in the mangrove ecology and restoration training will provide voluntary awareness campaigns with the tour operators.

The lessons

Initially, the women's sense of ownership of the project was weak, likely due to a lack of sufficient community and stakeholder engagement and, therefore, lack of clarity and agreement on what they were trying to achieve. The project was implemented too quickly, before all stakeholders were on board — and required going back to step 1 to scope context, needs and options.

This time, the process was inclusive of women, men and government departments and much more detailed information was gathered on the communities' use of mangroves. Activities to increase awareness on the role and benefits of mangroves were then identified as the next step forward.

Economic benefits to pay for schooling, food and shelter were identified as a priority, along with environmental benefits that help preserve livelihoods.

Ensuring that the community needs were supported, helped increase: a) ownership, as well as strengthen governance, for the effort; b) influence and effectiveness of women's groups; and c) success of activities related to the effort.

Plans exist to scale up and become a model for women and mangroves globally.

FURTHER RESOURCES

- Watch the video on the Nature's Leading Women 2017 event (4:52)
- Watch the video on MMM and hear the women explain their concept and activities (2:05)
- Read a story on some of the MMM results

Case study B.4: Belize

Young stewards with a passion

How a youth-based program created new stewards and changed attitudes

Location
Port Honduras Marine Reserve, Belize

The Port Honduras Marine Reserve is a national protected marine reserve in the Toledo District of Belize. It covers 40,470 hectares of mangroves and other coastal ecosystems, including caves, soft-bottom seagrass beds and fringing reefs.

The Toledo Institute for Development and Environment (TIDE), a local NGO, employs rangers to manage the reserve, monitor ecosystem conditions, and enforce rules.

The challenge

Due to the large size of the reserve, management and monitoring has been a challenge for the small staff of rangers. Prior to the establishment of the reserve, fishers had been unaccustomed to being regulated.

Support from stakeholders for the reserve had been limited. With this area of Belize being particularly vulnerable to hurricanes, ideas were sought to help better protect the reserve and adjacent coastal communities.

The actions

TIDE created the community researcher program and trained 15 young people from the nearby communities in scuba diving and environmental monitoring methods. The best performers were then employed to conduct monitoring on an ongoing basis.

Monitoring included coral reef health (MBRS and AGGRA methods), seagrass health (SeagrassNet method), mangrove ecosystem productivity (MBRS method), water quality, fish stock, turtle nests and conch and lobster surveys. The teams also undertook lion fish culling (an introduced invasive species) and other fisheries monitoring activity.

As part of their training, the teams also learned the use of GPS and GIS analysis, emergency first response, as well as basic environmental science, including the impact of human activity.

The results

An independent assessment concluded that "the community researcher program provides a good model for other organizations, with integration of community researchers into the science programme activities, and capacity-building targeted to ensure reliable data collection."

The initiative built a passion for conservation amongst the young participants — with some changing their career pathways to natural resource management.

Community researcher Alana Barillas: "it makes you appreciate the environment more. It makes you see what's really happening. You see what is affecting the seagrass and the benefits that seagrass brings in terms of the nursery and sedimentation control. Knowing that makes you want to cherish it."

The community researchers are also fishers or come from fisher families. Their influence in the community has shifted the way in which fishers view the reserve and the conservation efforts.

Fishers now buy in to the idea that resource management is something that should be done by the community, for the community.

One fisherman commented that he believes TIDE's research results because his own daughter is involved in the data collection. "I come from a fishing family," says Willie Caal. "My family loves to see me working in this kind of field. They ask me about the abundance of conch and lobster in the sea. I tell them they are more abundant in the conservation zones and they are reproducing there."

Thanks to the program, TIDE has been able to monitor more sites and with a higher standard, and teams have been utilized by other organizations in the region, developing important collaborations.

Through interactions with international volunteers, the young researchers have been able to engage with others feeling passionate about environmental issues.

Attitudes have also shifted as a result. With the initial group of community researchers, it was very difficult to get them to do anything without paying them. Now, most of them volunteer for extra duties because they care about the work and the research. They want to gain experience and enjoy the work.

The next steps include a level 2 course and media training, so that they can act as spokespersons promoting reef stewardship across Belize. Furthermore, the community researchers will visit schools, where they will speak about environmental protection and their own experiences, in an effort to encourage others follow their path of passion.

REEF STEWARDS

Trainees under the community researchers program receive scuba and monitoring training. Photo: TIDE

The lessons

Recruit the right people through a competitive application and interview process. TIDE selected people based on some key criteria, including:

- Coming from the local community
- Be aged 18+
- Have graduated from high school
- Be able to swim
- Be contactable by phone and email
- Demonstrate an interest in the environment and willingness to learn

Train them well: use continuous reinforcement, handouts to minimize note taking, and most importantly: learn by doing! Practice techniques under expert supervision and encourage lots of questions and exploration of topics, learn from mistakes. Use existing teaching resources, monitoring tools and manuals. Try to use standardized tools from your region where possible. Ensure there is a quality control mechanism in place.

Ensure competency: Trainees passed theoretical and practical exams to qualify, and research and monitoring is supervised by an experienced marine biologist. Data entry is double-checked and accountability trails are in place. Only community researchers who demonstrate competence and reliability continue to be employed.

Ensure high safety standards: accidents can happen and can impact on work, so ensure you maintain health and safety at all times. TIDE's community researchers are insured for diving (the cost is shared) and they receive training in emergency first response and practice implementing an emergency action plan.

TIDE's research vessel is equipped with an O_2 kit and first aid kit, and TIDE ensures that a rescue diver is present on all monitoring trips involving diving and insists that community researchers submit their dive logs before they can get paid.

FURTHER RESOURCES

- Read the full story of the TIDE program
- See more information on the Healthy Reefs initiative under which TIDE developed the youth stewardship program.

Case study B.5: Grenada

Reducing coastal erosion

Using reefs and mangroves to protect a community at risk

Location
Grenville Bay, Grenada

"It hurt my heart to see how the beach had been deteriorated", says Norris Henry of St. Andrew's Development Organization. "I know in the past there was a nice beachfront, where you could play cricket, you could play football, you could run. But it's so sad to see it is no longer there."

The Nature Conservancy (TNC) partnered with Grenada Red Cross, Grenada Fund for Conservation, the Government of Grenada government and the Grenville Bay Area (GBA) community in a five-year climate resilience project to restore Norris' beach.

Sharing a vision of a better protected GBA, a diverse range of people demonstrated how small island states can increase their resilience. Restoring and protecting coastal ecosystems was key.

The challenges

The densely populated GBA had been witnessing worrying trends for years: the coastline was being eroded, while increased storm surges caused significant property damage. The natural ecosystems in the area — coral reefs, mangroves and seagrass meadows — had all been degraded to some extent and were no longer able to provide the protection they once did. Degraded coral reefs also meant there now was less fish nearby, impacting livelihoods and food security. To address these challenges, a range of partners and specialists were needed.

The actions

The Grenville Bay Area was identified as the project site through consultation with local partners, the use of national-level data and assessments such as sea level rise and storm surge modelling. A Vulnerability and Capacity Assessment (VCA), which incorporated natural resources was designed to determine the communities' strengths and vulnerabilities, was conducted by Grenada Red Cross.

A mapping exercise was also carried out with community members to ensure that local knowledge and intangible cultural heritage were captured and incorporated into project design and action plans. Furthermore, a community resilience plan was developed with the support of the National Disaster Management Agency and other partners.

Measures included the construction of a pilot hybrid artificial reef to test the absorption of wave energy (thus reducing shoreline erosion) while providing habitat for marine life, as well as the restoration of targeted coastline areas with mangroves.

The results

The community-based adaptation project was the first collaboration between TNC and a Red Cross Society to integrate nature-based measures in disaster risk reduction. This started the momentum towards global collaboration between the IFRC and TNC.

Trained by Grenada Red Cross, fishers in the Bay Area communities adapted fishing safety practices and gained insights on the links between marine habitats and the local economy.

Other community members, trained by Grenada Fund for Conservation in mangrove care and planting, now support mangrove restoration across other areas of the island.

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The lessons

- Coalitions of partners with a range of skills and strengths can help to design and implement effective and sustainable approaches to community resilience.
- Partnering with Grenada Red Cross and the Grenada Fund for Conservation helped increase community participation in activities such as reef week and beach clean-ups.

WATCH: AT THE WATER'S EDGE (4:02)

Case study B.6: The Philippines

With seaweed to win-win outcomes

How a community-based organization succeeded in a political battle

Location
Matarinao Bay, Eastern Samar, The Philippines

To the communities in Matarinao Bay, fishing is central to lives and livelihoods. But as a result of unsustainable practices such as dynamite fishing, coral reefs, mangroves and seagrass had been degrading in the early 2000s, with fish stock declining.

In response, the fishing communities from four municipalities established the Matarinao Bay Management Council (MBMC). Through their new community-led organization, they successfully advocated for the creation of the Marine Protected Areas (MPA). With appropriate regulations and adequate mechanisms for enforcement in place from 2007 onwards, the local ecosystems and fish stock were set to recover.

The challenges

Shortly after the creation of the MPAs, municipal elections were held. One candidate made the MPAs and associated fishing regulations an election issue — arguing that the MPAs were to blame for reduced income from fishing in the area.

This candidate won the election and became mayor of one of the municipalities. As one of his first actions, he stopped financial and logistical government support to MBMC and called for the MPAs to be scrapped.

The actions

Instead of accepting this defeat, MBMC liaised with a local university to obtain independent evidence. The university led a survey amongst fisherfolk from 25 communities around Matarinao Bay on their perceptions and concerns. The results showed that the communities supported the MPAs and understood their roles. However, the survey also showed that fisherfolk were concerned about the lack of alternative livelihoods to fishing.

In response, MBMC partnered with the Bureau of Fisheries to explore options for alternative livelihoods. Inspired by the economic success of a local seaweed farmer, MBMC then offered alternative livelihood training to fisherfolk and supported the creation of seaweed farms across the Bay.

The results

Numerous seaweed farms were created after the training. The seaweed production led to increased income in fishing communities and had the added benefit that the reefs and seagrass underneath the farms were protected: with seaweed lines criss-crossing the production areas, access to fishing grounds was automatically restricted.

For the MBMC, the success meant that the political opposition to MPAs was overcome: the MPAs were retained and government support to the MBMC restored.

The lessons

- Understanding the main concerns of the communities is paramount to the success of NbS.
- While the population may be supportive to NbS, the implementation can be jeopardized by other important issues to their daily life.
- Liaising with external organizations for technical support and unbiased judgment can be critical.
- Local champions (persons and/or communities) can be instrumental to inspiring and leading NbS.

Case study B.7: Kenya

Blue carbon: financing mangroves

How a project in Kenya has been funded through carbon credits

Location
Gazi Bay,
Kenya

Mikoko Pamoja is a mangrove conservation and restoration project that aims to provide long-term incentives for community involvement and benefit. Started in 2010, communities protect and restore mangroves under the project and in turn sell the carbon credits to international buyers, for about $5–$6 per tonne. This revenue then goes into financing forest protection and restoration, and to other community-chosen projects. Mikoko Pamoja also promotes other sustainable income-generating activities such as beekeeping and eco-tourism.

Thanks to its success, it has become a demonstration project for the feasibility and desirability of community-led mangrove conservation through carbon credit funding. It also serves as a best-practice model for national and regional policy in this regard.

However, there are site-specific factors that have aided its success. This includes the close relationship that has been built between the project developers and the community, and the latter's engagement in the design process, as well as a long history of community participation in and support for mangrove research and restoration in Gazi village.

The village is host to a field station run by the Kenya Marine and Fisheries Research Institute (KMFRI), which specialises in mangrove research. Additionally, planning for Mikoko Pamoja was developed by a Community Forest Association (CFA) and includes a zonation map, detailing activities of different stakeholders in the project area.

The plan is approved by the Kenya Forest Service (KFS), Kenya's state agency in charge of forest management. This agreement is a legal tool for the implementation of the Participatory Forest Management Plan and officially secures community ownership of carbon credits. The Mikoko Pamoja project will ensure community tenure through a special user agreement with the KFS and all income from the sale of Plan Vivo Certificates from the project will be used for the community's benefit.

The ability of community members to benefit directly from the revenues generated from selling mangrove carbon credits has aided buy-in.

In addition, the Mikoko Pamoja Steering Group provides technical support for the Mikoko Pamoja Community Organisation (MPCO), which consists of staff from the KMFRI, KFS, a representative of the Tidal Forests of Kenya Project and a representative of the community organisation.

It must be noted that carbon-offset projects are complex and require a rigorous scientific basis to determine carbon stocks and baselines, as well as a range of technical expertise. In the case of Mikoko Pamoja, the KMFRI has provided this support. The Association for Coastal Ecosystem Services, a charity registered in Scotland, also helps to facilitate the transfer of international funds, reporting to the Plan Vivo Foundation.

Also important is an inclusive stakeholder process for the lifecycle of the project, which included various engagement forums such as village-level meetings and group discussions to promote general understanding of the significance of mangroves and the use of carbon credits. The MPCO consists of representatives of Gazi Bay, specifically Gazi and Makongeni villages, as incomes will benefit people in those areas.

Mikoko Pamoja has received a lot of international attention and was awarded the prestigious UN Development Programme's Equator Prize in 2017 for its contribution to finding innovative solutions to tackle poverty, the environment and climate change. Mikoko Pamoja is currently being replicated on Kenya's south coast at Vanga (with new funding from the DiCaprio Foundation). There are many other opportunities for the application of a similar model in mangrove-rich Western Indian Ocean countries, including in Tanzania's northern marine park near Tanga.

For additional case studies with a focus on Africa, read:

- Chevallier, R. (2019). Marine and coastal ecosystem-based adaptation for enhanced resilience in Southern Africa: Synthesis Report
- UNEP (2019): Ecosystem-based adaptation: Selected case studies from Africa.

B.8 Case study collection

Practical inspirations

An overview of experiences from around the globe

Nature-based solutions come in many shapes: this collection gives ideas, insights and inspirations from around the world.

PHILIPPINES

Engaging youth in mangrove afforestation

In the Philippines, the International Federation of Red Cross and Red Crescent Societies (IFRC) has been partnering with Habitat for Humanity for several years to support specific Philippine Red Cross youth groups who promote safe shelter awareness as part of the Participatory Approach to Safe Shelter Awareness (PASSA).

Under the program, IFRC scanned existing DRR projects for opportunities to 'piggyback': where projects had no youth engagement components, they offered to add specific activities for PASSA Youth groups.

One such case was located in Tangalan City in Aklan province. Here, the vulnerability and capacity assessment (VCA) had highlighted issues of coastal flooding, storm surges and solid waste management.

A PASSA youth group was formed and decided to take on several measures of environmental action. This included a scheme for solid waste management with the municipal administration (waste segregation, recycling, composting), safe shelter awareness-raising, and mangrove afforestation of along the city's mudflats.

The members of the youth group became strong advocates of a greener environment, and appreciated their role in planting mangroves. A short video of their efforts is available here.

COSTA RICA

Healthier mangroves, richer communities

In many of Costa Rica's mangrove forests, an aggressive fern became a problem: after many mangroves had been cleared for firewood since the 1980s, a fern spread in vacant mudflats, taking over the expanse of remaining mangroves. Over 10% of an important wetland of 20,000 hectare wetland is now covered by the fern.

A project by Osa Foundation that aims to restore this area (initially through a 30 hectare pilot) also seeks to create benefits for communities — by better protecting communities from coastal hazards such as storm surges, by restoring biodiversity (including a valuable mollusc that many collect and sell, the mud cockle), and by earning communities money through Blue Carbon financing (see also case study B.7).

By mid-2020, more than 28,000 mangroves had been planted, with many standing two meters tall three years after planting. Community members are engaged in the process and already recognise benefits. The case is described in an article here, which also includes a short video.

UNITED STATES

Combining community engagement and modelling

In communities at the Breton Sound Estuary in Louisiana, a novel approach was applied that brought together residents and researchers. Community members helped identify 21 suitable measures to address coastal hazards through an iterative process, taking local needs and traditional ecological knowledge into account.

The effects of 16 of these were then modelled by ecologists and engineers over a 20-year timeframe, using the Delft3D ecosystem model. The innovative process of collaborative modelling is described in a recent paper available here.

INDIA

Valuing the protective effect of mangroves

While the protective benefit of mangroves for coastal communities is strong (as revalued in a powerful 2020 global study), few empirical cases exist that demonstrate what this means in practice. A 2005 study by Badola and Hussain analysed hazard damage three coastal villages in India's Orissa State, taking prior cyclone as a reference point.

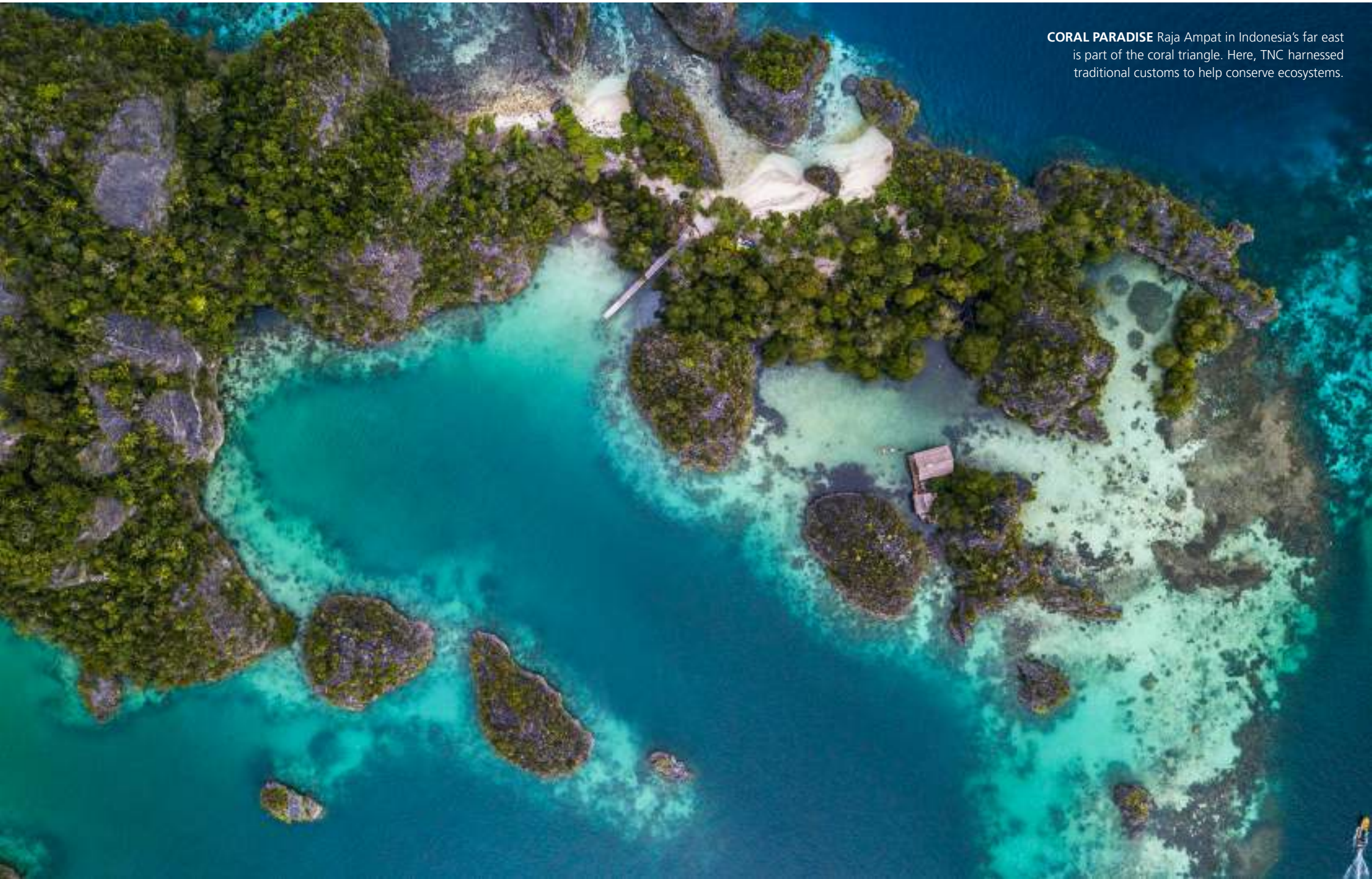
The reported damages per household differed significantly, ranging between USD 153.74 per household in a community not protected by mangroves and USD 33.31 in one that was sheltered by mangrove belt. Surveyed residents appreciated the functions performed by mangrove forest and were willing to contribute to restoration. The study is available here.

BANGLADESH

Harnessing traditional customs (1)

The coastal ecosystems of the Sundarbans that straddle India and Bangladesh have an immense protective benefit to local

IMPORTANT HABITAT The Sundarbans that straddle Bangladesh and India are rich in flora and fauna, and help protect communities from storm surges and cyclone impact.



CORAL PARADISE Raja Ampat in Indonesia's far east is part of the coral triangle. Here, TNC harnessed traditional customs to help conserve ecosystems.

communities. They are also an important source of food and income. In Bangladesh, a local research institute partnered with the forestry department and cooperatives (with honey, wood, fruit collectors and fisherfolk) to analyse and strengthen traditional practices and customary rules in an effort to manage natural resources more sustainably.

Coupled with technical innovations, a more profitable and less damaging approach was developed that showed benefit-cost ratios of up to 32 for livelihood benefits alone. The detailed case study can be found here.

INDONESIA

Harnessing traditional customs (2)

Traditional practices were also incurred in Indonesia's far east: in the area of Raja Ampat that is part of the coral triangle, TNC Indonesia/YKAN helped strengthen the traditional marine resource management practices known as *sasi laut* (a 2009 study describing these practices and their potential for conservation is available here).

In particular, the harvesting of sea cucumbers was restricted from 2014 onwards, invoking *sasi laut* rules. This plant is of value both to the coral ecosystems and as a source for various food items. Monitoring showed that as a result of restrictions, the mean size of harvested sea cucumbers and its overall stock increased swiftly.

Women played an important role in collaborative management and also engaged in food processing. The households involved increased their annual income by USD 300 as a result on average.

TANZANIA

Green and gray measures, direct and indirect benefits

In Tanzania's major city of Dar-es-Salaam as well as nearby Zanzibar and other coastal districts, the Tanzanian government sought to stop coastal erosion and to better protect communities from storm surges. With the support of UNEP, two projects were launched under an integrated coastal zone management (ICZM) approach.

This included numerous measures, both green and gray. In seven locations, seawalls and dikes were built or upgraded, encompassing a total length of 2,400 meters. With the help of 87 newly formed community groups, some 1,000 hectares of mangroves were rehabilitated and 3,000m^2 of coral reefs restored. The restoration was carried out using locally available, climate-resilient species. No-take zones were declared to reduce further deforestation of mangroves.

Addressing community concerns of water scarcity, the project furthermore brought direct benefits through the construction of boreholes and storage tanks as well as the promotion of rainwater harvesting at households. More than 3,000 efficient cookstoves were distributed to help reduce the demand for firewood.

Almost one million people benefitted from the projects and are now better protected from coastal hazards. See a video here and read an article on the projects here.

MORE CASE STUDIES

Panorama - Solutions for a Healthy Planet
Marine and coastal solutions

This partnership initiative features more than 750 case studies across five thematic areas. The marine and coastal solutions are alone has more than 250 solutions and many more shorter descriptions of 'building blocks'.

Oppla case studies

Oppla is the European Union's repository of nature-based solutions. It partners with universities and research centres from Europe and around the world. It features a case study finder as well as a community of practice.

NbS Case Studies
The Nature-based Solutions Initiative
University of Oxford

This website features several case studies of NbS in coastal contexts, including some from Vanuatu, Costa Rica, India, Bangladesh and Mexico.

The Ecosystem Disaster Risk Reduction Case study and Exercise Source Book | CNRD 2014

This book features seven detailed case studies. The studies of integrated coastal zone management (case study 2, Indonesia) and coastal ecological engineering (case study 6, USA) are very insightful.

Nature-based solutions for disaster risk management World Bank 2020

This new booklet draws from a forthcoming publication by the World Bank and the World Resources Institute, and presents snapshots of 'NbS in Action'.

APPENDIX C
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APPENDIX D
Glossary

Adaptation Source: IPCC 2018:542	The process of adjustment to actual or expected changes and their effects, in order to moderate harm or exploit beneficial opportunities. Adaptation can be proactive (adjustment to expected changes) or reactive (adjustment to changes that have occurred), or a mixture of both.
Adaptive capacity Source: IPCC 2018:542	The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences.
Benefit-cost ratio (BCR)	Indicator used in cost–benefit analysis, that attempts to summarize the overall value for money of a project or proposal. A BCR is the ratio of the benefits of a project or proposal, expressed in monetary terms, relative to its costs, also expressed in monetary terms.
Biodiversity Source: IPCC 2018:543	Biological diversity means the variability among living organisms from all sources, including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems
Climate change Source: IPCC 2018:544	Climate change refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer.
Community Source: IFRC 2014:10	A community is a group of people who may or may not live within the same area, village or neighborhood, share a similar culture, habits and resources. Communities are groups of people also exposed to the same threats and risks such as disease, political and economic issues and natural disasters.
Coping capacity Source: IPCC 2018:546	The ability of people, institutions, organizations and systems, using available skills, values, beliefs, resources and opportunities, to address, manage and overcome adverse conditions in the short to medium term.
Cost-benefit analysis Source: IPCC. 2018:546	Monetary assessment of all negative and positive impacts associated with a given action. Cost–benefit analysis enables comparison of different interventions, investments or strategies and reveals how a given investment or policy effort pays off for a particular person, community or country.

Damages and losses

Sources:
*. IPCC 2018: 553
** UNISDR 2015

Damages and losses have been taken to refer broadly to harm from (observed) impacts and (projected) risks.*

While the two terms are often used interchangeably, the Blue Guide refers to **damages** as the harm to buildings, assets and infrastructure, whereas **losses** refer to harm all non-structural aspects (income, produce).

Losses can be further divided into direct and indirect types: **direct losses** refer to directly quantifiable losses that occur immediately (e.g. harvest lost), whereas **indirect losses** include declines in output or revenue, and impact on well-being of people, and generally arise from disruptions to the flow of goods and services as a result of a disaster.**

Direct costs and indirect costs

Direct costs refer to all expected or materialized expenditures associated with the measures pursued by a project. These are budgeted for by the implementing organization.

Indirect costs refer to the long-term or post-project costs (financial or in-kind) that are borne by community members and stakeholders.

Disaster and hazard

Sources:
* IPCC 2018:551
** IPCC 2018:547

A **hazard** is the potential occurrence of a natural or human-induced physical event or trend that may cause loss of life, injury or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources.*

A **disaster**, by contrast, concerns severe alterations in the normal functioning of a community or a society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic or environmental effects that require immediate emergency response to satisfy critical human needs and that may require external support for recovery.**

When a hazard event overwhelms the capacity of a system to cope with its effects, it leads to a disaster.

Disaster risk management

Source:
IPCC 2018:547

Processes for designing, implementing and evaluating strategies, policies and measures to improve the understanding of disaster risk, foster disaster risk reduction and transfer, and promote continuous improvement in disaster preparedness, response and recovery practices, with the explicit purpose of increasing human security, well-being, quality of life and sustainable development.

Disaster risk reduction

Source:
UNISDR 2015

The policy objective of anticipating and reducing risk is called disaster risk reduction (DRR). Although often used interchangeably with DRR, disaster risk management (DRM) can be thought of as the implementation of DRR, since it describes the actions that aim to achieve the objective of reducing risk.

Ecosystem

Source:
IPCC 2018:548

An ecosystem is a functional unit consisting of living organisms, their non-living environment and the interactions within and between them.

Ecosystem services

Source:
IPCC 2018:548

Ecological processes or functions having monetary or non-monetary value to individuals or society at large. These are frequently classified as (1) supporting services such as productivity or biodiversity maintenance, (2) provisioning services such as food or fiber, (3) regulating services such as climate regulation or carbon sequestration, and (4) cultural services such as tourism or spiritual and aesthetic appreciation.

Exposure

Source:
IPCC 2018:549

The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected.

Food security

Source:
FAO 2001

A situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.

Gender

Source:
USAID, Guide to Gender Integration and Analysis: Additional Help for ADS Chapters.

Gender is a social construct that refers to relations between and among the sexes, based on their relative roles. It encompasses the economic, political and sociocultural attributes, constraints and opportunities associated with being male or female.

As a social construct, gender varies across cultures and is dynamic and open to change over time. Because of the variation in gender across cultures and over time, gender roles should not be assumed but investigated. Note that "gender" is not interchangeable with "women" or "sex."

Gray measures (infrastructure)

Source:
WWF 2016: 188

Manufactured, engineered components of a system. Also known as hard or traditional infrastructure or engineering.

Green measures (infrastructure)

Source:
WWF 2016: 188

An adaptable term used to describe an array of products, technologies and practices that use natural systems, or engineered systems that mimic natural processes, to enhance overall environmental quality and provide utility services.

Governance

Source:
IPCC 2018:550

A comprehensive and inclusive concept of the full range of means for deciding, managing, implementing and monitoring policies and measures.

Whereas government is defined strictly in terms of the nation-state, the more inclusive concept of governance recognizes the contributions of various levels of government (global, international, regional, sub-national and local) and the contributing roles of the private sector, of nongovernmental actors, and of civil society to addressing the many types of issues facing the global community.

Hazard

See disaster and hazard.

Indirect costs

See direct costs and indirect costs

Land subsidence

Source:
WWF 2016: 189

Land subsidence occurs when large amounts of groundwater have been withdrawn from certain types of rocks, such as fine-grained sediments. The rock compacts because the water is partly responsible for holding the ground up. When the water is withdrawn, the rock falls in on itself. Land subsidence is most often caused by human activities, mainly the removal of subsurface water.

Livelihoods

Source:
IPCC 2018:553

The resources used and the activities undertaken in order to live. Livelihoods are usually determined by the entitlements as well as the human, social, natural, physical and financial assets to which people have access. ?? ?????? ?????? ???? ??????

Losses

See damages and losses

Measure, option and solution

The Blue Guide refers to these three terms in the following way:

Measure: refers to an individual action item, for example the afforestation of mangroves or the rehabilitation of reefs.
Option: the combination of different measures in a package. This may include green and gray structural measures, as well as non-structural ones (e.g. improved evacuation systems).
Solution: the eventual option you decide on. The solution should ideally be based on the best performance in terms of sustainability and effectiveness.

Mitigation

Sources:
(1) IPCC 2018:554
(2) UNISDR 2017

The term mitigation is used in in two different ways.

(1) In the context of **climate change**, it refers to human interventions to reduce emissions or enhance the sinks of greenhouse gases.

(2) In the context of **disaster risk management**, it refers to the lessening or limitation of the adverse impacts of hazards and related disasters. For instance, constructing flood defenses, planting trees to stabilize slopes and implementing strict land use and building construction codes.

Nature-based solution

Source:
IUCN 2016

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. Common societal challenges are climate change, food security, disaster risks, water security, social and economic development as well as human health.

Non-structural

See structural and non-structural

Option

See measure, option and solution

Preparedness
(disaster preparedness)

Source:
UNISDR 2017

The knowledge and capacities of governments, professional response and recovery organizations, communities and individuals to effectively anticipate, respond to and recover from the impacts of likely, imminent or current hazard events or conditions. For instance, installing early warning systems, identifying evacuation routes and preparing emergency supplies.

Resilience

Sources:
* Walker/Salt 2005:1
** IFRC 2014:6

Resilience is the ability of a system to cope with adverse impact and return to a state that allows it to resume its original functions.* The term was originally used in material science, describing why certain types of timber would break or withstand certain loads. It has since been used by numerous disciplines (e.g. biology, psychology, sociology).

The Blue Guide uses the term in relation to **ecosystems** and **communities**. There are two distinct perspectives: The outcome perspective looks at whether, how quickly and how much a system rebounds. The functional perspective looks at the extent to which functions/aspects are present that allow a system to rebound.

In terms of community resilience, the Blue Guide adopts the definition of the IFRC, which combines functional and outcome elements: Here, resilience is understood as "the ability of […] communities […] to anticipate, prepare for, reduce the impact of, cope with and recover from the effects of shocks and stresses without compromising their long-term prospects."**

Risk

Source:
IPCC 2018:557

The potential for adverse consequences where something of value is at stake and where the occurrence and degree of an outcome is uncertain. Risk results from the interaction of vulnerability (of the affected system), its exposure over time (to the hazard), as well as the (climate-related) hazard and the likelihood of its occurrence.

Scenario

A projection of future conditions over a given timeframe. These can be used to test the effectiveness of options under different assumptions.

Sensitivity

The quality or state of a system to be receptive to an external stimulus. In the context of disaster risk management and climate change, sensitivity refers to the susceptibility of a system to be affected by a hazard or stressor. For instance, making buildings, infrastructure, systems, business, livelihoods and households more robust means they are less sensitive and can better withstand direct physical effects.

Shocks

Source:
CARE 2019: 7

Shocks are short-term events or disruptions that have negative effects on people's well-being, assets, livelihoods, safety or their ability to withstand future shocks. Rapid-onset hazards such as earthquakes, cyclones and floods, as well as economic crises, industrial accidents and terror attacks are examples.

Storm surge

Source:
WWF 2016: 192

An abnormal rise in sea level accompanying a hurricane or other intense storm, whose height is the difference between the observed level of the sea surface and the level that would have occurred in the absence of the cyclone. Storm surge is usually estimated by subtracting the normal or astronomical high tide from the observed storm tide.

Stresses

Source:
CARE 2019: 7

Stresses are continuous, long-term trends or pressures that negatively impact people's lives and the systems they live in.

Solution	See measure, option and solution
Stakeholder Source: TDM Encyclopedia	Individuals or groups that are affected by a decision and have an interest in its outcome.
Stewardship (environmental)	The responsible use and protection of the natural environment through conservation and sustainable practices.
Structural and non-structural measures Source: WWF 2016: 114	**Structural** measures refer to the creation or reinforcement of the physical landscape. This can include gray or green measures. **Non-structural** measures do not involve any physical interventions (engineering or ecological). They can be categorized mainly into two categories, those aiming for governance changes, and those aiming for changes in community and household practices
Sustainability Source OECD 2010: 36	The ability to be maintained at a certain rate or level. The term has two connotations: From a **project management** perspective, it refers to the continuation of benefits from a development intervention after major development assistance has been completed.* Project outcomes are likely to be sustained if local actors are willing and able to pursue the activities underpinning the outcome. In **ecology**, sustainability refers to the avoidance of the depletion of natural resources in order to maintain an ecological balance.
Vulnerability Sources: IPCC 2018:560 CARE 2019:7	The propensity or predisposition to be adversely affected. Vulnerability to the same risks may differ based on gender, wealth, mobility and other factors. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.

APPENDIX E **Key resources**

CORAL REEFS

Shaver et al. (2020): A Manager's Guide to Coral Reef Restoration Planning and Design.

Specific guidance on the restoration of coral reefs.

SHELLFISH REEFS

Fitzsimons et al. (2019): Guidelines for Shellfish Reefs.

Specific guidance on the restoration of shellfish reefs.

MANGROVES

UNEP (2020): Guidelines on Mangrove Ecosystem Restoration for the Western Indian Ocean Region

Specific guidance on mangrove ecosystem restoration. While focussed on the Western Indian Ocean, the principles apply globally.

The resources listed here are a small selection of manuals and reports that allow you to explore certain aspects more deeply. **Click on the title to view the documents**.

SEAGRASS

Björk et al. (2008): Managing seagrasses for resilience to climate change

Specific guidance on the restoration of seagrass meadows.

RESILIENCE PROGRAMMING

IFRC (2016). Road map to community resilience

This process manual is designed for Red Cross and Red Crescent Societies and can be used together with the Blue Guide.

DISASTER RISK REDUCTION

UNDRR (2019): Global Assessment Report on Disaster Risk Reduction

The status of disaster risk reduction, with an outlook and recommendations.

RESTORATION PRINCIPLES

Gann et al. (2019): International principles and standards for the practice of ecological restoration

This standard reference offers excellent guidance on ecological restoration. It also includes great monitoring tools.

COMMUNITY ASSESSMENTS

CARE (2019). Climate vulnerability and capacity analysis handbook

This updated second edition includes a range of great tools for community-based risk assessments. Very useful for Stages 2 and 3 of the Blue Guide.

DISASTERS & CLIMATE CHANGE

IFRC (2020): Come Heat or High Water. World Disasters Report 2020

The report analyses climate disaster trends and shows how humanitarian impacts of the climate crisis can be tackled.

FLOOD MANAGEMENT

WWF (2016): Natural and nature-based flood management: A Green Guide

A comprehensive guide for reducing flood risk. See Green and Blue Guide relate to each other at the first page of all Blue Guide stages.

DISASTER COSTS & PROJECTIONS

IFRC (2019): The cost of doing nothing. The humanitarian price of climate change and how it can be avoided

In this report, the IFRC looks at the impact of climate change under different scenarios, and what it means for the humanitarian world.

RESILIENCE & POVERTY

Hallegate et al. (2017): Unbreakable. Building the resilience of the poor in the face of disasters

Study that looks at the disproportionate impact of disasters on poor populations, and what can be done about it.

THE BLUE GUIDE
TO COASTAL RESILIENCE

Protecting coastal communities through nature-based solutions

A handbook for practitioners of disaster risk reduction (DRR)

Where land and water meet, there is unparalleled potential. But coastlines are also frontlines: it is here where many natural hazards cause the greatest havoc. The impact of climate change already poses stress to coastal communities and ecosystems - and trends are reason to worry.

The Blue Guide was designed to help DRR practitioners identify and implement nature-based solutions (NbS) in their efforts to enhance coastal resilience. It guides the user through eight stages and offers numerous tools and external resources. Read it. Use it. Help communities enhance their resilience.

USAID FROM THE AMERICAN PEOPLE
The Nature Conservancy
Protecting nature. Preserving life