



Options for Ecosystem-based Adaptation in Coastal Environments

A Guide for environmental managers and planners



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On the heavily eroded Telescope beach in Grenada as part of the Telescope Mangrove Propagation Nursery in Grenada, a man inspecting newly planted mangrove saplings. The project aims to restore the mangroves that act as part of a natural coastal protection mechanism.

This guide

This guide is about taking account of, and managing, ecosystems to help people adapt to climate change in coastal areas: coastal Ecosystem based Adaptation (EBA). Vital to human wellbeing, adaptation to climate change is increasingly important in international policy discussions such as the UN Framework Convention on Climate Change (UNFCCC) and Convention on Biological Diversity (CBD), which have acknowledged the potential importance of EBA in meeting this challenge. In coastal environments climate change impacts can be especially acute, and people's dependence on services from ecosystems is often intricately tied to the security of their livelihoods. Coastal EBA is therefore of paramount importance and this guide is a strategic resource for those involved in its planning and implementation.

The guide is aimed at environmental and adaptation managers and planners, principally in government departments and agencies but also in business and civil society organisations. As such, the guide aims to provide a broad understanding of the principles and concepts of coastal EBA, present a range of different coastal EBA options, illustrated with existing examples, and discuss the issues and challenges that need addressing in EBA implementation. The guide is intended as a resource that can be consulted according to need. Together with the accompanying Coastal EBA Decision Support Tool (available online at <http://web.unep.org/coastal-eba/coastal-EBA-DST>), it supports environmental decision-makers in choosing, implementing, monitoring, evaluating and, over time, adaptively managing coastal EBA. Whilst some technical detail is included, the broad scope of this publication means it cannot include all of the practical detail required for coastal EBA implementation. For this reason, an important component of the guide is the list of useful resources under each of the main sections. Technical officers responsible for designing EBA projects will need to consult this literature and other source material.

Many of the approaches discussed in the following pages will be recognisable to environmental managers and planners. These practical adaptation measures are rarely new, but instead have been tried and tested through ecosystem-based management (EBM), integrated coastal zone management (ICZM) and marine spatial planning (MSP). Due to the overlap in approaches and actions involved, planning and implementing coastal EBA must always be done with reference to these and other such regimes as applied within the terrestrial and marine environments concerned. What is distinctive about coastal EBA, however, is its specific focus on the vulnerability of coastal communities and ecosystems to future climate change impacts and how to reduce that vulnerability through decisive, positive and joined up action. The objectives, targets and indicators for success of a coastal EBA project will always focus on this long-term, over-arching goal.

Structure of the guide

The guide begins by establishing the many different values of coastal ecosystems and why they play an essential role in coastal communities' adaptation to climate change (Chapter 1). The following chapter then describes the key elements or steps involved in planning and implementing adaptation, noting that it will usually be an iterative rather than linear process. The Coastal EBA Decision Support Tool is further described, as well as the need to embed coastal EBA approaches in the wider planning and policy context. At the heart of this guide (Chapters 3 and 4) we present practical options for coastal EBA, in terms of policy measures (Chapter 3) and a portfolio of ten ecosystem or sector focused options (Chapter 4), highlighting for each the key issues that can affect success. Case studies of these coastal EBA approaches are presented throughout the guide. We conclude in Chapter 5 with a discussion on getting results: the all-important need to monitor, evaluate and steer ongoing management of the EBA project. No EBA approach is a 'set-and-forget' solution; a commitment is needed to realise its fullest benefits over the long term. Monitoring and evaluation are critical for developing evidence on what works where and, through communicating experience and results, for helping to mainstream EBA approaches into all relevant sectors.

The guide has been designed as an important resource for the building of a successful, collective adaptation effort for the benefit of coastal communities, ecosystems and biodiversity. It has been developed under the UNEP 'Building Capacity for Coastal Ecosystem-Based Adaptation for Small Islands Developing States (SIDS)' project, which has been made possible by funding from the European Commission. In keeping with the target audience of the overall project, the primary focus of this guide is on coastal EBA in the context of developing nations. For this reason, case studies and other examples, lessons learned and references are mainly drawn from developing coastal nation states.

BOX 1: DEFINITIONS

Adaptation: Adjustment in natural or human systems to a new or changing environment (Millennium Ecosystem Assessment 2005).

Ecosystem: A dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit (United Nations 1992).

Ecosystem approach: A strategy for the integrated management of land, water and living resources that provides sustainable delivery of ecosystem services in an equitable way (CBD Secretariat 2000).

Ecosystem services: Benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as regulation of floods, drought, land degradation and disease; supporting services such as soil formation and nutrient cycling; and cultural services such as recreational, spiritual, religious and other non material benefits (Millennium Ecosystem Assessment 2005).

Ecosystem-based adaptation (EBA): The use of biodiversity and ecosystem services to help people adapt to the adverse effects of climate change (SCBD 2009).

Link to the Coastal EBA Decision Support Tool: <http://web.unep.org/coastal-eba/coastal-EBA-DST>

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United Nations. 1992. Convention on Biological Diversity. Montreal, Canada: Secretariat of the Convention on Biological Diversity.



The value of
coastal ecosystems

01

In Jamaica, coral nursery at Oracabessa bay, allows coral to be rejuvenated. Small pieces of specific coral are allowed to grow before being re-planted on the reefs. Coral reefs are crucial to protect the coast especially in small island states.

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Coastal ecosystems occur where the land meets the sea. They extend along more than 1.6 million km of coastline in a total of 123 countries (UNEP 2006). These ecosystems include a diverse set of habitat types, encompassing both terrestrial (e.g. sand dunes) and marine habitats (e.g. seagrass beds) (UNEP 2006). Coastal areas are home to approximately one third of the world's population (UNEP 2006) and almost 40% of the world lives within 100 km of the coast (Agardy et al. 2005). As we consider ecosystem-based adaptation to future climate change in coastal areas, it is important to be clear about the many different values of the ecosystems, and why ecosystems play an essential role in adaptation.

Social values of coastal ecosystems

Coastal ecosystems support many of the world's poorest communities, who rely on the provisioning services of these systems for their food supply and livelihoods. Coral reefs, mangroves and other ecosystems are important for fisheries and fish nurseries, which provide people with a key source of protein as well as livelihood opportunities.

Other livelihood options provided by coastal ecosystems include tourism and the sustainable harvesting of mangroves (Baba, Chan, and Aksornkoe 2013): coral reef ecosystems can generate income for local coastal communities through diving and snorkelling tourism and mangroves can provide a variety of wood and non-wood products, such as honey, dye, fodder and herbal remedies.

Coastal ecosystems also provide important regulatory services, helping to protect people's lives against environmental hazards and degradation of resources. For example, coral reefs, mangroves and seagrasses help to attenuate wave energy and thereby reduce the

severity of coastal flooding, storm damage and erosion following storm and hurricane events (Spalding et al. 2014). This protective role also diminishes the need for coastal protection structures and therefore reduces the amount of financial investment required to pay for these structures. Sand dune system aquifers contribute to water regulation and purification (van Dijk 1989; Carretero and Kruse 2012), while mangroves hold large stores of carbon which help to regulate the earth's climate (Donato et al. 2011).

Coastal ecosystems can also be of cultural significance, providing space and inspiration for recreation, aesthetic enjoyment, artistic and spiritual fulfillment and intellectual development (UNEP 2006).

Economic values of coastal ecosystems

Coastal ecosystems and their services have economic as well as social value. They directly underpin or contribute to a number of economic sectors, including tourism, commercial fisheries, salt, minerals, oil and construction (e.g. by providing goods such as rock, sand, lime and



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wood; Martinez et al. 2007). Estimates of their annual contribution to the global economy range from billions to trillions of dollars (Costanza et al. 1997; Martinez et al. 2007). Fish are one of the most heavily traded food commodities in the world, particularly in developing countries where they can account for more than half of the total value of all traded commodities (FAO 2014). In 2012 the total global value of fishery exports amounted to US\$ 129 billion (FAO 2014). Coastal ecosystems such as coral reefs, mangroves and seagrasses support the global fishery export market through their role in providing habitat for commercially relevant fish species.

Biological values of coastal ecosystems

In addition to their social and economic values, coastal ecosystems sustain a wealth of terrestrial and marine fauna and flora. For example, coral reefs contain almost a third of the world's marine fish species (Moberg and Folke 1999) and mangrove forests provide habitat for numerous species,

including the endangered Bengal tiger (Gopal and Chauhan 2006) and the hawksbill turtle (Gaos et al. 2012). The biological values of coastal ecosystems are not simply intrinsic; many of the social and economic values of coastal ecosystems, described above, are underpinned by their biological richness. A rich fauna and flora can enhance appeal for ecotourism and represents a bank of genetic resources that can be drawn upon for medicine and biotechnology (Martinez et al. 2007). For example, many species found in coral reef ecosystems

produce chemicals that are currently being used as sources for new medicines, including those for cancer, arthritis, heart disease and asthma (NOAA 2015).

Recognition of the social, economic and biological values of coastal systems has led to the increasing application of ecosystem-based management approaches. These treat coastal areas as 'socioecological' systems, managing human activities and their impacts based on the consideration of the whole ecosystem (UNEP 2011).

Links between coastal and terrestrial ecosystems

Coastal ecosystems are intricately connected to both upstream terrestrial/freshwater ecosystems and marine ecosystems. Processes and activities in one system invariably cause impacts on other systems, in positive and/or negative ways (see Figure 1). For example, forest ecosystems help to stabilize soils, thereby preventing erosion and downstream sedimentation, which are processes that can smother coral reefs and otherwise negatively impact these ecosystems.

Growing awareness among land and natural resource planners and managers of the interconnectivity between systems has resulted in the development of management approaches that take into account the multiple interactions within the land-sea interface. Approaches such as integrated coastal zone management (ICZM), integrated coastal management (ICM), marine spatial planning (MSP) and 'ridge-to-reef' focus on the links

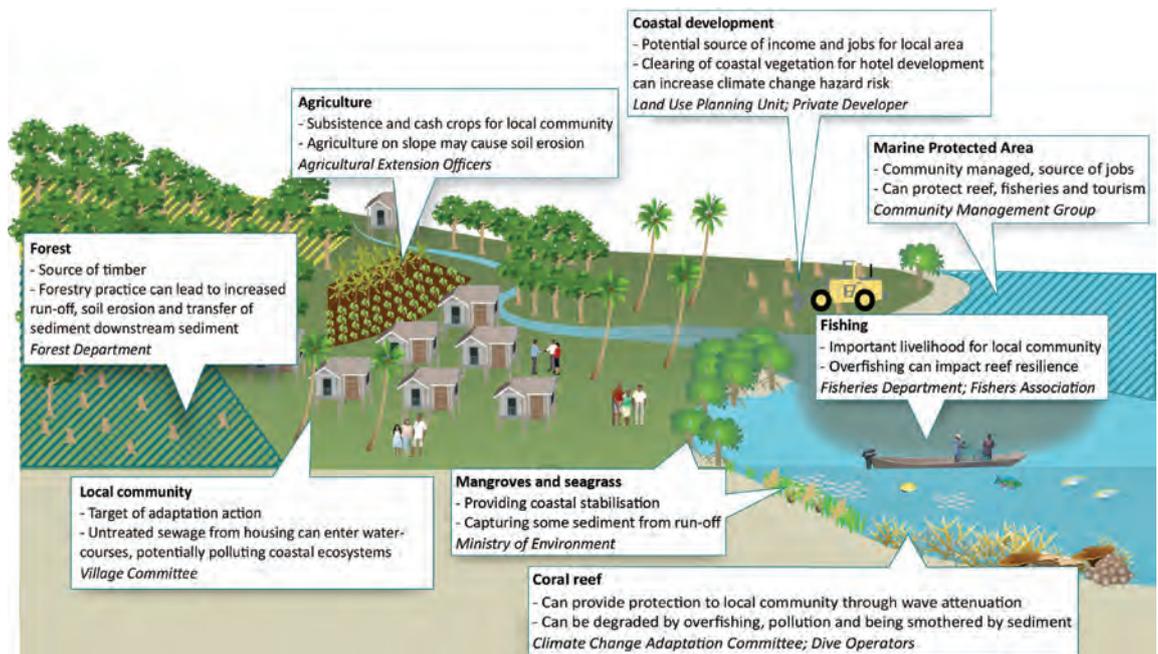


Figure 1: Connections between activities and their impacts on coastal ecosystems. Assessment, 2005)

Source: adapted from p. 30, Jupiter et al. (2013). Symbols used in diagram are courtesy of the Integration and Application Network, University of Maryland Centre for Environmental Science (ian.umces.edu/symbols/).

between coastal and terrestrial ecosystems, including addressing terrestrial-derived pressures. More specifically, this involves understanding the linkages between activities within a whole ‘catchment’ (the area from which rainwater drains – via surface drainage, streams and rivers – to a particular stretch of coastline and into the sea). These comprehensive approaches aim to manage the activities of multiple sectors within a natural boundary to ensure natural resource sustainability, biodiversity conservation, risk reduction and livelihood generation. They draw from other integrated approaches to coastal management such as:

- **Integrated water resources management:** A process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems¹.
- **Integrated catchment management:** Brings the various parties and interests in a catchment together through land-use and water management plans to achieve whole catchment improvements². and
- **Ecosystem-based management:** The management of human activities and their impacts on ecosystems and natural resources based on consideration of the whole ecosystem³.

Whether undertaking ecosystem-based adaptation or one of the related, integrative management approaches, recognising the interconnectivity of systems is fundamental to their design and effectiveness. So also is the coordinated working of multiple sectors and jurisdictions, as each area is affected by the others’ actions (Clarke and Jupiter 2010; GEF 2013; Mataka et al. 2013). This requires holistic and consultative planning that involves key stakeholders in the management of the ecosystems whilst still the interests of other stakeholders. It also benefits from an adaptive management approach, which learns by doing and reduces the uncertainty inherent in ecosystems (Green and Garmestani 2012).

For an example of one application of ridge-to-reef and other integrative management approaches, see Case Study 1 study on page 95.

The value of coastal ecosystems in climate change adaptation – some key concepts

Coastal environments are expected to undergo a variety of important changes due to climate change (see Table 1). In such areas, many of the same ecosystem services that coastal communities rely on also play a role in helping them to adapt to climate change. The aforementioned coastal protection role of some ecosystems, for example, can help counter the increased risk posed by sea level rise of waves reaching key assets (e.g. homes, infrastructure and business).

Ecosystem-based adaptation (EBA) is the term used to

¹ See: <http://www.unep.org/geo/geo4/report/Glossary.pdf>

² See: http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=home.showFile&rep=file&fil=LIFE04_ENV_GB_000807_LAYMAN.pdf

³ See: http://www.unep.org/pdf/EBM_Manual_r15_Final.pdf

describe the use of biodiversity and ecosystem services as part of an overall strategy to help people adapt to the adverse effects of climate change. It is also important to be aware of how the expected changes in coastal areas will directly impact coastal ecosystems themselves, the ecosystem services they provide and the communities which depend on them. Resilience is the term used to describe the ability of a social or ecological system to maintain basic structural and functional characteristics over time despite external pressures.

Conserving, restoring and managing ecosystems to increase their resilience and secure continued supply of the services they provide will ultimately help coastal communities to adapt to climate change. It is also important to develop the adaptive capacity of those same communities: increase their ability to adjust to climate change in order to moderate potential damages, take advantage of opportunities, or cope with the consequences. Well managed, resilient, ecosystems can help to increase adaptive capacity, for example by providing a range of potential livelihood options. Therefore, increasing resilience and adaptive capacity are essential to the success of coastal EBA approaches.

EBA often involves, if not depends on, community based, participatory principles to adapting to climate change. EBA measures can range from on-the-ground environmental management actions to changes in governance and policy. They should be based on initial strategic and integrative planning. The management of ecosystems can be combined with built infrastructure to create hybrid adaptation (or grey-green) approaches, which capitalize on the best characteristics of ecological and engineering options (Sutton-Grier, Wowk, and Bamford 2015). Although the formal concept of EBA has only gained attention over the last decade, the

management of ecosystems for societal resilience has a longer history. EBA activities are increasingly being implemented across a wide range of countries, including Small Island Developing States (SIDS, Box 2) and other coastal developing states where there is an obvious interdependence between people and the coast (see Figure 1 for more details).

Conclusion: the need for coastal ecosystem based adaptation

Coastal ecosystems are some of the most productive yet most threatened ecosystems in the world (Agardy et al. 2005). Recent decades have witnessed a sharp increase in pressure on coastal ecosystems, and the services and values they provide, mainly due to human activities. Trends in human population growth, unsustainable fishing methods, overfishing, land use change, coastal development (e.g. tourism) and pollution are all exerting significant pressure.

Added to these threats are climate change, which has emerged as a significant and real threat to the integrity and productivity of coastal ecosystems globally. Good, well-managed and thereby resilient coastal ecosystems can help mitigate this growing stress from climate change – the goal of coastal EBA. The combination of anthropogenic and climatic threats means that many coastal ecosystems face unprecedented challenges to their long-term viability and resilience (see, for example, the climatic and non-climatic threats to coral reef ecosystems in Table 2). However, understanding coastal ecosystems, their wide range of social, economic and biological values and how these are needed for, and contribute to, human and ecosystem adaptation to climate change is an essential first step in planning towards the longterm maintenance of the ecosystems and effective adaptation.

BOX 2: THE IMPORTANCE OF COASTAL ECOSYSTEMS FOR ADAPTATION IN SMALL ISLAND DEVELOPING STATES

Small Island Developing States (SIDS) comprise 51 island countries which are spread throughout the Atlantic, Indian and Pacific Oceans, and the Caribbean Sea. SIDS are often small in size and have steep geomorphological, hydrological and ecological gradients, making them particularly sensitive to watershed management and its breakdown. Such states also share some common economic and development challenges, including small but rapidly growing populations, low resource availability, high dependence on international trade, geographic remoteness, and susceptibility to natural hazards. As elsewhere, they are also subject to climate-related phenomena such as trade winds, El Niño, monsoons, tropical cyclones and sea level rise. The combination of these physical, climatic, economic and development factors make SIDS some of the most vulnerable countries to climate change.

Adaptation to climate change is already a pressing issue for many SIDS, especially as many are already experiencing some of the impacts of climate change (e.g. rising sea levels). It is therefore of paramount importance to manage coral reefs, mangrove forests, dune systems, seagrass beds and other ecosystems to ensure their continued resilience in the face of climate change, and continued provision of services to the people who rely on them.

Informed by: United Nations Framework Convention on Climate Change (2007). Vulnerability And Adaptation To Climate Change In Small Island Developing States. Background paper for the expert meeting on adaptation for Small Island Developing States.

Table 1: Main biophysical changes affecting coastal areas as reported by The Intergovernmental Panel on Climate Change in their Fifth Assessment Report (IPCC AR5, 2013)

Change	Evidence/discussion
Sea surface temperature rise	Coastal sea surface temperature will, with high confidence, increase with projected global temperature increases.
Sea level rise	Global mean sea level is very likely to increase, but with regional variability.
Ocean acidification	Ocean acidification will, with high confidence, increase at unprecedented rates, but with local and regional variability.
Storms and hurricanes	The overall frequency of tropical cyclones is likely to decrease or remain stable, but an increase in the frequency of the most intense tropical cyclones is likely.
Flooding	As sea level rises, the extremes of sea level and so coastal flooding will with high confidence also increase. However, there is low confidence in how storms will change and therefore in how they will affect coastal flooding. As sea level rise increases it will eventually lead to permanent submergence of some areas. Coastal flooding also arises from mismanaged watersheds upstream.
Coastal erosion	Higher waves will, with low confidence globally and medium confidence for the Southern Ocean, increase the probability that coastal sand barriers and dunes will be over-washed or breached, and more energetic and/or frequent storms may exacerbate this. In the absence of adaptation measures, beaches, sand dunes and cliffs currently affected by erosion will, with high confidence, continue to be affected under increasing sea levels.
Coral reef bleaching (See also Table 2)	Acidification will increase with high confidence at unprecedented rates, but with local and regional variability. Along with high confidence of increases in sea surface temperature, this will with high confidence lead to coral bleaching, mortality, and reduced ability to develop reef structure.

Source: Wong et al. (2014) In particular, Chapter 5: "Coastal Systems and Low-Lying Areas", and IPCC table 5-1, and FAQ box 5.2.

Table 2: Threats to coral reefs, illustrating that a wide range of threats may simultaneously affect coastal ecosystems

Possible climate change impacts on coral reefs

- Increasing sea temperatures affecting frequency and intensity of coral bleaching events, prevalence of disease, and associated coral mortalities
- Sea surface temperature change affecting coral growth and reproduction rates impacting potential recovery rates from acute stresses (e.g. bleaching events)
- Changing acidity of sea water impacting calcification and reef building processes
- Sea level rise affecting reef growth with some reefs potentially not able to keep up with the photic zone
- Changing intensity of tropical storms/hurricanes that damage the physical structure of reefs and associated biodiversity
- Changing variability of rainfall impacting freshwater run-off volumes that carry sediment and land-based pollution that damages reefs

Non-climatic threats to coral reefs (some may be indirectly increased by climate change)

- Shipping channel extraction, dredging and other extractive activities for coastal development
- Overfishing of key herbivore species and destructive fishing techniques
- Invasive species outcompeting native algae grazers (e.g. lionfish consuming young parrot fish)
- Eutrophication, increased macroalgal growth and algal blooms
- Land-based pollution
- Marine pollution
- Boat anchorage damage
- Damage from tourism activities (e.g. divers or snorkelers touching, breaking or removing coral)
- Predator outbreaks such as the Crown-of-Star starfish, sea urchins, *Drupella*

Natural impacts to coral reefs

- Hurricanes, typhoons
- Tidal wave breaking reef
- Tidal emersion stress as long periods of exceptionally low tides leave shallow water coral heads exposed, damaging reefs

Informed by: CDKN (2014), Wong et al. (2014), and Mumby et al. (2014)

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**Planning for
adaptation**

02

Introduction

Developing and implementing adaptation options through a comprehensive process of planning and coordination can help ensure that adaptation activities are effective and have the desired results (Moser and Ekstrom 2010). Making this process iterative enables emerging information and changing contexts to be taken into account. Consideration of the complex interactions between human and ecological systems and between the different sectors and actors that form the context for adaptation is also essential for effective adaptation. Transformational adaptation, which occurs at a large scale or is new to a particular situation, may be necessary if there is large vulnerability and potentially severe climate change in that place (Kates, Travis, and Wilbanks 2012).

Although planning and implementation of adaptation will rarely be a linear process (instead, cyclic and iterative) a common set of steps or elements tend to be involved. These are outlined in the Coastal EBA Decision Support Tool (DST)⁴, a companion to this Guide, which has been designed to support national environmental units in the selection, design, implementation and evaluation of options specifically for effective EBA in coastal areas (available online here <http://web.unep.org/coastal-eba/coastal-EBA-DST>). It complements UNEP's EBA Decision Support Framework, a tool that addresses EBA planning across all ecosystems and environments. Different countries are likely to have already undertaken different stages of EBA planning, and which steps are most relevant will depend on individual national circumstances.

The Coastal EBA DST provides more details on each of the following steps:

- **Step 1.** Understanding ecosystem-based adaptation to climate change (EBA): This step is about understanding what EBA is and how it relates to other adaptation approaches and to biodiversity conservation and ecosystem-based management, as well as considering the potential benefits and challenges of considering EBA within adaptation.
- **Step 2.** Understanding the planning context: This step is about understanding the planning context in terms of existing and wider national plans and strategies and how it relates to EBA planning.
- **Step 3.** Setting the adaptation context: This step aims to provide a comprehensive understanding of the climate change hazards and vulnerabilities in an area and identify potential adaptation options to respond to them.

Step 3.a Understanding climate change hazards:



Ko Panji fishing village at Phang Nga Bay, a National Park in Thailand

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⁴ The DST has also been developed as part of the 'Building Capacity for Coastal Ecosystem-Based Adaptation in Small Island Developing States (SIDS)' project. Funded by the European Commission, this project is working in two pilot countries, Grenada and the Seychelles, and aims to promote sharing of good practice and experiences with other SIDS (in particular Caribbean and West Indian Ocean SIDS).

BOX 3: THE SEYCHELLES NATIONAL CLIMATE CHANGE STRATEGY 2009

The shared vision of the Seychelles National Climate Change Strategy is “to minimise the impacts of climate change through concerted and proactive action at all levels of society”. This vision is underpinned by a set of key principles, which seek to establish the framework for effective implementation of the action plan. The Strategy contains eight key principles, ranging from early action being more cost effective and creating long-term resilience capacity, to the importance of capacity building and empowerment at different levels of society. One of the key principles of the Strategy is “Ecosystem-based adaptation needs to be further developed to decrease vulnerability to climate change”. The Strategy notes that the rationale behind this principle is that “the use of ecosystems to respond to adaptation, combined with engineering technology, presents the optimum opportunity to adjust to natural variability and change” and “ecosystem conservation and management provides additional services which can significantly reduce impacts of climate change”. Hence the strategy provides a framework and broad objectives under which EBA activities within the country will be undertaken.

The Strategy also provides a framework and priorities for more specific EBA activities, as well as highlighting the links between EBA and different sectors. Reference to threats to coral reefs, and the link between healthy coral reef ecosystems and livelihoods (including the tourism industry) is made in several places in the Strategy. Coral reefs are included as part of a suite of actions fulfilling the Strategy, including an action to “implement [a] fisheries-independent monitoring system for coral reef fisheries resources that incorporates resilience indicators” under “Strategy 1.3 Establishment of sustainable long-term monitoring programmes in strategic areas, with focus on climate scenarios, risk assessments and adaptation” and an action to “enhance the management of coral refugia and resilient areas” under “Strategy 2.3. Implementation of adaptation activities”.

Understanding the different components of climate change including frequency, intensity, variability and uncertainty and how these relate to ecosystems.

Step 3.b Understanding vulnerability: Understanding the vulnerability of people to climate change in terms of sensitivity and adaptive capacity and how these can vary between sectors and populations, relate to ecosystems and can be assessed. It is important that the socioeconomic and cultural context of the target area is fully considered in any EBA approach.

Step 3.c Identifying adaptation options: Identifying potential adaptation options in relation to existing policies, adaptation goals and barriers.

- **Step 4.** Selecting adaptation options: This step is about selecting the most appropriate adaptation options, grounded on an understanding of their potential benefits and limitations, the evidence base, using appraisal criteria and cost-benefit analysis.
- **Step 5.** Developing an implementation strategy: This step outlines how to develop an EBA implementation strategy within the wider adaptation and national context, developing a theory of change and a monitoring system.

- **Step 6.** Monitoring and adaptive management: This step provides guidance on developing a monitoring system for EBA activities and outlines the importance of adaptive management of EBA activities.

- **Step 7.** Capacity building and mainstreaming: This step outlines aspects of capacity building for relevant stakeholders and sectors (including how to share and communicate information to different audiences and conduct capacity building workshops) and principles of effective adaptation mainstreaming.

Integration into plans and policies

Wherever possible adaption measures should be integrated into other processes and sectors; the importance of this ‘mainstreaming’ is further described in Chapter 5 ‘Getting results’. Two key approaches are particularly important in underpinning coastal EBA planning processes: (i) integration with national policy objectives in relevant sectors and international commitments (e.g. under MEAs); and (ii) linking to and/or building on wider national climate change and disaster risk reduction strategies and processes.

The latter (such as national adaptation plans and/ or national adaptation programmes of action) provide a framework for EBA planning, and may have already outlined how different sectors or places are likely to be impacted by climate change and include recommendations for adaptation approaches. An example of a national climate change strategy is given in Box 3, whilst the essential functions of a national adaptation plan (NAP) process are outlined in Box 4. Further guidance on the importance of policy measures is given in Chapter 3.

Stakeholder involvement

A large range of sectors and actors will be affected by climate change, including through its impacts on ecosystems and ecosystems services, and may undertake activities that have relevance to adaptation options and their effectiveness. Therefore, EBA requires a multisector and multidisciplinary approach to adaptation planning, and identifying and including the stakeholders involved in ecosystem use and management is especially important. This can affect the scope and scale of the adaptation strategy, as well as help determine which adaptation options will be most appropriate. A wide range of actors can also be involved in adaptation implementation. In the case of EBA, these can include actors related to biodiversity conservation, fisheries, water resources, transport, extractive industries, rural development and tourism (UNEP 2015). Implementing adaptation policy can become a bottleneck where resources are limited. Therefore, the private sector (such as fisheries) should be

considered as part of an EBA strategy and incentivised to be involved in adaptation measures.

Ultimately, the coordination of EBA activities, from planning through to implementation and monitoring, across different levels of government, and with different sectors and actors, will be needed to achieve the objectives of adaptation. Step 2 of the Coastal EBA DST, on the coordination of the adaptation planning process, provides further detail on how such coordination can be promoted.

Useful resources

Ecosystem-based adaptation guidance: Moving from principles to practice ('EBA Decision Support Framework')

http://www.unep.org/climatechange/adaptation/Portals/133/documents/Ecosystem-Based%20Adaptation/Decision%20Support%20Framework/EBA%20Guidance_WORKING%20DOCUMENT%2030032012.pdf

Travers et al. 2012.

The Coastal EBA DST complements a related, non coastal specific, tool for EBA developed by UNEP in 2012, the "EBA Decision Support Framework (DSF)". The EBA-DSF was developed to provide assistance to adaptation practitioners in the selection, design and implementation of adaptation activities that consider EBA in light of all available adaptation technologies. For more information on the EBA-DSF, please refer to Travers et al. 2012 in the Useful resources section above.



Volunteers join together and plant young trees in deep mud for a mangrove reforestation project in 2014 in Samutsakorn, Thailand
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BOX 4: THE NATIONAL ADAPTATION PLAN (NAP) PROCESS

The 17th session of the Conference of the Parties to the UNFCCC held in 2011 established the National Adaptation Plans (NAP) process to facilitate effective adaptation planning in LDCs and other developing countries, assess vulnerabilities and mainstream efforts to reduce climate change risks and address adaptation. The 10 essential functions of the NAP process are:

- Helping governments to provide national leadership and coordination of adaptation efforts at all levels and to act as the main interface with regional and international mechanisms.
- The collection, compilation, processing and dissemination of data, information and knowledge on climate change and relevant development aspects in support of adaptation planning and implementation.
- Identifying and addressing gaps and needs related to capacity for the successful design and implementation of adaptation.
- Assessing climate development linkages and needs and supporting the integration of climate change adaptation into national and subnational development and sectoral planning (through policies, projects and programmes).
- Analysing climate data and assessing vulnerabilities to climate change and identifying adaptation options at the sector, subnational, national and other appropriate levels.
- Appraising adaptation options to support decision-making on adaptation investment plans and development planning.
- Promoting and facilitating the prioritisation of climate change adaptation in national planning.
- Facilitating the implementation of adaptation at all levels through appropriate policies, projects and programmes, taking into account opportunities for synergy.
- Facilitating the monitoring, review and updating of adaptation plans over time, to ensure progress and the effectiveness of adaptation efforts and to demonstrate how gaps are being addressed.
- Coordinating reporting and outreach to stakeholders nationally and internationally on progress to the Convention.

These Steps were developed by United Nations Framework Convention on Climate Change (UNFCCC) Least Developed Countries (LDCs) Expert Group's *National Adaptation Plans: Technical guidelines for the national adaptation plan process*⁵ (or NAPTG) which based it on a series of recommended steps or 'functions' to be considered by LDCs when developing NAPs.

Source: Adapted from Munroe and others (in press). How can ecosystem-based adaptation to climate change be integrated into national adaptation planning? UNEP, Nairobi, Kenya.

⁵ The NAPTG was developed by the United Nations Framework Convention on Climate Change (UNFCCC) Least Developed Countries (LDCs) Expert Group in 2012 to support the NAP process. The guidance is available at https://unfccc.int/files/adaptation/cancun_adaptation_framework/application/pdf/naptchguidelines_eng_high_res.pdf

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Importance of policy measures

03

lack of labour opportunities for girls education due to
day care centre for children
intrusion in farms/garden
intrusion in farms
drinking water
community

Introduction to EBA policy measures

An important option to deliver EBA is through the development and implementation of EBA policy measures, including laws, regulations, and enabling instruments and institutions. EBA policy measures are designed to ensure that EBA is included in relevant decision-making and policy-making processes. As such, policy measures can provide the drive, direction and resources for the delivery of EBA. More broadly, policy measures can provide an enabling context for the delivery of on-the-ground EBA. Supporting EBA through policy measures also promotes the longterm political and resource commitment to EBA.

EBA policy measures can be incorporated into existing policies or can provide a catalyst for the development of new policies that support EBA objectives. It is therefore important that any EBA approach first evaluates the prevailing policy context in order to seek opportunities to incorporate EBA policies or to generate new policies that support EBA. As EBA involves multiple sectors and activities, the relevant EBA policy context is not restricted to climate change and biodiversity, but includes all policy measures that affect the management and planning of coastal areas.

Policy measures include the following elements:

- Laws provide a legal foundation for obligations, powers and entitlements. Law is an essential ‘policy vehicle’ for the implementation of any policy measure in any sector by conferring rights and imposing obligations, providing the architecture for regulating behaviour and activities, establishing the framework for public participation in decision making and arbitrating and resolving disputes (McDonald 2011).

- Regulations can serve to further specify how a law will be interpreted and/or enforced. Regulatory measures can include instruments such as prohibitions, licensing schemes and planning tools, which are often introduced across different sectors and activities, such as marine spatial planning, biodiversity conservation, emergency management or natural-resource management (McDonald 2011).
- Enabling instruments and institutions provide the mechanism to implement policies. Instruments can include taxes, financial or administrative incentives. Institutions oversee and support the implementation of policy measures and include government agencies and regulatory bodies. Measures to support institutions can include contributing to financial and human resources, as well as to building the necessary technical capacity.

Policy measures and EBA

Coastal EBA is an approach to the management of coastal areas that seeks to build the resilience of coastal



Discussing existing environmental issues in Niimi National Park in The Gambia
©Sylvia Wicander



African Penguin (*Spheniscus demersus*) tourist attraction at Boulders Beach, South Africa. The African Penguin (the only penguin species breeding in Africa) is one of the species to which the Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA) applies. The African Penguin is also listed in the Red Data Book as an endangered species. These are important to take into consideration in policy-making

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communities, and the ecosystems upon which they rely, to changes in coastal ecosystems generated by climate change. EBA can also increase community and ecosystem adaptive capacity and reduce climate change vulnerability. There are already numerous policies applied to coastal areas, many of which are framed around ecosystem-based management, in which the coastal socio-ecological system is managed as a single holistic system. As EBA has considerable synergies with ecosystem-based management, it is important that any EBA approach seeks to build on existing policy approaches. Conversely, any attempt at EBA that does not take account of the prevailing policy context is likely to be flawed or risk outright failure. EBA policy measures can be delivered in two main ways: 1) through existing policy measures in any sector; and 2) as the catalyst for new EBA policy measures.

EBA and existing policy measures

As EBA requires a holistic approach, policy measures related to any sector have the potential to affect the delivery of EBA, either positively or negatively. Integrated coastal zone management (ICZM) and marine spatial planning (MSP) are common policy and governance frameworks used in coastal areas that adopt ecosystem-based multisectoral approaches to the sustainable planning and management of coastal areas (EC 2002; EC 2014). As such, ICZM and MSP are particularly well-suited

to support the delivery of EBA and potentially remove the need for the design and implementation of a new policy, governance and institutional framework solely for EBA. The integration of EBA policies into suitable existing policy frameworks is a potentially efficient and effective mechanism to support EBA. In addition, by linking EBA to existing legal, institutional and policy frameworks, ready-made regulatory systems and existing resources can be applied to the delivery of EBA. EBA-relevant existing policy measures include:

- Development policies (e.g. national development strategy, sustainable development strategy, green economy/growth strategy).
- Infrastructure policies (e.g. national water, sanitation and waste management; energy or transport policies).
- Environmental policies (e.g. national biodiversity strategies and action plans, protected areas systems plans, endangered species legislation).
- Area based planning framework tools (e.g. ICZM plans, MSP plans and marine protected area regulations).
- Other specific sectoral policies (e.g. tourism, fisheries, forestry, agriculture, aquaculture, energy, health, transport).

EBA as a catalyst for new policy measures

Where an existing policy framework does not exist or the existing policy framework is unsuitable, EBA can be used as a catalyst for the development of new policy measures. New policy measures can be developed as 'EBA-specific' in which EBA is the sole focus of the new policy measures. An advantage of this approach is that new policy measures can be tailored to EBA in their framing, enforcement and institutional arrangements to maximize their effectiveness. Whilst such an approach is likely to offer some success, it may not fully recognise the multisector holistic approach needed to deliver EBA. The alternative is the development of broader ICZM or MSP approaches into which EBA can be integrated.

Although the generation of new policy measures might initially appear daunting and resource intensive, efficiencies can be achieved by adopting elements of an existing policy and governance framework that support the objectives of the new EBA policy measures. For example, it might be beneficial to work with existing agencies or institutions with jurisdiction over relevant policy measures. However, such institutions must have sufficient financial and human resources, as well as the necessary technical capacity and credibility, to effectively respond to the evolving challenges of EBA.

Policy alignment

When designing EBA policy measures, it is important that policies targeting different spatial and temporal scales are aligned. This ensures that EBA policy measures are all 'pulling in the same direction' and do not work against

each other. For example, when developing on-the-ground or site-level policy measures, it is important that they are in line with national and subnational policies to ensure the effective use of resources and a greater likelihood of successful outcomes. When considering the policy landscape, it is therefore important to understand policy measures at several levels as well as their vertical interplay (Urwin and Jordan 2008). Policy alignment is not restricted to EBA, biodiversity, or climate change sectors, but should be viewed holistically and include all policy areas with a potential influence on the outcome of EBA policy measures. An approach to achieving improved policy alignment is 'EBA policy proofing', in which new and existing policies in all sectors are evaluated to identify potential misalignment with EBA objectives. Where misalignment is identified and considered to be detrimental to the delivery of EBA policy measures, the non-aligned policy is modified to remove the negative impact, which effectively 'proofs' EBA policy against the negative impacts of misalignment.

Key issues that can affect success

Effective policy measures will support effective coastal EBA outcomes. EBA policy measures should aim to:

- **Where possible, link EBA policy measures to the wider policy context, including ICZM, MSP, and adaptation strategies.** This can help ensure that activities are implemented in a coordinated and complementary way and are supported over the long-term.



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- **Enhance awareness, capacity and engagement with EBA across relevant stakeholder sectors.** This can help ensure that the EBA activities are widely supported, and replicated (where appropriate). A key stakeholder in adaptation efforts is the affected community, which should be empowered to facilitate adaptation processes that take traditional knowledge into account (Vignola et al. 2009).
- **Define the EBA role and responsibilities of all relevant institutions.** Policy measures which define the nature of the roles and responsibilities among these institutions will help coordinate efforts, build a common understanding of each institution's remit and scope, and establish clear institutional mandates.
- **Take account of existing governance mechanisms and promote good governance in the delivery of EBA policy measures.** Policy measures which support good governance across all levels, scales and sectors will increase the likelihood of coastal EBA implementation success.
- **Encourage sustainable and innovative long-term financing options.** Access to adequate resources in the long term is vital for the success of any EBA policy measure. For example, payments for ecosystem services (PES) can be used as a complementary finance source to international adaptation funding (Vignola et al.2009).
- **Ensure long-term capacity for implementation and enforcement.** Policy measures which develop and retain human and technical capacity for coastal EBA implementation and enforcement will contribute to the long-term viability of the coastal EBA measure.

Useful resources

Adaptation and Governance – African and Latin American Resilience to Climate Change (ARCC)

http://community.eldis.org/.5b9bfce3/Adaptation%20and%20Governance_CLEARED.pdf

Schaar and Caffrey, 2014. USAID.

A study of the challenges that developing countries face in making decisions on adaptation to climate change and how power needs to be shared and used in this context. It highlights the importance of institutional design, governance and linking stakeholders to overcome future challenges associated with climate change in developing countries. Sections are summarised in useful boxes that help to highlight main points presented.

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Overview of Coastal EBA options

04

Introduction to EBA options

Many options exist for adapting to climate change in the coastal environment. These include options which use infrastructure to help people adapt to the adverse effects of climate change ('hard adaptation'⁶), options which use biodiversity and ecosystem services as part of an overall adaptation strategy (ecosystem-based adaptation; EBA), and hybrid options which seek to capitalise on the characteristics of both hard and EBA approaches. EBA options, like other adaptation options, range from policy and governance-focused approaches (e.g. ensuring that the impact of climate change, including on ecosystems, is considered within wider marine spatial planning) to on-the-ground actions (e.g. restoring mangroves).

A range of different approaches can be needed to increase the resilience of coastal communities and the ecosystems they rely on, as well as to increase their adaptive capacity, and so reduce climate change vulnerabilities in the whole socio-ecological system. As discussed in Chapter 3, approaches such as the development of policies, laws and regulations are often essential, both on their own and as support to on-the-ground approaches. Additionally, EBA options need to be implemented within the context of, and can draw on, wider policy options such as integrated coastal zone management (ICZM), ecosystem-based and community-based management (EBM and CBM), marine spatial planning (MSP). Therefore, the integration of both ecosystems and climate change within such policies and development of related regulatory measures can be considered EBA options.

EBA options can also include more specific ecosystem-, area- and sector-related approaches, which are the focus of this chapter. Common EBA approaches used in coastal areas include the conservation and restoration of particular ecosystems such as coral reefs, mangroves, seagrasses, and dune and beach systems to maintain the resilience of communities who rely on their goods and services. EBA options focusing on specific sectors and areas include managing the incursion of rising sea levels into coastal lands ('managed realignment' or 'coastal retreat'), marine protected areas (MPAs), fisheries management and increasing the range of available livelihood options.

Together, these various approaches address a wide range of climate change-related risks, from increases in sea surface temperature, sea level rise, and ocean acidification, to more intense storms and hurricanes. For more details on how ten different coastal EBA options address a range of climate change risks, see Table 3 below. The sections that follow expand upon these listed options. They cover a breadth of different types, including an example of a hybrid approach (living breakwaters), existing areabased management framework (marine protected areas) and sector approach (fisheries management planning).

For each option, the EBA role or function is described in relation to the climate change hazards the option addresses. Additional benefits provided by the option are then noted (e.g. biodiversity and tourism benefits), before key issues

that can affect success are considered. More detail is given for mangroves and coral reefs because of their particular relevance in small island developing states. A key resources section at the end points the reader to tools and knowledge products for further reading. Case studies highlighting examples of coastal EBA applied in practice are presented for selected options.

In considering these options, it is important to remember that their effectiveness will depend on many variables. Monitoring an EBA project and evaluating its effectiveness is the subject of Chapter 5. EBA needs to be undertaken as an ongoing, longterm process and monitoring must be done to allow management to be adapted to the changing situations. Equally, EBA approaches cannot provide effective protection against all climate related hazards in coastal areas, and for this reason care needs to be taken to manage expectations of stakeholders and avoid creating a false sense of security. The long-term success of any adaptation effort will ultimately depend on the involvement, acceptance and ownership of the measure by local actors, including local government agencies and local communities. This last point is critical and engagement with relevant stakeholders is key to ongoing success. For each coastal EBA option, every effort should be made to ensure that the community is an integral part of both planning and implementation processes (see Case Study 1 on page 96 for a practical example of this).

As discussed in Chapter 2, which options are chosen for implementation will depend on a variety of factors. These include existing and anticipated climate change impacts, site and ecosystem characteristics of the location, resilience priorities for the target community/ies, resources available, the costs and benefits of different options, the planning and policy context, and available capacity to design, implement and manage a specific EBA option into the future. The online Coastal EBA Decision Support Tool (available online here <http://web.unep.org/coastal-eba/coastal-EBA-DST>) that accompanies this Guide takes decision makers through the steps in choosing and planning coastal EBA approaches. It should also be noted that adaptation options are not necessarily implemented in isolation; in combination they are more effective at increasing the social resilience and adaptive capacity of a community (for practical examples, please see Case Studies 2 and 3 on pages 97 and 98 below).

⁶ This manual uses the term hard adaptation; meaning the built infrastructure options for adaptation. Similar terms are grey adaptation or grey infrastructure.

In some cases, other forms of adaptation, including hard and hybrid approaches, will need to be integrated. Spatial information can be a very effective means of helping to plan and select the most appropriate adaptation options

for a target area although it is not a pre-requisite to action. However, in many cases spatially explicit data may be lacking and may need to be collected to enable such processes.

Table 3: Overview of how different EBA options can help address a range of climate change risks and impacts on coastal areas. See individual chapters for more details on each option

Coastal EBA option	Relevance to climate change impacts on coastal ecosystems			
	Sea surface temperature rise	Sea level rise	Ocean acidification	Increased intensity of storms and hurricanes
Coral reef restoration and conservation	Reducing non-climate pressures (e.g. pollution) and encouraging temperature tolerant species may reduce incidence of coral bleaching and increase the resilience of services provided by reefs (e.g. habitat for fish, tourism) to temperature increases.	Reefs can attenuate (reduce the height and power of) waves. Reducing the height of waves reaching the shore can decrease wave inundation (to a certain extent). When corals grow as sea level rises this attenuation service can be maintained.	Reducing non-climate pressures (e.g. high nutrient pollution and overfishing of herbivorous fish) increases the resilience of reefs to climate change impacts. Services provided by reefs are more likely to be maintained if other threats are effectively managed.	Wave attenuation by reefs can reduce the power of storm waves reaching the shore and thereby reduce coastal flooding and erosion.
Living breakwaters	If implemented in ways that help restore ecosystems (e.g. reefs) and the services they provide, rather than primarily for physical protection, living breakwaters may make these services more resilient to temperature rises.	The maintenance of the wave attenuation service of reefs is encouraged where living breakwaters enable establishment of corals such that they can grow as sea level rises.	As for sea surface temperature rise, if living breakwaters are implemented in ways that help restore ecosystems and the services they provide, they may make these services more resilient to acidification.	Living breakwaters can attenuate storm waves, reducing the wave energy reaching the shore. In particular, larger waves may break on the structure, thereby reducing the impact on the coast.
Mangrove restoration and conservation	Reducing non-climate pressures (e.g. pollution) and encouraging temperature tolerant tree species may increase the resilience of services provided by mangroves (e.g. habitat for fish) to temperature increases.	Mangroves can attenuate waves and so reduce wave inundation (to a certain extent). They also capture sediment and so help counteract coastal erosion. Where mangroves accrete (vertically build up soil) as sea level rises these coastal protection services can be maintained (up to certain thresholds).	Reducing non-climate pressures increase the resilience of services provided by mangroves to acidification. Mangroves have also been found to act as a refuge for corals from ocean acidification. Therefore, protecting a mosaic of habitats (e.g. mangroves near coral reefs) could provide resilience benefits.	Mangrove forests attenuate waves and slow storm surge water flows if mangroves areas are wide enough.
Seagrass restoration and conservation	Reducing non-climate pressures (e.g. pollution) and encouraging temperature tolerant tree species may increase the resilience of services provided by mangroves (e.g. habitat for fish) to temperature increases.	Seagrasses can reduce current velocity, dissipate wave energy and stabilize the sediment, most reliably in shallow waters. Reducing the height of waves reaching the shore can decrease wave inundation (to a certain extent). Stabilizing sediment can help seagrasses accrete with sea level rise under certain sedimentation and accretion rates.	Seagrass meadows have been shown in some locations to have a buffering effect on pH, modifying it through photosynthetic activity. As a result, healthy seagrass beds may provide a refuge for calcifying organisms. In addition, seagrass biomass is increased by ocean acidification leading to increased carbon sequestration.	Seagrass can reduce current velocity, dissipate wave energy and stabilize the sediment most reliably in shallow waters and low wave energy environments.
Dune and beach restoration and conservation (dune stabilization)		Reducing non-climate pressures (e.g. clearing and trampling) and encouraging dune plant development increases the resilience of services provided by dunes and beaches. Dunes can act as a physical buffer to waves and so provide some barrier to wave inundation as sea levels rise.		Dunes can act as a buffer to waves and storm surges. Their porous structure absorbs and dissipates wave energy, protecting inland structures from flooding and damage. Dunes also provide additional material which re-enters the marine system and forms a new beach profile after erosion events.

Table 3: Overview of how different EBA options can help address a range of climate change risks and impacts on coastal areas. See individual chapters for more details on each option

Coastal EBA option	Relevance to climate change impacts on coastal ecosystems			
	Sea surface temperature rise	Sea level rise	Ocean acidification	Increased intensity of storms and hurricanes
Coastal wetland conservation and restoration	Reducing non-climate pressures (e.g. pollution) and encouraging temperature tolerant species may increase the resilience of services provided by wetlands (e.g. habitat for fish) to temperature increases.	Depending on the type, wetlands can help attenuate waves and so reduce wave inundation. They may also act as a water store during times of high water, reducing flooding of coastal areas. Wetlands, including salt marshes, can trap sediment and so may vertically build up soil as sea level rises. Coastal wetlands can also help manage the hydrology of the area providing a freshwater source necessary to maintain other habitats such as salt marsh and mangroves that then provide some protection against sea level rise.		
Managed realignment/ coastal setbacks		Redefining the location of the coastline and maintaining buffer ecosystems (such as saltmarshes) can help to reduce the impact of sea level rise on communities.		Redefining the location of the coastline and maintaining buffer ecosystems can help protect communities against storm surges.
Livelihoods diversification and protection of ecosystem based livelihoods	Supporting communities to protect and diversify their livelihoods can help reduce their reliance on livelihoods which may be at risk from sea surface temperature rises (e.g. fishing of a particular species).	Supporting communities to protect and diversify their livelihoods can help reduce their reliance on livelihoods which may be at risk from sea level rise.	Supporting communities to protect and diversify their livelihoods can help reduce their reliance on livelihoods which may be at risk from acidification (e.g. harvesting of a particular crustacean or mussels may become unsustainable in the face of acidification).	Supporting communities to protect and diversify their livelihoods can help reduce their reliance on livelihoods which may be at risk from storms and support them in recovering after storm events.
Marine protected areas (MPAs) and other area-based management measures	MPA management, through helping to reduce non-climate pressures, can help to increase the resilience of ecosystems (and the services they provide) to temperature rise.	Where MPAs protect ecosystems that help to attenuate waves and can accrete, they can help reduce wave inundations as sea levels rise.	MPA management, through helping to reduce non-climate pressures, can help to increase the resilience to acidification of ecosystems and the services they provide.	Where MPAs protect ecosystems that help to attenuate storm waves, they can help reduce associated coastal flooding and erosion.
Sustainable fisheries management plans or Ecosystem approach to fisheries (EAF)	Where such plans take into account the impact of temperatures on shifting species distributions and abundances, they can help to manage the impacts.		Where such plans take into account the impact of acidification on shifting abundances and reproduction/growth patterns, they can help to manage the impacts.	

Coastal wetland conservation and restoration

4.1



Introduction to coastal wetlands

The term 'wetlands' refers to a diverse range of habitats. The Ramsar Convention defines them as 'areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres' (Article 1.1). Therefore, coastal wetlands include saltwater marshes, estuaries, mangroves, lagoons and coral reefs. The conservation and restoration of coral reefs and mangroves are presented in sections 4.2 and 4.4 respectively. This section focuses on more general issues around EBA in coastal wetlands which are further elaborated in the subsequent sections.

Common onsite approaches to wetland conservation and restoration

Across all wetland areas, establishing protected areas to safeguard wetland ecosystems should be one of the primary considerations because it results in more effective ecosystem function (Moreno-Mateos et al. 2012). Where restoration is the only option, it needs to consider the hydrology of the local environment. Coastal wetlands such as mangroves rely on a balance of salt and freshwater. Therefore inland restoration of freshwater sources, including through approaches such as integrated water resource management (IWRM) and ridge-to-reef, can be key to the success of coastal management and restoration. Another example of an onsite approach is the creation of plant nurseries to provide material for habitat restoration. There are many others and they will vary depending on the habitat type (Meli et al. 2014). More details on the broader range of issues that can affect success are presented below and within the individual options that follow.

Coastal wetland conservation and restoration as an EBA measure

Wetlands have been widely recognised as providing a range of valuable ecosystem services (Millennium Ecosystem Assessment 2005; Keddy et al. 2009). Of particular importance for adaptation is their role in reducing incoming wave and tidal energy by enhancing energy dissipation through increasing the roughness of the surface over which incoming waves and tides travel (Nicholls and Wong 2007). This reduces the erosive power of waves and helps to reduce coastal flood risk by diminishing the height of storm surges. Additionally, in contrast to hard defences, wetlands are capable of keeping pace with sea level rise through increased accumulation of sediments raising the elevation of the wetland (Nicholls and Klein 2005). Therefore, provided that the rate of sea level rise does not outpace accretion rates, sediment supply is sufficient and that wetlands are not hemmed in by inland developments, they are capable of maintaining their wave attenuation functions as sea level rises without further investments.



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Wetland restoration is relevant to another important climate change impact on coastal areas. Sea level rise leads to salt water intrusion and a likely rise in the freshwater-saltwater interface in ground water sources in coastal areas. Groundwater is the main source of fresh water for domestic, industrial and agricultural purposes for coastal communities especially in SIDS. Restoring inland wetlands can promote the flow of more fresh water from inland aquifers to recharge coastal aquifers and re-balance the freshwater-saltwater interface. Such measures need to be accompanied by effective ground water monitoring: developing a network of monitoring wells around high risk areas to ensure decision makers have timely data on the progression of intrusion so they can provide communities with cost-effective, timely alternatives.

Additional benefits

Coastal wetlands also provide a variety of other ecosystem services, including breeding and nursery grounds for a variety of birds, fish, shellfish and mammals, as well as water filtration functions and ecotourism opportunities. The conservation and restoration of wetlands can support the resilience of these ecosystem services and the livelihoods they provide.

The increasing loss and degradation of the world's wetlands (van Asselen et al. 2013; Davidson 2014) has undermined the capacity of these habitats to provide their valuable ecosystem services and has raised global concerns, given that these services may become more

important with ongoing climate change (IPCC 2013). A wide range of activities have been undertaken to conserve and restore wetlands; although most have not previously focused on climate change adaptation, its emphasis is now increasing. Key issues that can affect success Restoration techniques and their degree of success are highly dependent on wetland type and local specific characteristics (Meli et al. 2014). However, all types of wetland conservation and restoration require areas of land that are set aside for the relevant ecosystem and this can conflict with planning and implementation of various types of coastal development (Linham and Nicholls 2010).

Coastal habitats are inter-connected and therefore it can be important to consider how different coastal wetlands interact with one another and with surrounding marine and terrestrial habitats. For example, seagrasses can help trap sediment and thus maintain clear water that coral reefs need and reduce the chances of sediment smothering coral reefs. Wetlands are also inter-connected with different human activities and sectors (e.g. fisheries and coastal development). Mapping the locations of different habitats and human activities can help in understanding these relationships.

Another key element is the social aspect of conservation and restoration. Participatory principles are crucial for the implementation of successful management. It is also essential that any on-the-ground coastal wetland conservation and restoration activities are integrated

with, and supported by, policy measures (such as relevant laws and regulations, e.g. zoning for development, environmental impact and offset regulations; see Chapter 3 for more details on the importance of policy measures in adaptation). Developing coastal wetland adaptation activities as part of integrated coastal zone management (UNEP/ MAP/PAP 2001; Clark, 1992) and/or marine spatial planning (UNEP and GEF-STAP 2014) that considers all of the components of the coastal zone can help to ensure that activities in different coastal wetlands are complementary.

Useful resources

All Wetlands

<http://www.wetlands.org/>

The Wetland Restoration Specialist Group. Wetlands International.

Through publications, expert databases and case studies, it promotes the successful restoration and conservation of wetlands worldwide by developing networks and by encouraging information exchange and cooperation.

Wetland Habitats: A Practical Guide to Restoration and Management

<http://www.publish.csiro.au/pid/6349.htm>

CSIRO Publishing, Australia.

A practical and easy to use manual for wetland restoration and conservation of diverse animal species.

An Introduction and User's Guide to Wetland Restoration, Creation, and Enhancement

http://water.epa.gov/type/wetlands/upload/2006_11_29_wetlands_restdocfinal.pdf

US Environmental Protection Agency.

Written for the public containing 1) background on wetlands and restoration, 2) information on project planning, implementation, and monitoring, and 3) lists of resources, contacts, and funding sources.

Restoring a Wetland

<http://www.waikatoregion.govt.nz/Environment/Natural-resources/Water/Freshwater-wetlands/Restoring-a-wetland/>

Waikato Regional Council, New Zealand.

Presents a simple flowchart to find out more about each step in the restoration process and allows the users to create their own Wetland Plan.

Saltmarsh Management Manual

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/290974/scho0307bmkh-e-e.pdf

UK Department of the Environment, Food and Rural Affairs.

Describes what it is that needs to be managed and aims to help develop an understanding of how to evaluate the need for management intervention and the form that intervention might take.

Community Estuarine Monitoring Manual

www.epa.sa.gov.au/files/8539_cemm_a.pdf

South Australia Environment Protection Agency.

Presents an estuarine monitoring framework that is suitable for use by a wide range of community groups, including a range of activities that these groups may wish to explore.

Guidelines for Tidal Wetland Restoration in the San Francisco Bay

<http://www.wrmp.org/design/>

Philip Williams & Assoc., Ltd. The Bay Institute, and the California State Coastal Conservancy.

Was produced for all individuals who have some degree of responsibility for decisions made on tidal wetland restoration design, including regulatory agency staff, land managers, resource managers and restoration practitioners.

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Coral reef conservation and restoration

4.2

Introduction to coral reef ecosystems

Coral reefs are marine ecosystems located in shallow coastal zones of tropical and subtropical regions. The ecosystem is shaped by the calcium carbonate structures secreted by the coral polyps (Kleypas, 2012). Coral reefs occupy a small percentage of the world's oceans, but they contain a disproportionately high share of its biodiversity (Pandolfi et al. 2011).



Coral reefs are the most diverse and beautiful of all marine habitats. Large wave resistant structures have accumulated from the slow growth of corals. The development of these structures is aided by algae that are symbiotic with reef-building corals. Coralline algae, sponges, and other organisms, combined with a number of cementation processes also contribute to reef growth.

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Common onsite approaches to coral reef conservation and restoration

Common approaches for coral reef conservation include establishing protected areas or no-take zones that exclude anthropogenic disturbance of reef ecosystems. Conserving existing areas of coral reef often results in improved ecosystem service provision (Rey Benayas et al. 2009). For coral reef restoration, rearing, transplanting and monitoring of coral reef fragments are possible approaches. The re-establishment of corals is very challenging. It may be possible to rear coral larvae on a large enough scale for coral reef restoration but experts, such as specially trained coral biologists, and possibly large facilities will be required (Edwards 2010).

Coral reef conservation and restoration as an EBA measure

The importance of coral reefs for a wide range of ecosystem services has been widely recognised, leading to conservation and restoration projects to maintain these services. Despite the potential adaptation benefits

available from coral reefs, only a small number of restoration projects have been undertaken that focus on adaptation (Beck 2014). Nevertheless, coral reef conservation and restoration represent promising options for coastal adaptation.

Coral reefs provide coastal protection

Coral reefs can make an important contribution to the protection of shorelines from the destructive action of waves (Ferrario et al. 2014; Vaselli, Bulleri, and Edetti-Cecchi 2008), providing comparable wave attenuation benefits to artificial defences such as breakwaters (Ferrario et al. 2014). Storm protection may become more important in a changing climate as sea levels rise and storm patterns change. However, the effectiveness of coral reefs as a form of coastal protection depends on many variables, such as reef crest profile, width and depth of the reef flat and surface roughness (Sheppard et al. 2005). The value of coastal protection provided by existing coral reef ecosystems can be large; for example, in the Virgin Islands, it has been estimated as US\$ 1.2 million per year (Van Zanten et al. 2014). Coastal

protection of Bermuda's coral reefs were estimated to be US\$265.9 Million per year (Sarkis, Beukering, and McKenzie 2010). In general, coastal protection values for coral reefs are difficult to calculate because of the uncertainty in the data.

Many coral reefs also support herbivorous grazers such as parrotfish, which produce sand that helps to replenish beaches and thus maintain beach profiles (Moberg and Folke 1999). Sediment flow to beaches may become more important as sea levels rise and storm patterns in coastal areas exert pressure on dune and beach ecosystems (Burke et al. 2012; Webb and Kench 2010).

Coral reefs may keep pace with sea level rise

Under certain circumstances, coral reefs (along with mangroves and saltmarshes) can raise their surface elevation as sea levels rise, keeping pace with or even exceeding those rises being experienced (Spalding 2014; Montaggioni 2005). This will depend on factors such as water quality and the absence of human stressors, but where accretion is possible the reefs are likely to be able to maintain their wave attenuation function.

Coral reefs serve as habitat and nursery grounds for fish, supporting fisheries and livelihoods

Coral reefs, together with adjacent mangrove and seagrass ecosystems, provide habitat in the form of food and shelter for many fish and marine invertebrate species that coastal human communities depend on for their livelihoods (Pratchett et al. 2009). It is estimated that coral reefs produce 10 to 12% of the fish caught in tropical countries, and 20 to 25% of the fish caught by developing nations (Garcia and Moreno 2003). In the context of a changing climate, the continued provision of food and income from coral reefs could therefore play a significant role in maintaining people's resilience and capacity to adapt.

Coral reefs support diversified livelihoods

Healthy coral reefs support a variety of different types of livelihoods: not just fishing, but also recreation and tourism industries (Moberg and Folke 1999). Conserving and restoring coral reefs can therefore contribute to the maintenance of these livelihoods. Additionally, diverse livelihoods can increase people's resilience to climate change; if climate change makes some livelihoods less reliable (e.g. due to declines in, or decreased predictability of, crop yields) access to a variety of other livelihood options can mean people and communities are less impacted.

Additional benefits

There are benefits for biodiversity

Almost a third of the world's marine fish species are found on coral reefs (Moberg and Folke 1999). Restoring

or conserving coral reefs may therefore have a positive impact on biodiversity.

Coral reefs contain species which are important for medicine

Many species found in coral reef ecosystems produce chemicals that are being used as sources of new medicines, including for cancer, arthritis, asthma, heart disease, ulcers, bacterial infections and other diseases (NOAA 2015) and show potential for use in nutritional supplements, enzymes and cosmetics (Bruckner 2002).

Coral reefs can support tourism and recreation

The recreational value of reefs, as indicated by income from tourism, is potentially enormous (Moberg and Folke 1999). For example, estimated reef recreation value in the Caribbean is approximately US\$ 1,654 per hectare per year (Chong, Ahmed, and Balasubramanian 2003). Maintaining healthy coral reef ecosystems for coastal protection can also protect tourism and recreation sectors.

Coral reef restoration can be cost-effective

Depending on the circumstances, the restoration of coral reefs can be more cost-effective than building artificial structures. For example, an analysis of the economics of climate change adaptation across eight Caribbean nations (Anguilla, Cayman Islands, Antigua and Barbuda, Dominica, Barbados, Jamaica, Bermuda and St. Lucia) found that reef restoration was the most cost-effective approach in the majority of these nations (CCRIF 2010). Another study examined the costs of coral reef restoration versus tropical breakwaters and found that, on average, the costs of restoration projects were significantly cheaper than the costs of building tropical breakwaters (Ferrario et al. 2014). The same study noted that if maintenance costs for breakwaters and other benefits of reefs (such as fisheries and recreation) were also considered the relative cost-effectiveness of coral reefs for coastal defence purposes would be likely to increase.

Key issues that can affect success

Anthropogenic pressures

Almost three quarters of the world's coral reefs are thought to be deteriorating as a consequence of environmental stress (Mumby et al. 2001). Much of this pressure is anthropogenic, being a combination of terrestrial pressures (such as coastal urban development, pollution and nutrient enrichment), resource use pressures (such as mining and overfishing) and management activities (e.g. dredging). Together, they threaten the viability of coral reefs for wave energy attenuation, maintenance of fisheries and recreation (Roberts et al. 2002). It is important, therefore, that coral reef conservation and

restoration focuses on mitigating and reducing these human-induced pressures.

Climate change pressures

Climate change is another challenge faced by coral reef ecosystems. Increasing sea temperatures and ocean acidification, when combined with anthropogenic pressures, are likely to result in losses of ecosystem function and services (Edwards 2010) and coral bleaching, mortality and reduced ability to develop reef structure (IPCC 2014). However, some coral ecosystems are already showing signs of recovery following bleaching events: a study by Graham et al. (2015) found that Indo-Pacific corals which were structurally complex and had a deep water depth were more likely to recover following such events. Coral reef conservation and restoration efforts as part of EBA need to consider the impacts of climate change. Restoration may therefore consider structural complexity and water depth of reefs, as well as reducing anthropogenic stresses.

Site and ecosystem characteristics

Of all reef components, the relatively high and narrow part of the reef, known as the 'reef crest', is the most critical component for wave attenuation benefits, as it is known to dissipate more than 80% of the total wave energy (Ferrario et al. 2014). Therefore, reef conservation should prioritise protection of coral reef areas which include reef crests. In addition to reef crests, reef flats also play a role in wave energy attenuation, dissipating about half of the remaining wave energy. The degree of wave energy reduction by the reef flat is dependent on its depth, particularly at the shallowest points, and bottom roughness (Lowe et al. 2007, Ferrario et al. 2014). Therefore, any reef degradation that increases water depth or reduces bottom roughness may reduce coastal protection benefits by increasing exposure to coastal erosion.

Maximum biophysical thresholds

Given that the effectiveness of coral reef wave attenuation is partly dependant on water depth, the coastal protection power of coral reefs is likely to be reduced during extreme weather events that raise water levels (e.g. storm surges). However, the effectiveness of reef crests in reducing wave height is increased as the waves become stronger, indicating that reefs as a whole can still reduce risk during extreme events (Ferrario et al. 2014), even if part of their attenuation power is lost.

Recovery after disturbance

Healthy reefs are able to recover or self-repair to a certain degree following environmental disturbances such as tropical cyclones or multi-year fluctuations in warm oceanic currents, which are responsible for mass

bleaching and mortality. However, reefs which are under anthropogenic pressure do not generally recover well from such natural disturbance events (Edwards 2010). This further emphasises the need for management practices that reduce levels of anthropogenic disturbance (e.g. high nutrient pollution and overfishing of herbivorous fish) on coral reefs and that work towards ensuring the resilience of these systems to climate change related impacts (Anthony et al. 2011).

Relevant policy context and developments

Creating an appropriate enabling environment, both in terms of the policy context and at the local level through a community-based emphasis, is needed for effective coral reef management. Coral reefs can be impacted by a range of pressures, including from outside sources such as terrestrial pollution, and many valuable reef seafood species also need adjacent ecosystems such as seagrasses and mangroves as a part of their life cycles (Moberg and Folke 1999). Additionally, reef restoration can potentially impact other groups (e.g. through potential reductions in diving activities to protect reef or restrictions to navigation routes and moorings to prevent boats damaging reefs). Therefore, it is especially important that the whole social and policy context is considered. Concepts such as integrated coastal (zone) management (IC(Z)M) and marine protected areas (MPAs) have received significant attention for their usefulness in this respect (Mercer et al. 2012). For more information on the importance of policy measures in adaptation, see Chapter 3.

Ongoing management

Reef conservation and restoration activities depend on ecological processes that are time-demanding. As an indication, natural recovery of reefs after acute disturbances takes 5–10 years in the absence of chronic anthropogenic stressors (Edwards and Gomez. 2007). Restoration projects should not expect to see results any sooner. Ongoing management of reef ecosystems is therefore key if they are to serve as a successful EBA measure. Effective management for resilience includes understanding EBA when planning, designing and implementing any management measure. Monitoring and using its results to adapt ongoing management is important. It will also require collaboration between a number of different types of stakeholders, including policy -makers, scientists, environmental managers and local communities. For more information on effective coral reef management strategies, including management of local stressors, reducing land- based impacts, managing for disturbance, and integrated approaches, see the Reef Resilience Program's Coral Reef Module in the 'Useful resources' section below.

Restoration

Restoration of degraded coral reef ecosystems most commonly involves the rearing of coral fragments in coral nurseries, transplantation of these fragments to degraded reef areas, and subsequent management and monitoring to facilitate restoration. To date, most successful coral nurseries have been those which are located in mid-water, away from the natural reef, and where the fragments are free from predation (e.g. by corallivorous snails) and interference from divers (Edwards 2010). Subsequent transplantation of coral fragments should ensure that the corals being transplanted are of the appropriate species and from a similar environmental setting, so that they are well adapted to survive at the restoration site (Edwards 2010). These and other types of restoration activities need to take place alongside wider management efforts that address coastal land use patterns, water quality issues and fishing activities in order to improve ecosystem conditions. For more information on factors that determine on the ground reef restoration success, including good practice guidance, see Edwards (2010) Reef Rehabilitation Manual in the 'Useful resources' section.

Useful resources

Coral Reef Module, Reef Resilience Toolkit

<http://www.reefresilience.org/coral-reefs/>

[The Nature Conservancy.](#)

An online module providing information, resources, and principles for how to select, design and manage coral reef protected areas for resilience to climate change. Includes module sections on management of local

stressors, reducing land-based impacts, managing for disturbance, integrated approaches, monitoring and assessment, and a resources section providing links to useful resilience-related literature and tools.

Reef Restoration: Concepts & Guidelines: Making sensible management choices in the face of uncertainty.

www.gefcoral.org/portals/25/workgroups/rr_guidelines/rrg_fullguide.pdf

[Edwards & Gomez. 2007. Coral Reef Targeted](#)

Research and Capacity Building for Management Program. A succinct yet comprehensive set of reef restoration planning and implementation guidelines for coastal managers, decision-makers and technical advisers involved in community based reef restoration efforts. The guidelines cover setting goals and success criteria for coral reef restoration projects; factors to consider in the physical and biological restoration of reefs; monitoring and maintenance of reefs; and costs of reef restoration projects. A final section presents lessons learned from five case studies, in locations ranging from the western Indian Ocean to French Polynesia.

Reef Rehabilitation manual

http://www.gefcoral.org/Portals/53/downloads/Reef%20Rehabilitation%20Manual_web.pdf

[Edwards \(ed.\). 2010. The Coral Reef Targeted Research and Capacity Building for Management Program.](#)

A manual complementing Edwards & Gomez (2007) "Reef Restoration: Concepts & Guidelines: Making sensible management choices in the face of uncertainty"



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with greater detail and hands-on advice, and based on lessons learned. Includes detailed technical information on how to construct and manage nurseries to farm coral fragments, rear coral larvae and deploy coral transplants to degraded reef areas.

A Reef Manager's Guide to Coral Bleaching

http://www.gbrmpa.gov.au/__data/assets/pdf_file/0013/4450/Gbrmpa-ReefManagersGuidetoCoralBleaching.pdf

Marshall & Shuttenberg. 2006. Great Barrier Reef Marine Park Authority.

A guide collating the latest scientific knowledge and management experience to help managers respond to mass coral bleaching events, including sciencebased suggestions for adaptive management.

Ocean data viewer

<http://data.unep-wcmc.org/>
UNEP-WCMC.

An online tool providing access to a range of datasets that are useful for informing decisions on conserving marine and coastal biodiversity. Users are able to

view and download a range of data, including data on: the global distribution of coral reefs, seagrasses and mangroves; global seagrass species richness and data from the World Mangrove Atlas.

Manual for Restoration and Remediation of Coral Reefs

<http://sekiseisyouko.com/szn/pdf/report/RSTR2004a.pdf>
Japan Ministry of Environment.

Collects the methods, achievements, and problems of measures including 1) seeding production and settlement induction by utilizing coral sexual reproduction, 2) transplantation of coral fragments by utilizing asexual reproduction, 3) transplantation of colonies or entire reef and 4) management of settled seeding, transplanted colonies and coral communities.



Fishermen clean out their nets in Grenada, Seychelles.

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**Living
breakwaters** **4.3**

Introduction to living breakwaters/artificial reefs

Breakwaters are off-shore, often submerged, structures that form a barrier between the sea and the land. The term living breakwaters is often used when such structures have been deliberately constructed to provide a habitat for species or to aid the restoration of coastal reef ecosystems and support the services that they provide. Artificial structures that aim to mimic some of the characteristics of natural reefs, including their function as breakwaters, are sometimes referred to as artificial reefs.

Common onsite approaches to living breakwaters

Living breakwaters/artificial reefs are always underwater structures, but they are of many different types, ranging from purpose-built concrete structures to objects previously used for other purposes (e.g. old ships and gas platforms). They are also used for a wide range of purposes, from ecosystem restoration to hard infrastructure development. Therefore, approaches to living breakwaters/artificial reefs vary depending on their main purpose.

Living breakwaters/artificial reefs as an EBA measure

The extent to which living breakwaters/artificial reefs are simply hard structural measures compared to an ecosystem-based measure will depend on whether they are constructed primarily as a physical barrier and defence or as part of wider ecosystem management approach (see section 4.2 for information on coral reef restoration). Living breakwaters/artificial reefs are considered an example of a ‘hybrid’ approach, which combines natural and built infrastructure and

can enhance coastal resilience by providing coastal protection as well as other social and environmental co-benefits (Sutton-Grier et al. 2015).

Living breakwaters/artificial reefs provide coastal protection

Living breakwaters can be designed to ensure that larger waves break on the breakwater structure (Harris 2009; Antunes do Carmo et al. 2011) and so can help protect the coast from flooding and erosion (Black 2001; Moschella et al. 2005; Kim and Mun 2008), two hazards that are predicted to increase in severity with a changing climate. The depth of the structure (submergence) and its size and position relative to the shoreline (Antunes do Carmo et al. 2011) as well as external factors such as the currents, wave actions and tidal height (Baine 2001) will determine the level of coastal protection provided.

However, there is little information available on how the coastal protection function of breakwaters may vary depending on whether they are primarily built as hard adaptation measures or are designed as living breakwaters/artificial reefs to support ecosystems.



Bamboo sticks to slow waves as they hit the coast on the Gulf of Thailand
©Baitong / Shutterstock.com



Biorocks of coral reefs in Lombok, Indonesia.
©fenkieandres / Shutterstock.com

Living breakwaters/artificial reefs serve as a habitat and nursery ground for fish, supporting fisheries and livelihoods

The use of artificial structures for enhancing fish catches has been documented since the late eighteenth century (Perkol-Finkel 2006) and it is widely assumed that artificial reefs can locally enhance fish catches (Broughton 2012). However, there is debate within the scientific community about whether artificial reefs really contribute to enhancing commercially valuable fish populations, or just aggregate fishing resources in specific areas. If the latter, this could actually increase the vulnerability of coastal communities: making it easier for fishermen to locate and catch fish can increase the risk of overfishing (Showstack 2001; Powers et al. 2003). The impact of living breakwaters/artificial reefs is likely to depend on how they are constructed and the target species. Where structures mimic some of the characteristics of natural reefs to increase structural complexity, they can provide microhabitats that can potentially be colonised by many species (Firth et al. 2014). Depending on how and where they are deployed, the use of living breakwaters/artificial reefs as an EBA measure may therefore assist in supporting continued provision of food and income from fish in the face of climate change.

Additional benefits Living breakwaters/artificial reefs and biodiversity

The impact of living breakwaters/artificial reefs on biodiversity will vary depending on how and where they are constructed. Relatively stable benthic communities

can establish on submerged artificial structures in five years or less (Clark and Edwards, 1994; Jensen et al. 2000) and as artificial reefs age, coral abundance, species diversity, and colony size increase (Perkol-Finkel 2006). However, they are not likely to develop benthic communities comparable to the ones found in natural reefs (Carvalho et al. 2013; Simon et al. 2013) unless they possess structural features which are similar to those of the natural surroundings (Perkol-Finkel et al. 2006). Additionally, if natural ecosystems are destroyed in their construction they can have an overall negative impact on biodiversity.

Living breakwaters/artificial reefs can support tourism and recreation

Where living breakwaters/artificial reefs provide habitat for marine life, they are a potential source of revenue from scuba diving (Seaman 2002; Harris 2009; Sutton and Bushnell 2007). Artificial reefs can also potentially help to alleviate tourism pressure on natural reefs.

Key issues that can affect success

Clarity on purpose and approach

For all adaptation options it is crucial to be clear on the objectives of undertaking a particular approach. It is especially important when considering living breakwaters or artificial reefs as the terms can be used to refer to a wide variety of structures and purposes. Clarity is needed on the objectives and how the chosen approaches can be implemented to meet them. For example, if re-establishing coral ecosystems is one of the

objectives then a structure needs to be chosen that will provide an appropriate substrate for coral colonisation, and supplementary coral propagation may be needed (see section 4.2).

Site characteristics

Factors such as the depth of the structure and its size and position relative to the shoreline will determine the level of coastal protection it provides (Antunes do Carmo et al. 2011). How the structure is constructed will also have a large impact on its biodiversity impacts, for example increased structural complexity can provide microhabitats that can potentially be colonised by many species (Firth et al. 2014). If the construction site is in a location that is already rich in biodiversity the construction may have very negative impacts on biodiversity and so full environmental impact assessments would be vital. Whether structures do provide habitat for species will also depend on whether they are sited in locations that are suitable for the species of interest (e.g. in terms of temperature, salinity, exposure) and whether source populations are present that can colonise the structure.

Materials used

The materials used for living breakwaters/artificial reefs can greatly influence their performance and different materials have different benefits and drawbacks (see Broughton 2012 for more details). The material should provide enough structural complexity to maximize species diversity through providing a range of different surfaces and spaces. The use of inert materials, which are non-polluting (e.g. through leaching, or physical or chemical weathering and/or biological activity) and which resist rapid corrosion is recommended. Purpose built structures can enable the creation of more carefully planned habitats, integrating biology and engineering (Bohnsack et al. 1991). Recent experimental approaches have also used so-called 'ecosystem engineering species' (Borsje et al. 2011) or 'biogenic materials' (Scyphers et al. 2011), such as oyster shells.

Ongoing management

Although artificial reefs have the potential to fulfil many of the objectives for which they are promoted, careful planning and ongoing management are needed in order to ensure effective performance in relation to adaptation objectives. There are a number of examples around the world of unsuccessful artificial reef projects. A review by Baine (2001), showed that only 50% of those case studies examined met their objectives, with the remainder having no, little or limited success. As the development of coral communities on bare substrates will usually take many years to show evidence of target outcomes, ongoing management supported by monitoring programs may need to continue for 5 to 10 years or more (A Practical Guide to the Construction and Management of Artificial Reefs in North-western Australia, in Useful resources

below). If artificial reefs are planned to increase fish catches, artificial reef deployment should be accompanied by a sound exploitation strategy within reef-based fisheries. This is especially important where the reef causes the aggregation of fish rather than enhancement of their population (Whitmarsh et al. 2008). See the fisheries management section 4.10 for more information.

Useful resources

Office of National Marine Sanctuaries Science Review of Artificial Reefs

http://sanctuaries.noaa.gov/science/conservation/pdfs/artificial_reef.pdf

Broughton, K. 2012.

This contains a useful table comparing benefits and drawbacks of various materials that can be used for establishing living breakwaters/artificial reefs, and includes materials prohibited for use by the U.S. Army Corps of Engineers for artificial reefs (including automobiles, tyres and wood), highlighting their negative effects.

Biological and ecological aspects of artificial reefs

<http://primage.tau.ac.il/libraries/theses/lifemed/free/2115189.pdf>

Perkol-Finkel, S. 2006.

The thesis describes what to consider when designing an artificial reef with biodiversity objectives in mind. In its introduction, it describes what surface composition and shape, orientation, complexity, substratum motion and environmental conditions produce best effects for benthic communities including corals. Information is based on long-term studies monitoring species turnover rates on artificial reefs when compared to natural reef communities.

A Practical Guide to the Construction and Management of Artificial Reefs in North-western Australia

http://www.msscience.net.au/wp-content/uploads/2015/06/AR-Guide-Current_online.pdf

RIO TINTO & MScience Pty Ltd.

Includes a useful table (page 9) that clarifies which factors need to be evaluated when selecting sites for the placement of living breakwaters/artificial reefs. The guide also provides details on most aspects of construction and management of artificial reefs including siting, materials, reef configuration and construction, coral transplantation and management.

A guide to managing coastal erosion in beach/dune systems. Summary 10 Artificial Reefs

http://www.snh.org.uk/publications/on-line/heritagemanagement/erosion/appendix_1.10.shtml

Scottish Natural Heritage. 2015.

A website article providing detailed methodology for placement and monitoring of artificial reefs.

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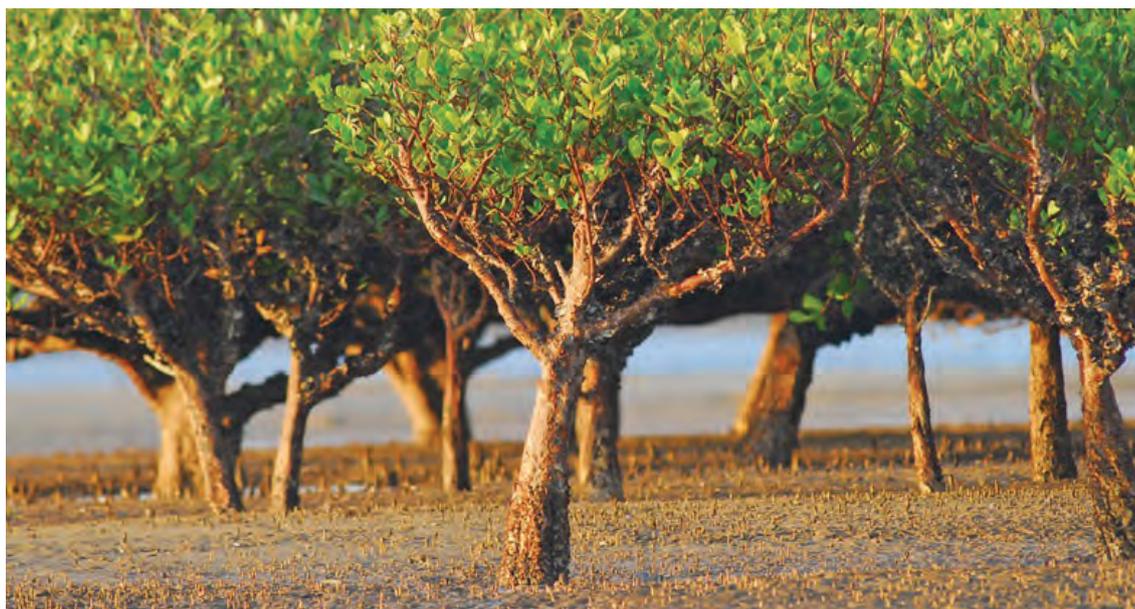


Mangrove conservation and restoration

4.4

Introduction to mangroves

Mangroves are trees or large shrubs which are salttolerant and grow in intertidal zones in tropical and subtropical regions (Spalding, Kainuma, and Collins 2010). They form dense forests along many tropical and subtropical coasts, are found in 123 countries and territories and are estimated to cover over 150,000 square kilometres globally (Spalding et al. 2010). Mangroves form two groups known as true mangroves and associate mangroves. True mangroves are highly adapted to the intertidal zone where all or part of them are regularly submerged in saltwater. The length of inundation tolerated varies between true mangrove species.



Mangroves in the Lamu area, Indian Ocean coast of Kenya.

© Peter Prokosch / grida.no

Globally, there are 69 species in 27 genera, belonging to 20 families that are considered as true mangrove species (Kathiresan and Bingham 2001). Plant species other than the true mangroves are known as associate mangroves and include species such as *Hibiscus tiliaceus* (Var/ Cotton Tree) or *Acrostichum aureum* (Fouzer Lanmar/ Mangrove Fern). These are species found in mangrove forests and should be included as mangrove species for the purposes of conservation management and can greatly increase the potential of mangrove forests as an ecosystem-based adaptation approach. They are also highly adapted to salty conditions, but less so than true mangroves, and will only tolerate infrequent inundation by saltwater during extremely high tides or wave run-up due to storm events.

Common onsite approaches to mangrove conservation and restoration

A common approach to mangrove conservation, as with conservation of many ecosystems, involves establishing

protected areas that reduce anthropogenic pressures. Mangrove restoration often involves reforestation using appropriate species, for example red mangrove *Rhizophora* spp. (Sow 2012). It usually follows three main stages: sorting propagules, supplying propagules to planters and planting. More details on the broader range of issues that can affect success are presented below.

Mangrove conservation and restoration as an EBA measure

There is good evidence that, in the right circumstances, mangroves can help to reduce vulnerability to climate-related coastal hazards. As a result, mangrove restoration has been used as an ecosystem-based disaster risk reduction and adaptation measure, particularly following the 2004 Asian Tsunami, when many affected countries embarked on ambitious replanting programmes (Barbier 2006).

Mangroves provide coastal protection

Mangrove forests can reduce wave energy, erosion (Mazda et al. 2006; Quartel et al. 2007), and storm surge water levels (Zhang et al. 2012) and by doing so mitigate coastal flooding (Gedan et al. 2011). This is particularly relevant in the context of climate change, as coastal flooding and erosion are predicted to increase in severity as sea levels rise.

Mangroves may keep pace with sea level rise

There is evidence that mangroves support soil stabilization and sediment capture, and are able to build up soil levels vertically (accrete) through formation of layers of peat (Lee et al. 2014). This ability means that mangroves are able, in the right conditions, to keep pace with sea level rise (McKee, Cahoon, and Feller 2007). However, mangrove tree health and the supply of incoming sediment are both important determinants of the scale of the accretion process (Beck 2014). By comparing accretion rates with projected rates of sea level rise, it becomes clear that in some locations there will be a threshold beyond which mangroves will not be able to keep up with the rising sea levels (McKee et al. 2007).

Mangroves may provide a refuge from ocean acidification

It has been recently found that mangroves may provide a refuge for coral reef species from climate change. Scleractinian corals were found growing in shaded colonies on mangrove prop roots, which provided a refuge from thermal and acidification stress (Yates et al. 2014). It is uncertain whether mangroves themselves will be directly affected by ocean acidification (Gosling 2013). However, there are potential negative indirect effects if coral reefs, which in some cases supply sediment to mangrove systems, are affected so that the sediment supply is reduced (Gilman et al. 2008).

Mangroves serve as a habitat and nursery ground for fish and other marine species, supporting fisheries and livelihoods

Many commercially important marine species utilize mangroves for some, or all, parts of their lifecycle, for example species of snapper, mullet, shrimp, crab and sharks (Rönnbäck 1999). Mangroves therefore support the income of coastal communities and potentially reduce their vulnerability to climate change, by increasing access to sources of income and nutrition (Beck 2014). Mangroves have been found to be highly beneficial as nursery habitats (Kimirei et al. 2013), however, this is not ubiquitous and a number of features have a bearing on the nursery value. Beneficial features include connectivity with adjacent habitats such as coral reef and

seagrass beds, large spatial extent and high diversity of tree species (Lee et al. 2014).

Mangroves support diversified livelihoods

Mangroves supply a range of products that support livelihoods (UNEP-WCMC 2014). Wood is a particularly important mangrove product, with many coastal and indigenous communities relying on mangroves for timber and construction material, as well as for fuel. In addition, non-timber mangrove forest products can provide significant revenue through the provisioning of, for example, honey, dye, fodder, herbal remedies and fruits (Baba, Chan, and Aksornkoe 2013).

Additional benefits

There may be additional benefits for biodiversity

The structural diversity of mangrove roots and their position at the interface between land and sea gives mangroves an important role as habitats for numerous species (Kaiser et al. 2005). Mangroves provide habitats for threatened species, including the endangered Bengal tiger which occurs in the Sundarban mangrove ecosystem shared by India and Bangladesh (Gopal and Chauhan 2006) and the critically endangered hawksbill turtle (Gaos et al. 2012). Mangroves have also been found to act as a refuge for corals from ocean acidification (Yates et al. 2014).

In addition, mangroves provide a number of important benefits for surrounding habitats contributing to water quality and nutrient transfer. Mangroves filter and trap sediment from run-off and river water before it reaches adjacent ecosystems reducing the turbidity of the water and allowing essential light to reach ecosystems (Gillis et al. 2014). Mangroves therefore contribute to the survival of these adjacent ecosystems and the species they support.

There may be additional benefits for carbon storage

On average, the carbon stock of one hectare of mangroves, including soil carbon, is approximately 1,000 tonnes, more than twice the carbon storage of upland forests and five times that of savannah (Donato et al. 2012), meaning that mangroves are among the most carbon-rich forests in the tropics. Therefore, despite mangroves constituting less than 1% of the area of tropical forests globally, deforestation in these systems releases a disproportionate amount of carbon into the atmosphere as the carbon protected by mangroves is released. As a result, it is estimated that mangroves may be responsible for as much as 10% of all emissions from deforestation globally (Donato et al. 2011). Conservation and restoration of mangroves can therefore contribute significantly to climate change mitigation. Their ability

to trap organic sediment and thus store carbon is why mangroves, among other systems, are referred to as 'blue carbon' sinks. It should be recognised that older stands of mangroves generally have accumulated large amounts of peat below them and thus store more carbon, therefore providing greater climate change mitigation benefits. In addition, as mangroves age, they store proportionally more carbon in their biomass because of higher productivity (Kristensen et al. 2008). Protection of mangroves should, where possible, prioritise older stands.

Key issues that can affect success

Anthropogenic pressures

Approximately one quarter of the world's mangrove cover has been destroyed (Spalding et al. 2010) and the rate of mangrove loss is still very high, estimated to be around 2 to 5 times higher than the average rate of loss for all forests (FAO 2007). Human activities, including conversion to aquaculture, coastal development, overexploitation of timber and pollution, have been the primary causes of mangrove loss (UNEP-WCMC 2014).

Climate change pressures

A variety of climate change related pressures are likely to affect mangroves, including increased storm frequency and severity, sea level rise and changes in species distributions (summarised by Hoegh-Guldberg and Bruno 2010) with sea level rise potentially being one of the greatest climate related threats (Gilman et al.

2008). This threat is exacerbated if there is development directly inland of mangroves, as it is impossible for the system to move inland with sea level rise (Di Nitto et al. 2014).

Site and ecosystem characteristics

Mangrove forest width is an important determinant of the likely effectiveness of the system for EBA. While narrow bands of mangrove forests, between 40 and 80m, can slow storm surge water flows, relatively wide bands of mangroves (several hundred meters or wider) are needed to significantly reduce storm surge flooding. The protection received also depends on the structure of the mangrove forest with denser structures needed to support protection by these relatively narrow bands of mangroves (McIvor et al. 2012). In areas with gently sloping topography, even a small reduction in water level can result in a relatively large reduction in flood area. More information can be found in the Mangroves for Coastal Defence Guidelines (see the 'Useful resources' section).

Maximum biophysical thresholds

As with any ecosystem, there are tolerance thresholds beyond which mangroves will not survive. These predominately relate to extreme storm events where mangroves can be destroyed or seriously degraded through defoliation, erosion, burial by sediment and uprooting by high winds (McIvor et al. 2012; UNEP-WCMC 2006). In addition, exceeding water quality thresholds



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through high levels of, for example, salinity, heavy metals and chlorine can cause tree death (Snedaker and Brown 1981). Sea level rise and sediment availability vary by location and generalized tolerances are difficult to specify, however, there is a threshold of sea level rise beyond which the mangroves will no longer be able to keep pace. In some locations it has been estimated that a more than 5mm rise in sea level per year will mean that mangroves die off (McKee et al. 2007). Globally, it is estimated that by 2100 there will be a loss of between 10 and 15% of mangrove habitat due to sea level rise (Alongi 2008).

Timeframes

Wherever possible, preservation of existing mangroves is to be prioritised as biodiversity and ecosystem services values are generally lower in restored habitats when compared to intact areas. However, restoration can increase ecosystem services provision and therefore is worth considering where suitable locations are available (Rey Benayas et al. 2009). Planting is often used as a restoration technique, although, mangrove restoration can occur naturally in 15-30 years if the tidal hydrology of the site is not disrupted and if there is a good supply of waterborne seeds or seedlings. (Lewis and Streever 2000).

Successful restoration requires an understanding of the causes of mangrove loss. If the causes are not addressed, then re-establishment may not be effective. This is particularly important if one of the causes is hydrological change (Mcleod and Salm 2006). Five critical steps for mangrove restoration can be found in the Importance of Mangroves to People Report (see the 'Useful resources' section).

Relevant policy context and developments

Common policy approaches for conserving mangroves include assessing existing policies and regulations for their adequacy in promoting sustainable management of coastal forests, bridging gaps between existing policies and implementation, development of forest rehabilitation plans, clarifying tenure and jurisdictions over mangrove areas, developing guidelines on incorporating forestry into coastal disaster management strategies and promoting best practices in collaborative coastal forest protection (FAO 2006). For more information on the importance of policy measures in adaptation, see Chapter 3.

Ongoing management

Management of mangroves that have previously demonstrated resilience to climate stressors, and/ or are naturally situated to survive global threats, will increase

the resilience of mangroves as an EBA measure. Climate resilient management also includes controlling human stresses on mangroves by establishing inshore buffer zones to reduce impacts from adjacent land use and allow mangroves to migrate in response to sea level rise (Mcleod and Salm 2006) (for more details see Managing Mangroves for Resilience to Climate Change in the 'Useful resources' Section). For mangroves to contribute optimally to risk reduction, their conservation needs to be incorporated into broader coastal zone management and planning, including the protection of intact habitat in protected areas (Spalding et al. 2014). Community involvement is also key to successful mangrove management, protection and restoration (Freda and Actmang 2012).

On the ground implementation

Restoration efforts need to first consider the hydrology, nature of the substratum, planting period (e.g. middle of the rainy season for Rhizophora) and seedling quality before undertaking re-planting. Reforestation then involves three main stages, including sorting propagula, supplying propagules to planters, and planting. Subsequently, monitoring is required to evaluate success rates – see Sow (2012) in 'Useful resources' for helpful guidelines on reforesting mangroves using Rhizophora. For mangrove ecosystems, local conditions such as the availability of sediment and freshwater to compensate for increased salinity, will also aid mangrove survival and increase their resilience to sea-level rise.

Local community involvement

Although to some extent mangrove management requires specialised knowledge and equipment, many aspects of conservation and restoration can be implemented at the community level (Linham and Nicholls, 2010), for example in re-planting activities and – following some training – post-planting monitoring (Primavera et al. 2012). Community-led vegetation planting has had varying success, depending on local commitment, so awareness-raising campaigns may assist in promoting local efforts to protect mangroves (Linham and Nicholls, 2010). Community ownership and sense of responsibility is important in long-term successful conservation and restoration efforts (Primavera et al. 2012). Creating policy measures which enhance the awareness, capacity and engagement across relevant stakeholders will support effective EBA outcomes. See Case Study 5 on page 100 for an example of a community-based mangrove restoration programme.

Useful resources

Mangroves for Coastal Defence

https://www.conservationgateway.org/ConservationPractices/Marine/crr/library/Documents/MangrovesforCoastalDefence_Decision_makers_Guide_WebVersion.pdf

Spalding et al. 2014.

This practical guidebook summarises the findings of the reviews and provides practical management recommendations to coastal zone managers and policymakers. It includes three key elements:

- Understanding of the risk to the shoreline;
- The role of mangroves in risk reduction;
- How to manage mangroves for coastal defence (including integrated solutions with other problems).

Livelihood Support

repository.usfca.edu/cgi/viewcontent.cgi?article=1011&context=capstone

Baba et al. 2013.

The report discusses different products that can be gathered from mangroves. Wood and non-wood products are examined through case studies. The different species of mangroves are referenced with their uses. There is a Pacific and South East Asia focus for the material but some examples are also highlighted from Africa and the Caribbean.

Manual on Community-Based Mangrove Rehabilitation

<https://www.zsl.org/sites/default/files/media/2014-05/Manual%20on%20Community-Based%20Mangrove%20Rehabilitation.pdf>

Primavera et al. 2012.

Expertise and support for community-based mangrove rehabilitation. It is focused on the Philippines but is applicable to other locations. If used in other locations, the native mangrove species should be used.

Managing Mangroves for Resilience to Climate Change

<https://portals.iucn.org/library/efiles/documents/2006-041.pdf>

McLeod. 2006.

This report provides some considerations for conservation practitioners as they design conservation strategies for mangroves. These ideas build upon the concept of resilience and include strategies, tools and methods for managers to promote resilience.

Coastal Protection

Wetlands International provides some good resources on mangrove restoration including the following two reports helping understand storm management by mangroves:

Storm Surge Reduction by Mangroves

www.wetlands.org/WatchRead/Currentpublications/tabid/56/mod/1570/articleType/ArticleView/articleId/3406/Storm-Surge-Reduction-by-Mangroves.aspx

Mclvor et al. 2012.

Reduction of wind and swell waves by mangroves

<http://www.wetlands.org/Portals/0/publications/Report/reduction-of-wind-andswell-waves-by-mangroves.pdf>

Mclvor et al. 2012.

The Importance of Mangroves to People: A Call to Action

<http://www.unep-wcmc.org/resources-and-data/the-importance-of-mangroves-to-people--a-call-toaction>

UNEP-WCMC. 2014.

Provides an overview of the Ecosystem Services available from mangroves, the threats faced and conservation measures.

Biodiversity A-Z – Mangrove Page

<http://www.biodiversitya-z.org/content/mangrove--2>

Short introduction to mangroves with links to sources of data.

Ocean Data Viewer

<http://data.unep-wcmc.org/>

UNEP-WCMC.

An online tool providing access to a range of datasets that are useful for informing decisions on conserving marine and coastal biodiversity. Users are able to view and download a range of data, including data on: the global distribution of coral reefs, seagrasses and mangroves, global seagrass species richness and data from the World Mangrove Atlas.

Five Steps to the Successful Ecological Restoration of Mangroves

http://www.mangroverestoration.com/pdfs/mangrove_restoration.pdf

Mangrove Action Project.

Illustrates five important steps that should be tailored to each unique situation and coastal region where mangrove restoration is being attempted.

Mangrove Forest Restoration in Andhra Pradesh, India

http://www.globalrestorationnetwork.org/uploads/files/CaseStudyAttachments/60_andhra-pradesh.pdf

MS Swaminathan Research Foundation, India.

Reflects the process and results of restoration activities carried out over seven years by the project Coastal Wetlands: Mangrove Conservation and Management and is meant for foresters, field technicians, researchers and others interested in restoration of degraded mangroves.

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Seagrass conservation and restoration

4.5

Introduction to seagrass ecosystems

Seagrass beds are formed by a group of approximately 60 flowering plant species that grow underwater in sandy substrate of the shallow coastal zone of most continents. They display a considerable latitudinal range and have been recorded as far north as Norway and as far south as New Zealand (Green and Short 2003).

Common onsite approaches to seagrass conservation and restoration

The most common approach to conserving seagrass ecosystems is to reduce common threats to them (e.g. pollution, damage by boats), for example through new regulations. Restoring seagrass ecosystems can include harvesting and transplanting seagrass plants and subsequent management and monitoring of restored sites. More details on the broader range of issues that can affect success are presented below.

Seagrass conservation and restoration as an EBA measure

Seagrasses provide coastal protection

A review by Ondiviela et al. (2014) on seagrasses in Europe found that these ecosystems can reduce current velocity, dissipate wave energy and stabilize the sediment, most reliably in shallow waters with low wave energy environments, and where biomass does not fluctuate through time. Reducing wave energy can contribute to reducing flooding and erosion in coastal areas and settlements, two hazards that may increase in severity with a changing climate.

Seagrass beds may keep pace with sea level rise

Seagrass beds can trap sediment and thus raise their surface elevation. Where sedimentation and accretion rates keep pace with sea level rise, there is more chance that seagrass beds will maintain their coastal protection services in the face of climate change (Ondiviela et al. 2014).

Seagrass beds serve as a habitat and nursery ground for fish, supporting fisheries and livelihoods

Seagrass beds provide habitat for fish and other commercially relevant marine animal stocks (Unsworth et al. 2008; Watson et al. 1996; Needelman 2012). Supporting seagrass ecosystems through conservation or restoration can help with the continued provision of food and income, and therefore contribute to maintaining people's resilience and capacity to adapt to climate change.

Seagrass beds may support diversified livelihoods

The contribution of seagrass beds to stable fisheries may mean that communities that do not presently rely on fisheries as a source of livelihood could benefit from this source of livelihood in the future, if other livelihoods come under threat.



Children are planting tiny seagrass in the sea in Nakornsrihamaratch in Thailand.

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Additional benefits

There may be additional benefits for biodiversity

Seagrass habitat is important for a wide range of species that may spend all or part of their life cycle within the seagrass ecosystem, and conservation efforts are likely to be key for biodiversity protection (Carruthers et al. 2002). Seagrasses also provide key feeding grounds for endangered species such as turtles, and have been shown in some locations to have a buffering effect on pH, modifying it through photosynthetic activity.

There are additional benefits for carbon storage

Seagrass beds also provide carbon storage capacity in their own biomass but also through their ability to trap organic sediments (Nellemann et al. 2009; Duarte et al. 2005), thus contributing to climate change mitigation. This is why seagrasses are among the systems referred to as 'blue carbon' sinks.

Key issues that can affect success

Anthropogenic pressures

Seagrass beds are highly sensitive ecosystems, threatened by anthropogenic factors such as physical damage by boats, poor water quality, pollution, dredging and dumping. For seagrass conservation and restoration to be an effective EBA measure, efforts need to be made to mitigate and manage these local, human-induced pressures.

Site and ecosystem characteristics

Seagrass beds reduce waves and currents in shallow areas more effectively when they occupy a higher proportion of the water column (Fonseca and Cahalan 1992; Koch et al. 2006; Ward et al. 1984). Since some species are naturally taller and therefore occupy a greater proportion of the water column than others, it may be important to take this into account when selecting species for restoration efforts, or when prioritising management efforts for existing seagrass beds. Stiffness, biomass, density, leaf length and morphology are other species-specific characteristics that influence the coastal protection value of seagrass beds (Ondiviela et al. 2014). These characteristics should also be considered when making decisions about seagrass conservation and restoration for EBA.

Seagrass beds are most reliably effective at providing coastal protection services in shallow waters with low wave energies and low seasonality. In other circumstances, seagrass beds may less reliably provide coastal protection services (Ondiviela et al. 2014).

Since different species show different sea temperature tolerances, mixed species meadows may have a better chance of survival and resilience in the face of increasing sea temperatures as a result of climate change (Björk et al. 2008).

Critical environmental parameters which impact on the integrity and presence of seagrass beds include wave energy, salinity, temperature, water clarity and nutrient concentrations. Optimal conditions (e.g. for temperature) depend on the species used (US Army Corps of Engineers 2008), so there is a need to consider the species' ecological requirements in comparison to the local marine conditions.

Ability to protect commercially and subsistence relevant fish species

The significance of seagrass beds for commercial fish species production and/or subsistence purposes is likely to be species-specific and may vary geographically and over time (Saenger et al. 2013). Some fish species may require other habitats such as mangroves or mudflats at certain stages of their life cycle. Thus, solely focussing conservation or restoration efforts on seagrass beds may not have the desired effect for these species. Therefore, if the focus is on protecting fisheries, it is important to identify the specific fish species involved and their habitat requirements.

Recovery after disturbance

Natural recolonisation following disturbance may occur in some cases, though the recovery of disturbed seagrass beds varies and is likely to be greatly assisted by the removal of human stressors (Holtz 1986). Reducing the time that areas are bare following disturbance is important to prevent erosion of the substrate (Holtz 1986).

Relevant policy context and developments

Common policy approaches for seagrass conservation and restoration include legal designation (e.g. establishing general protection for seagrass ecosystems, or specific protection in the form of marine protected areas, see section 4.9), as well as establishing codes of practice, planning and zoning, stakeholder education and capacity building. The appropriate mix of these strategies is likely to depend on national circumstances and site location. For more information on the importance of policy measures in adaptation, please see Chapter 3.

Ongoing management

For seagrass restoration, since implementation success predominately depends on trial and error, employing adaptive management using native species is strongly recommended (Holtz 1986). Monitoring programmes should be set up with a time horizon of 5 years (or 10+ in more wave exposed sites) to document the effectiveness of the intervention (see Guidelines for the Conservation and Restoration of Seagrasses in the United States and Adjacent Waters in Useful resources, below).

On the ground implementation

Seagrass transplanting is labour intensive, and can require the use of divers in deeper water, which can result

in considerable financial expenditure where volunteers are not available (Holtz 1986). Transplanting also has an ecological cost, as inappropriate harvesting can damage the source ecosystem. The recovery time depends on the species harvested (Holtz 1986).

The effectiveness of a particular seagrass restoration method is very site specific and may require the use of different species at different stages to replicate natural succession processes (Holtz 1986). Also, the parameters of the transplant site must closely match those of the source or reference site (i.e. through the selection of similar ecotypes)(US Army Corps of Engineers 2008). Many efforts at transplantation have failed because of unsuitability of site conditions (US Army Corps of Engineers 2008).

Useful resources

Adapting to Coastal Climate Change: A Guidebook for Development Planners

www.crc.uri.edu/download/CoastalAdaptationGuide.pdf
USAID. 2009.

An adaptation guidebook outlining approaches on the process for planning and implementing adaptation measures in coastal areas. Features a useful “Adaptation measures” Annex, which contains a section on wetland conservation (including seagrasses), and related data and information requirements, design considerations, and factors improving the likelihood of success.

Seagrass syllabus: a training manual for resource managers

http://www.seagrasswatch.org/Info_centre/Publications/syllabus/seagrass_syllabus.pdf

Di Carlo & McKenzie. 2011. *Conservation International*.

A reference manual for those involved in the management of seagrass resources. Provides a comprehensive overview of seagrass ecosystems, and approaches to managing them in ways that take into account the ecology of seagrass ecosystems and the needs of local people. Includes sections on seagrass monitoring and the importance of communication and outreach.

Seagrass Meadows and Shellfish Beds Restoration of Seagrass Meadows

http://www.pradariasmarinhas.com/restoration_manual.pdf
Oceania.

Describes recent techniques for seagrass restoration that may be divided into two basic groups: 1) activities focused on collecting and transplanting plants, and 2) activities focused on obtaining and planting seeds.

Guidelines for the Conservation and Restoration of Seagrasses in the United States and Adjacent Waters

<http://www.seagrassrestorationnow.com/docs/Fonseca%20et%20al%201998.pdf>

US National Oceanic and Atmospheric Administration.

Discusses important issues that should be addressed in planning seagrass restoration projects, describes different planting methodologies and proposes monitoring criteria and means for evaluating success.

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Dune and beach conservation and restoration

4.6



Introduction to beaches sand dunes

Beaches are strips of sand or shingle between the land and sea. Sand dunes are landforms that develop where there is an adequate supply of sand and where prevailing winds are strong enough for sand movement to occur (Everard et al. 2010). They represent a dynamic spatial transition between terrestrial and marine ecosystems and occur worldwide from the tropics to circumpolar regions (Martínez et al. 2004). Sand dunes are naturally dynamic environments which are constantly changing in extent and form due to fluctuations in natural environmental forcing factors, such as winds, waves and tides (Pye et al. 2007).

Common onsite approaches to dune and beach conservation and restoration

Conservation and restoration of dunes and beaches involve similar processes. Further to minimizing disturbances, common onsite approaches include implementing physical barriers that trap sand, mechanically stabilizing dune ridges, and planting schemes using species adapted to the ecosystem to biologically fix or reforest the dune ridge (Diop 2012). More details on the broader range of issues that can affect success are presented below.

Dune and beach conservation and restoration as an EBA measure

Dunes and beaches are widely seen as a buffer between the land and sea and as providing important coastal protection and tourism opportunities. A range of conservation and restoration approaches have been developed to support these functions (including fencing of dune habitats and supporting the reestablishment of stabilizing vegetation), although few projects so far have had a focus on adaptation. Where beaches are currently eroding, 'beach nourishment' has been used as an approach to maintain the beach profile, and involves depositing sand onto the beach from offshore or quarries. As beach nourishment can involve artificially building up sand on the shoreline, it can be seen as a more structural or hybrid adaptation approach.

Dunes provide coastal protection

Beaches and sand dunes can provide a barrier between the land and the sea. In particular sand dunes can play a vital role in coastal stability, protecting against coastal erosion and flooding (USAID 2009; Everard et al. 2010; Temmerman et al. 2013; van Slobbe et al. 2013), two hazards that are predicted to increase in severity under climate change (Nicholls et al. 2007). The porous structure of dunes absorb and dissipate wave energy and provide additional material which re-enters the marine transport system and forms a new beach profile after erosion events (Everard et al. 2010). Dunes provide coastal protection by acting as a buffer from waves and

storm surges, preventing storm waters from flooding low interior areas, as well as providing a reservoir of sand to nourish eroding beaches during storms (US Army Corps of Engineers 1989). Indeed, a mature dune system can eventually experience severe episodes of erosion during storm events, but if the sedimentary budget is at equilibrium, the sand will gradually be renewed or stored in an offshore bar, reducing future shoreline erosion. On an eroding coast, however, a stabilized dune will slow but not prevent shore erosion (US Army Corps of Engineers 1989). The wider and higher the dunes are between populated areas targeted for protection and the sea, the greater the level of natural erosion protection, in the form of buffering capacity, is provided (French 2001).

Dunes and beaches can support tourism

Beaches are an important tourist attraction, but they are also likely to be under increased pressure as the climate changes and sea levels rise. Maintaining beaches and related dune systems can therefore increase the resilience of tourism, and the livelihoods that depend on it, to climate change.

Additional benefits

There may be benefits for biodiversity

Sand dunes represent unique and in some ways harsh environments for plant and animal life, and so the species associated with them tend to be specialised in nature and localised in distribution. Conserving dune habitat is therefore important for this specialist flora and fauna (Linham and Nicholls 2010).

Sand dunes contribute to water regulation and purification

Sand dunes play an important role in water regulation and purification, as coastal dune aquifers are an important source of water extraction (van Dijk 1989; Carretero and Kruse 2012).

Key issues that can affect success

Anthropogenic pressures

In recent centuries and decades, beaches and sand dunes have been significantly damaged by human actions and as a result are in decline, mainly due to

coastal development and tourism recreation (van der Meulen and Salman 1996). Coastal urbanization, for example, has in some cases destroyed dune systems, significantly reducing their capacity to supply sand during times of severe erosion, thereby increasing erosion risk. Additionally, dredging offshore can change beach profiles and so increase beach erosion. Managing these local, human-induced pressures is key to ensuring the success of dune conservation and restoration as an EBA measure.

The need for space

An important consideration for the use of sand dunes in coastal erosion and flood defence is the need for space, as they require more space than conventional, 'hard' engineering structures (Temmerman et al. 2013; Berry, Fahey and Meyers 2014). The more space available between the sea and human-populated areas, the higher the efficiency of the system. This however may be challenging in highly populated coastal areas, and conflicts of interest may arise, especially if coastal sand dune restoration takes place in areas primarily used for residential or tourism purposes (Linham and Nicholls 2010).

On the ground dune stabilization implementation

Over the years, several measures have been applied to restore and stabilize dune systems and preserve their capacity to prevent coastal erosion and flooding. The success of the applied measure, however, will mainly depend on local-scale environmental factors, such as patterns of wind and sand supply, among others (Huang and Yim 2014).

Vegetation planting techniques have commonly been used as a way to trap and stabilize sand blown from the beach, emulating the way coastal dunes are naturally created and maintained (US Army Corps of Engineers 1989). The plant species selected should originally be native to the region and be adapted to the harsh conditions present in dune environments. Transplantation in the growing season has been identified as a suitable approach (Dahl 1975, Huang and Yim 2014).

Vegetation planting can also be used in combination with soft physical structures to facilitate the establishment of a stable vegetation cover. Semipermeable physical structures such as wooden fences or nets have been effectively installed to reduce wind speed across the sand surface and increase sand deposition (van der Meulen and Salman 1996; Gómez-Pina et al. 2002; Huang and Yim 2014). Alternatively, natural materials such as brushwood or mulch can be directly placed onto the sand to increase surface roughness and provide a physical barrier to the wind (Pye et al. 2007). However,

since dunes formed by sand trapping devices may become unstable and highly vulnerable to changing wind conditions, it is common practice to further stabilize them with vegetation (Khalil 2008; USAID 2009), which further increases surface roughness so that more wind-carried sand will be trapped.

Local community involvement

Although to some extent dune management requires specialised knowledge and equipment, many aspects of dune conservation and restoration can be implemented at the community level (e.g. application of fences to stabilize bare sand, vegetation planting and maintenance; Linham and Nicholls 2010). The success of the community-led approach for vegetation planting has had varying success and is dependent on local commitment (Nordstrom and Arens 1998), therefore local awareness raising campaigns may assist in promoting local efforts to protect dunes (Linham and Nicholls 2010). Creating policy measures which enhance the awareness, capacity and engagement across relevant stakeholders will support effective EBA outcomes; (for more information on the importance of policy measures in adaptation, see Chapter 3).

Beach nourishment

Although depositing sediments onto beaches can help maintain their presence in the face of erosion, it can also cause a number of negative environmental effects. Negative impacts include direct burial of animals and organisms residing on the beach, lethal or damaging doses of water turbidity (cloudiness caused by suspended sediments) and altered sediment compositions. As a result, projects must be designed with an understanding of, and concern for, the potential adverse consequences for the environment. See Linham and Nicholls (2010) in the 'Useful resources' section for more information.

Beach nourishment is also not a permanent solution; where it is being undertaken to compensate for net erosion of a beach it will provide a buffer to the erosion but not prevent the new sediment also being eroded. Additionally, if sediment is supplied by off shore dredging it can alter the profile of the seabed impacting waves and currents, as well as negatively impacting on the ecosystem being dredged.

Useful resources

Technologies for Climate Change Adaptation:

Coastal Erosion and Flooding

http://www.unep.org/pdf/TNAhandbook_CoastalErosionFlooding.pdf

Linham and Nicholls. 2010. UNEP Risø Centre and University of Southampton.

A guidebook providing an overview of thirteen adaptation

technologies that reduce impacts of coastal erosion and flooding as a result of climate change. It features a section on dune rehabilitation, including advantages and disadvantages of dune rehabilitation, costs and financial requirements, institutional and organizational requirements, and barriers to and opportunities for implementation.

Adapting to Coastal Climate Change: A Guidebook for Development Planners

[http://www.crc.uri.edu/download/](http://www.crc.uri.edu/download/CoastalAdaptationGuide.pdf)

[CoastalAdaptationGuide.pdf](http://www.crc.uri.edu/download/CoastalAdaptationGuide.pdf)

USAID. 2009.

An adaptation guidebook outlining approaches on the process for planning and implementing adaptation measures in coastal areas. Features a useful “Adaptation

measures” Annex, which contains a section on dune and beach nourishment, and related data and information and data requirements, design considerations, and improving the likelihood of success.

Guide on adaptation options in coastal areas for local decision-makers: Guidance for decisionmaking to cope with coastal changes in West Africa

[http://unesdoc.unesco.org/](http://unesdoc.unesco.org/images/0021/002166/216603E.pdf)

[images/0021/002166/216603E.pdf](http://unesdoc.unesco.org/images/0021/002166/216603E.pdf)

Diop. 2012.

Includes a fact sheet with detailed information on restoring dunes, including coastal dune ridge level raising, mechanical stabilizing of the dune ridge and biologically fixing or reforesting the dune ridge.

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In Anse Kerlan beach, in the Seychelles, residents have had to take their own initiatives to protect their coast against erosion. Small islands have limited land area and are prone to natural hazards which make them highly susceptible to the effects of climate change, sea-level rise, and extreme events. Their vulnerability is further aggravated by their low adaptive capacity; and the cost of adapting to the changing climate is high as compared to the GDP.

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Managed realignment and coastal set-backs

4.7

Introduction

As sea levels rise, low lying areas are increasingly at risk of inundation. Coastal retreat is the proactive determination and implementation of realistic setback lines along coasts, whether the land affected is urban, rural or agricultural in nature (Roets and Duffell-Canham 2009). Managed realignment (also known as managed retreat, dike realignment, dike reopening, de-embankment and de-polderisation) and coastal set-backs are two forms of coastal retreat. Managed realignment is the deliberate altering of flood defences to allow planned flooding of a presently defended area. Coastal setback is a planning tool that identifies a zone next to the existing shoreline which is then managed as a type of buffer zone. It predefines distances from the shoreline or elevations from sea level and then excludes development (e.g. infrastructure) or restricts the types of activities in these areas where there is coastal hazard risks (Linham and Nicholls 2010).



Wild seaside landscape in Aruba in the Caribbean
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Common onsite approaches to managed realignment and coastal set-backs

Managed realignment commonly involves moving defenses inland and allowing intertidal habitats to reclaim coastal areas for defense. Coastal setbacks commonly involve predefining a distance from the shoreline that excludes new development, often in areas allocated for new coastal development. More details on the broader range of issues that can affect success are presented below.

Managed realignment and coastal setbacks as EBA measures

Historically, managed realignment has been implemented mainly to create new wetland habitats, but more recently it has been used as part of integrated adaptation schemes which also include technical or structural adaptation

measures, for example sea walls (Doswald and Osti 2011). Although not always branded as an EBA approach, managed realignment in Europe and North America has existed for some time and projects are generally well documented, with information being available in the public domain. Its application in developing countries to date has been limited (Linham and Nicholls 2010; Simpson et al. 2012).

Coastal setbacks have been implemented in a wider range of countries. Countries such as Antigua, Aruba, Australia, Barbados, Canada, Denmark, Finland, Germany, Norway, Poland, Spain, Sri Lanka, Sweden, Turkey and the United States all have policies that require new buildings to be set back a certain distance from the sea (Linham and Nicholls 2010). Similarly to managed re-alignment, coastal setbacks can create new habitat: they take advantage of the adaptive

capacity of coastal ecosystems including mangroves, sand dunes, wetlands, coral reefs, which are given room to grow and develop in the area that excludes development.

More recently, monitoring of the adaptive capacity of both approaches, along with their impacts on biodiversity and ecosystem services, is improving applicability and efficiency (Pendle 2013), however more work is needed in this area (French 2006).

Managed realignment and coastal setback provide coastal protection

Managed realignment and coastal setback provide coastal protection both through reducing the number of assets (e.g. houses, infrastructure, and businesses) that are in areas susceptible to coastal hazards, which are expected to increase with climate change, and through harnessing the adaptive capacity of natural habitats. For example, space is provided for wetlands, which can attenuate wave action, and reduce sediment transport and erosion by allowing natural erosion/accretion cycles to occur (Linham and Nicholls 2010).

Additional benefits

There may be benefits for biodiversity

Both managed realignment and coastal setbacks create the potential for new habitats for biodiversity (Linham and Nicholls 2010; Tinch and Ledoux 2006). It is important to recognise however, that by allowing the coast to reclaim land, important habitats behind already existing coastal defenses, such as grazing areas, will be altered by tidal inundation, which ultimately will have an effect on biodiversity (Esteves 2014; Linham and Nicholls 2010).

Managed realignment and coastal setbacks can be more cost effective

Managed realignment often has lower maintenance costs and can be more cost-effective in the long term (Scott 2011) than structural approaches, particularly when considering the combined benefits of increased habitat value and flood protection (Tinch and Ledoux 2006; Doswald and Osti 2011; Fletcher et al. 2013). However, due to competition for coastal areas and coastal squeeze, implementation costs may increase over time, necessitating spatial valuation and planning for sustainable implementation; see Linham and Nicholls (2010) in the 'Useful resources' section for factors affecting costs of managed realignment under different land use regimes in developed countries. Coastal setbacks are more cost-efficient than structural adaptation approaches to shoreline erosion or flood protection, mainly because the setback creates a natural buffer that diminishes the need for a structural approach. However, setbacks are only applicable in some locations (see Selecting appropriate sites below) and require careful consideration of setback distances (see Defining setback distances).

Managed realignment and coastal set-backs can support tourism and recreation

The ecotourism and recreational value of natural habitats can be increased as a result of managed realignment and coastal set-backs due to the provision of open spaces and access to the shoreline (Linham and Nicholls 2010; Luisetti et al. 2011; Fletcher et al. 2013).

Communities may benefit from additional ecosystem services

Intertidal areas provide ecosystem services such as maintenance of water quality and reduced saltwater intrusion (Fletcher et al. 2013; Linham and Nicholls 2010). Coastal setbacks allow erosion and accretion cycles to occur naturally, thus retaining sediment budgets (French 2006).

Key issues that can affect success

Selecting appropriate sites

Selecting sites for managed realignment is challenging, not least because it involves ensuring the acceptance and understanding of stakeholders. Low-lying areas potentially satisfy topographic and hydrological parameters, but do not necessarily consider future effects of climate change (rising sea level, increased coastal erosion, higher frequency of storms etc.). Luisetti et al. (2011) suggest evaluating coastal ecosystem services to develop an integrated coastal management approach that can include managed realignment. In selecting sites, opportunity costs need to be minimized, which can be achieved using criteria including historical land-use, location of transport networks, and sites historically reclaimed by nature (e.g. estuaries). For more information on GIS-based site location criteria for managed realignment, see Luisetti et al. (2011) in the 'Useful resources' section.

Coastal setbacks cannot be implemented retroactively and are not a viable adaptation measure in coastal urban areas, areas associated with the maritime industry and areas with traditional infrastructure incorporated into the coastal landscape (Linham and Nicholls 2010).

Defining setback distances

Setback distances can be fixed or variable (Linham and Nicholls 2010). Fixed distances may ease applicability in policy but may ignore locationspecific variability. Variable distances can change according to topography and shoreline movement, thus improving adaptive capacity, but may incur additional costs and resources when implemented over larger areas (Simpson et al. 2012). As with managed realignment, distances need to be defined according to sound scientific and historical evidence base that takes into account the unpredictable effects of climate change on nature. Managed realignment can be combined with structural approaches to limit the inland encroachment of wetland areas and maintain land for near-coastal

development. Coastal setbacks regularly need to be reevaluated to ensure adequate buffer zones.

Relevant policy context and developments

Despite jurisdictional interest in proactive planning for climate change adaptation, conflicts over land ownership complicate implementation of coastal setbacks and managed realignment as a policy measure (Simpson et al. 2012). Conflicts particularly arise when economic development of coastal areas is excluded by coastal setbacks, or when managed realignment requires relocation of culturally important monuments or reclamation of agricultural land (Fletcher et al. 2013). Dissemination of knowledge, public acceptance, involvement of land owners and stakeholders, consideration of compensation for loss of land and enforcement of policies are important requisites for reducing potential conflicts (Linham and Nicholls 2010; Scouller 2010). See the Managed Coastal Retreat Handbook (Siders 2013) in the 'Useful resources' section for more information on legal and policy tools. For more information on the importance of policy measures in adaptation, see Chapter 3.

Ongoing management

Strategies for coastal setback and/or managed realignment that are implemented regionally, can potentially cover a greater area, thus allowing countries to meet legislative requirements for promoting natural habitat and protecting biodiversity (Esteves 2014).

Useful resources

Costs and coasts: an empirical assessment of physical and institutional climate adaptation pathways

http://apo.org.au/files/Resource/McAllister-2013-Costs-Coasts-Climate-Adaptation-WEB_0.pdf
Fletcher et al. 2013.

Using specific examples from Australia and the UK, the report compares different coastal approaches to climate change adaptation. It analyses costs of damage from storm surge inundation events in current and future climate change scenarios, with and without implementation of adaptation approaches, including managed realignment and coastal setbacks. It also compares local government responses to "protect", "accommodate" and "retreat" adaptation strategies in terms of effectiveness, efficiency, flexibility, equity and acceptability.

IDB Coastal Setbacks in Latin America and the Caribbean

idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=37305263
Simpson et al. 2012.

A technical note that incorporates issues and trends for coastal planning and development in a developing

region. Includes helpful guidance (Appendix F) for coastal development adapted from a coastal areas protection policy for New Brunswick, including activities allowed inside and outside coastal setback areas, processes that require review, and precautions for construction and design.

Technologies for Climate Change Adaptation - Coastal Erosion and Flooding

http://www.unep.org/pdf/TNAhandbook_CoastalErosionFlooding.pdf
Linham and Nicholls. 2010.

A guidebook providing an overview of thirteen adaptation technologies that reduce impacts of coastal erosion and flooding as a result of climate change. It features sections on managed realignment and coastal set-backs, including advantages and disadvantages of these approaches, costs and financial requirements, institutional and organizational requirements, and barriers to and opportunities for implementation.

Coastal and marine ecosystem services valuation for policy and management: Managed realignment case studies in England

<http://www.sciencedirect.com/science/article/pii/S0964569110001961>
Luisetti et al. 2011.

A study that reviews two UK managed realignment case studies using decision support systems, including GIS criteria for locating sites for realignment. The criteria aim to locate areas with low opportunity costs and therefore exclude urban centers. Agricultural areas were only included for the purpose of saltmarsh recreation, but the decision support system also identifies future food insecurity as a significant opportunity cost in future climate change scenarios.

Managed Coastal Retreat. A Legal Handbook on Shifting Development Away from Vulnerable Areas

https://web.law.columbia.edu/sites/default/files/microsites/climate-change/files/Publications/Fellows/ManagedCoastalRetreat_FINAL_Oct%2030.pdf
Siders. 2013.

A handbook collating useful information on existing legal tools that assist federal, state and local governments in implementing managed retreat. On page 5, it includes a table that gives a description of legal and policy tools, and examples of cases where these have been implemented.

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Rising seas adaptation: mangrove nursery at the University of the West Indies at Port Royal, Jamaica.

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**Diversification and protection
of ecosystem-based livelihoods**

4.8



Introduction to livelihood diversification

Livelihoods are the set of capabilities, assets, and activities that are required to make a living (Ellis, Kutengule and Nyasulu 2003). They depend on access to natural, human, physical, financial, social and cultural capital – in other words, assets (IPCC 2012). In particular, ecosystem-based livelihoods are dependent on ecosystem services, which are sensitive to climate change impacts, such as changing rainfall patterns, saline intrusion from sea level rise, and changes to ocean temperature and acidity. These livelihoods are therefore strongly linked to peoples' vulnerability to climate change (IUCN 2004; The World Bank 2010) and must be adaptable to ecological changes in order to increase resilience and sustainability (Ferrol-Schulte et al. 2013).

Diversification of livelihoods and income sources can form an essential component of managing climate risk (Olsson et al. 2014), yet can also represent a challenging, or potentially maladaptive, option for resource-dependent communities whose identities are strongly linked to their occupations and sense of place (Marshall et al. 2012). Collaborative strategies such as the Sustainable Livelihoods Enhancement and Diversification (SLED) approach can help to form beneficial and community-based frameworks by building on local knowledge, strengths, and an understanding of the resources available to these communities (IMM 2008; see 'Useful resources' section below). This is especially important for developing nations and rural communities (IPCC 2012).

Livelihood diversification and protection as an EBA measure

People living in coastal communities are often dependent on natural resources and ecosystem services for their livelihoods, particularly fisheries, agriculture and ecotourism (Uy et al. 2011). Since ecosystem-based livelihoods are often linked to community values, culture, and identity (Marshall et al. 2013), EBA measures must be formed from community-led processes that identify areas where diversification could strengthen, rather than hinder, community resilience (Adger et al. 2012; Tanner et al. 2015). For instance, fisheries-dependent communities may alter targeted species, gear types, or fishing locations rather than shifting to new occupations (Ruckelshaus et al. 2013), while farmers may select alternative, more climate-resilient crops or methods, such as drip-irrigation (GEF and UNCCD Secretariat 2011; Girot, Ehrhart, and Oglethorpe 2012).

However, as noted by the World Bank (2010), shifting to new, climate-resilient livelihoods may also be needed to effectively reduce climate risk to communities. Uy et al. (2011) and IISD (2003) both argue that the more varied the assets of a community, the more sustainable and secure its overall future livelihoods, and the more likely that climate change efforts will be successful. Measures may also shift away from reliance on natural resources and ecosystem services that may be vulnerable to change by encouraging the

development of small businesses in more resilient sectors (Uy et al. 2011; The World Bank, 2010), which may also help to increase the resilience of ecosystems by reducing the number of pressures they face (Hansen et al. 2003). Other potential livelihood strategies include exploiting more climate-resilient natural resources and ecosystem services in a sustainable manner through promotion of ecotourism or value-added processing of natural products, for instance.

Key issues that can affect success

When considering or implementing livelihood diversification measures as part of an EBA strategy, there are also a number of risks or limitations to take into account. Livelihood measures for adaptation need to take climate change as their starting point, based on a vulnerability assessment. If climate change is not used as a starting point they may result in 'business-as-usual' livelihood strategies or community-based natural resource management outcomes, rather than actually reducing vulnerability of the community to climate change (Girot et al. 2012). In addition, livelihood diversification should take account of peoples' capacities, cultural values and need for socioeconomic security. Ultimately, it is important to include ecological concerns and foster an inclusive approach. Considering community and environment separately will make it difficult to achieve the goal of EBA (Girot et al. 2012; IMM 2008).

It is also useful to remember the principles of equity and differential vulnerability; new or diversified livelihoods are of little to no use for promoting community adaptation if the most vulnerable people cannot access them or lose access to other livelihoods in the process (Uy et al. 2011). For instance, financial constraints can prevent communities from successfully implementing new livelihood strategies or entering new sectors. As highlighted earlier, it is also important to consider potential trade-offs: for example, an increase in the resilience of some people's livelihoods may directly lead to a reduction in others' (Tanner et al. 2015). Therefore, it is important to frame these measures in accordance with human rights and improvement of living conditions, particularly for marginalised communities (Tanner et al. 2015).

Useful resources

Sustainable Livelihoods Enhancement and Diversification (SLED): A manual for practitioners

http://www.iucn.org/knowledge/focus/previous_focus_topics/2009_marine/?uNewsID=2653

IMM. 2008.

The approach outlined in this manual builds on the lessons of past livelihoods research projects and worldwide experience in livelihood improvement and participatory development practice. The manual aims to provide a set of guidelines and key principles for development and conservation practitioners whose task it is to assist people in enhancing and diversifying their livelihoods. The approach provides a framework within which diverse local contexts and the local complexities of livelihood change can be accommodated.

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Marine Protected Areas (MPAs) **4.9**



Introduction to MPAs

Marine Protected Areas (MPA) are areas set aside to protect marine ecosystems. They are an example of an area-based management measure relevant to EBA; others include integrated coastal management (ICM) and marine spatial planning (MSP). MPAs have a clearly defined geographical space, which is recognised, dedicated and managed (through legal or other effective means) to achieve longterm conservation of nature, along with associated ecosystem services and cultural values (Dudley 2008). Globally, MPAs cover 3.4% of the world's oceans, and over 10% of coastal waters (Juffe-Bignoli et al. 2014).

Common onsite approaches to establishing Marine Protected Areas

The most common approach to establishing an MPA or MPA network involves legally designating a defined geographical area or areas for the purpose of marine protection, and subsequently managing and monitoring the site. The selection of MPA sites should be informed by sound consideration of their effectiveness to fulfil their objectives, which beyond conserving biodiversity, may include climate change adaptation and livelihood diversification. More details on the broader range of issues that can affect success are presented below.

Marine Protected Areas as an EBA measure

MPAs are a tool to conserve species and habitats, maintain ecosystem functions and resilience, manage fisheries, reduce risks from natural disasters and protect natural and cultural resources and values important to human well-being (Salm et al. 2000). Increasingly, their relevance to climate change adaptation is being recognised (Dudley et al. 2010). MPAs often safeguard natural ecosystems in seascapes characterised by mounting development pressures and they benefit from legal recognition or institutional backing that ensure their long-term commitment to protection (Dudley et al. 2010).

Furthermore, in order to be a successful adaptation option, MPAs should have agreed governance and management approaches and the capacity to implement management plans and to carry out monitoring and evaluation (Dudley et al. 2010). With such structures and capabilities in place, coastal MPAs are well positioned to support EBA.

MPAs can support fisheries

Fishing and harvesting of marine resources are the primary livelihood activity of many coastal residents (Loper et al. 2008). The positive ecological impacts MPAs can have on fisheries, such as increased biomass, species density, species richness and size (Lester et al. 2009), can lead to spillover of adult species into surrounding areas, in particular from no-take zones (Halpern et al. 2010), therefore benefitting coastal economies through increased catch and catch per unit effort (Russ et al.

2004). MPAs can therefore provide a means for offsetting the combined impacts of over-fishing and climate change on fish stocks.

MPAs can lead to improvements in coral cover, reef ecology and structural integrity by limiting practices of destructive fishing on reefs (Christie, 2005), all of which contribute to building ecosystem resilience and reducing risks to humans from natural disasters, which are predicted to increase under climate change (Helmer and Hilhorst 2006).

Marine Protected Areas can contribute to diversified livelihoods

MPAs can also help people build their resilience by offering alternative sources of livelihoods and income. Tourism is often promoted in MPAs in the form of snorkelling, diving, wildlife viewing, cultural or eco-tourism in order to create employment and generate revenue (Leisher et al. 2007). Besides generating livelihood options through direct employment in park management, MPAs can also assist local communities in developing other alternative livelihood options that are sustainable in the context of the MPA and diversify people's income sources. Alternative livelihood options within MPAs could include climate change-resistant agricultural activities, raising livestock, aquaculture, mariculture, seaweed farming, beekeeping, handicrafts or tree nurseries. If climate change makes some livelihoods less reliable, access to a wide variety of livelihood options can mean people and communities may be less impacted by a reduction in any one livelihood.

If well managed, MPAs have great potential to contribute to EBA as they 'can lead to increased food security, wealth and household assets, and levels of employment (particularly from tourism), diversified livelihoods, improved governance, greater access to health and social infrastructure, revitalized cultural institutions, strengthened community organization, greater participation in natural resource management, increased empowerment of women and reinvigorated common property regimes for local communities (Bennett and Dearden 2014).



In Indonesia, the northern Raja Ampat limestone islands protect a beautiful lagoon where a shallow coral reef thrives
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Key issues that can affect success

MPAs need good design and management

Although MPAs do have the potential to create a wide variety of benefits to people through the use of nature-based approaches, their implementation as an EBA option needs careful consideration. As much as MPAs can have positive effects on building the resilience of coastal communities, they can equally have the potential to reduce resilience. These include worsened conflicts and political struggles, increased vulnerabilities, alienation or marginalisation of fishermen in natural resources management processes, loss of assets or tenure, inequitable distribution of benefits or decreased food security in the short term (Lutchman 2005). To avoid the generation of adverse socioeconomic impacts and negative ecological knock-on effects, MPAs need to be well designed and effectively managed. This requirement is met in only a minority of cases, however. Globally, only 24% of all protected areas are managed 'soundly' (Leverington et al. 2010) and of MPAs in South East Asia, for example, only 14% are estimated to be effectively managed (Burke et al. 2006). Limited management effectiveness and coverage of protected area networks reduces their ability to be robust enough to withstand climate change and contribute positively to response strategies (Dudley et al. 2010). The potential of MPAs to make contributions to biodiversity conservation, supporting livelihoods and fisheries management as well as climate change, therefore currently remains only partially realized.

In order for MPAs to fulfil their potential as tools to support

EBA, their design, effectiveness and limitations need to be fully considered. Other EBA options presented in this Guide have the potential to be incorporated into an MPA. Ecological guidelines in MPA design are also important, including habitat representation, risk spreading, protecting critical, special and unique areas, incorporating connectivity, allowing for recovery, minimizing local threats and adapting to ocean chemistry and climate change (see Green et al. 2014 in 'Useful resources' for more details). In relation to climate change, it is important to allow for responsiveness and flexibility in MPA design as possible effects of climate change on marine ecosystems could, amongst other things, shift critical ecological functions outside MPA borders (see Brock et al. 2012 in the 'Useful resources' section for more details).

MPAs need good governance

Good governance is crucial both for effective and equitable conservation and in determining the effectiveness and efficiency of MPA management (see Borrini-Feyerabend et al. 2013 in 'Useful resources' for more details). Good governance can build a solid base for management, development and the achievement of desired social and ecological outcomes by creating an enabling institutional environment, determining the process of implementation and design of MPAs and choosing the management structure and design (Bennett and Dearden 2014). Early and meaningful engagement with local communities and other key stakeholders is crucial in order to determine contextually appropriate and mutually-accepted MPA objectives, management structures and design that all

stakeholders agree to support, thereby reducing potential for future conflict (Bennett and Dearden 2014).

MPAs require adequate management capacity and resource availability

Even with effective governance in place, the potential of an MPA to achieve positive social and ecological outcomes is highly dependent on management capacities and available resources to carry out its planned actions, law enforcement, monitoring and evaluation.

Understanding the context in which MPAs operate is key

In addition to a myriad of other factors to take into account in creating an effective MPA (Pomeroy et al. 2005), in all cases it is important to consider its design and implementation in the appropriate local socioeconomic and planning context in order to avoid 'risk of misfit' (Jentoft et al. 2007). MPAs need to be integrated into broader marine and coastal management and zoning efforts. For MPAs to maximize their contribution to EBA not only within the specific area they are established to protect, but also to the wider land- and seascape, it is important to integrate them into broader marine and coastal management efforts (Agardy et al. 2011). MPAs can, for example, be more effective in supporting fisheries if they are nested within other fisheries management actions outside their boundaries (Gell and Roberts 2003). Also see section 4.10 on fisheries management plans.

Policies for MPAs need to recognise the interconnectivity between terrestrial and marine systems

As many threats to coastal and marine systems originate on land, it is important to create policies that span both terrestrial and marine realms so that they are managed consistently (Gell and Roberts 2003). Considering the interconnectedness of systems beyond MPA borders can also help increase ecosystem resilience to climate change, such as with coral reefs that can become more resilient when combined with the reduction of sedimentation and nutrient loading as well as land and marine-based sources of pollution (Keller et al. 2009). For this reason, local and national governments could usefully incorporate the role of MPAs in climate change response strategies and action plans (Dudley et al. 2010), including EBA.

Useful resources

Marine Spatial Planning in Practice –Transitioning from Planning to Implementation. An Analysis of Global Marine Spatial Planning Experiences

<http://www3.cec.org/islandora/en/item/10856-guide-planners-and-managers-design-resilientmarine-protected-area-networks-in-en.pdf>

Green et al. 2014.

Includes a useful table with ecological guidelines for marine reserve networks to fulfil three main objectives: fisheries management, biodiversity conservation and climate change adaptation. The guidelines are sorted according to categories, including habitat representation (e.g. suggesting that 20 – 40 % of major habitats be represented in marine reserve networks); risk spreading; protecting critical, special and unique areas; incorporating connectivity; allowing time for recovery; adapting to changes in climate and ocean chemistry; and minimizing and avoiding local threats.

Scientific Guidelines for Designing Resilient Marine Protected Area Networks in a Changing Climate

<http://www3.cec.org/islandora/en/item/10856-guide-planners-and-managers-design-resilientmarine-protected-area-networks-in-en.pdf>

Brock et al. 2012.

The guidelines promote best practice, collaboration and consistency of approach when designing MPAs. They provide detailed steps for scientists, managers and planners on how to work toward meeting objectives considered critical to improving resilience toward climate change and includes case studies for each objective. Additionally, Annex 2 provides a useful table: "Generalized effects of climate-driven oceanographic changes on components of the ecosystem" that uses species groups as indicators for climate-driven pressures. For example, an increase in water and/or air temperature would reduce size of phytoplankton, increase jellyfish abundance and result in a northward shift in distribution of benthos and fish.

Governance of protected areas: from understanding to action. Best practice protected area guidelines series No. 20.

http://cmsdata.iucn.org/downloads/governance_of_protected_areas___from_understanding_to_action.pdf

Borrini-Feyerabend et al. 2013.

Includes specific guidelines for governance of protected areas. The first part provides an explanation with examples of the four different governance types recognised by the IUCN: governmental, shared, private, and governance by indigenous or local peoples. Table 2 sums management objectives for different protected area categories and their corresponding international name. The second part of the report provides detailed and useful information on how to evaluate governance of protected areas, including a step-by-step framework for assessing governance, including key questions that can be asked in an evaluation of protected area governance. Furthermore, specific assessments of existing protected areas are used as case studies.

Governing Marine Protected Areas – Getting the balance right

<http://www.unep.org/ecosystemmanagement/Portals/7/governing-mpas-final-technical-reportweb-res.pdf>

Jones and Qiu. 2011.

Technical report that brings together 20 MPA case studies from different regions around the world. The report looks at MPAs from a governance perspective and deals with the question of how to “combine top-down, bottom-up and market approaches for reaching and implementing decisions in order to achieve effective and equitable MPAs”.

Changing tides – Climate Adaptation Methodology for Protected Areas (CAMP)

http://d2ouvy59p0dg6k.cloudfront.net/downloads/climate_adaptation_methodology_for_protected_areas_campa_web_1.pdf

WWF International. 2014.

Report on the Climate Adaptation Methodology for Protected Areas (CAMP) which has been developed to help managers of coastal and marine protected areas and other stakeholders to respond and adapt to climate change.

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**Sustainable fisheries
management** **4.10**

Introduction to fisheries management

Sustainable fisheries management is an integrated process that seeks to attain an optimal state that balances ecological, economic, social and cultural objectives for fisheries (see FAO 2003). Management strategies have increasingly turned towards the ecosystem approach to fisheries management (EAFM, or 'ecosystem-based fisheries management', EBFM) as an alternative to species-based management in order to account for the broad range of interdependent relationships that occur within ecosystems (FAO 2003).

The key features of EAFM include:

- Consideration of the ecological, social, and governance processes over broad spatial and temporal scales;
- A focus on resilience;
- Adaptive management, co-management, institutional cooperation and coordination; and
- A precautionary approach (Heenan et al. 2015).

These features, combined with those outlined in Table 1 of Heenan et al. (2015) (see details in the 'Useful resources' section), offer a valuable and adaptive framework for guiding coastal fisheries management under climate change.

Common on-site approaches to fisheries management

Common on-site approaches for fisheries management include regulating the volumes of different species which can be caught and the methods that can be used to catch them, as well as designating specific geographic

marine areas for protection or restricted fishing activity to encourage sustainable management of fisheries in the long term. Ongoing management, monitoring, and evaluation are also needed to ensure effective implementation. More details on the broader range of issues that can affect success are presented below.

Fisheries management as an EBA measure

Effective EAFM can achieve multiple objectives that increase coastal communities' resilience under climate change and therefore act as an ecosystem-based adaptation (EBA) measure. For example, community-based EAFM (CEAFM) strategies have been applied successfully in the State of Yap and the Federated States of Micronesia to address destructive fishing practices, land-based marine damages, and climate change impacts. These examples involved community-led consultations that identified longterm objectives and drafted Community Fisheries Management Plans, encouraging local participation and generating beneficial outcomes for fisheries (Martin, Bruncken, & Ropeti, 2015; for guidelines, see 'A Community-based Ecosystem Approach to Fisheries Management' in the



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'Useful resources' section below). Maximizing ecosystem services in degraded reefs and other marine habitats requires a portfolio of management strategies that include EAFM approaches (e.g., fish aggregation devices, herbivore management; Rogers et al. 2014), with a strong relationship between fisheries production and the health of coastal ecosystems. Likewise, while climate-induced ecosystem phase shifts can reduce fisheries production (Ainsworth and Mumby 2014), a reduction in fishing pressure has also been shown to aid ecosystem recovery, thereby providing benefits through restored ecosystem services (Bates et al. 2013).

EBA approaches can also result in enhanced food and economic security through restoration of shellfish and coral reefs that support species of importance to subsistence and commercial fisheries (Spalding et al. 2014). Furthermore, interdependence has been exhibited between coastal habitats: for instance, coastal vegetative habitats such as seagrasses and mangroves provide nurseries for the early life-stages of reef fish and are, in turn, sheltered from incoming waves by coral reefs (Saunders et al. 2014). Thus, EAFM can complement other EBA strategies to improve the holistic resilience of coastal human and ecological systems and the availability of ecosystem services.

Key issues that can affect success

To achieve successful implementation of an effective, climate-informed EAFM framework, planning processes must be inclusive, involving all relevant sectors of society and scientific disciplines in participatory decision-making to avoid conflicting priorities and mandates, with transparent definitions of management objectives and discussion of the trade-offs between these objectives (Heenan et al. 2015). Throughout this process, an EAFM framework must underpin and support local livelihoods and marginalised populations, with particular attention given to improving food and economic security.

Vulnerable communities should therefore be central to planning, with EAFM measures complementing community-based adaptation measures (see 'A Community-based Ecosystem Approach to Fisheries Management' in the 'Useful resources' section below). Policy measures which aim to strengthen these aspects will support effective coastal EBA outcomes (for more information on the importance of policy measures in adaptation, see Chapter 3). The package of EAFM measures should also be integrative, taking a balanced approach across all management options to identify the most suitable measures for each fishery in order to improve outcomes (Fulton et al. 2014). Biogeographic shifts of species and habitats are likely to challenge EBA strategies that are fixed in geographic location (Pörtner et

al. 2014). EAFM strategies therefore require the flexibility to respond to spatial and temporal shifts in ecological and climatic conditions (e.g., Levin & Mollmann, 2014). Geographic Information Systems (GIS) offer tools to model and map current and future environmental conditions, providing the capacity to explore different scenarios and thereby proactively create and implement EBA strategies that respond to these changes (see Carocci et al. 2009 in the 'Useful resources' section).

As an adaptive and precautionary process, EAFM must also be accompanied by ongoing monitoring and evaluation to determine whether the plan is meeting the original objectives, with the flexibility to alter the approach if necessary (Heenan et al. 2015). These objectives should be delineated using indicators (e.g., spawning stock biomass, % sustainable stocks) that enable comparison between the target and the baseline, requiring knowledge of the initial state of the system and the pressures it faces (for detailed discussion, see Jennings 2005; for a useful tool and examples of indicator selection criteria, see 'IndiSeas' in the 'Useful resources' section below).

Useful resources

A Climate-Informed, Ecosystem Approach to Fisheries Management

http://ac.els-cdn.com/S0308597X15000676/1-s2.0-S0308597X15000676-main.pdf?_tid=a2c8228c-8885-11e5-8f57-00000aacb35e&acdnat=1447254504_72f83503e258bf8a5bfcdca39cef03dad

Heenan et al. 2015.

This open access paper outlines the benefits of using the EAFM framework for approaching climate change adaptation in fisheries. The paper highlights activities essential to the successful implementation of EAFM: defining the fisheries management unit, identifying and prioritising issues and goals, and developing the EAFM plan with clear objectives.

Essential EAFM. Ecosystem Approach to Fisheries Management Training Course

http://www.pifsc.noaa.gov/cred/eafm_training/NOAA.

Offers access to training course materials and guidance for implementing EAFM.

Ecosystem Approach to Fisheries Planning and Implementation Tool.

<http://www.fao.org/fishery/eaf-net/eaftool/search/en>
FAO.

The EAF Tools Database provides access to descriptions of all identified tools that could assist facilitators, managers, and planners with adopting EAF into their management plans.

Ecosystem-Based Management Tools Network and Database

<https://ebmtoolsdatabase.org/>

[Coastal-Marine Ecosystem-Based Management Tools Network.](#)

This is an online platform that facilitates access to decision-support tools for innovative, interdisciplinary marine spatial planning and ecosystem-based management, with a broad geographic selection of case studies.

Geographic Information Systems to support the ecosystem approach to fisheries: Status, opportunities, and challenges

<http://www.fao.org/docrep/012/i1213e/i1213e00.htm>

[Carocci et al. 2009.](#)

This technical paper provides guidance for using GIS software as analytical and decision-support tools for developing EAFM strategies under current and future environmental conditions.

Community-Based Ecosystem Approach to Fisheries Management: Guidelines for Pacific Island countries

ftp://ftp.fao.org/fi/DOCUMENT/eaf/eafguidelines_278364.pdf

[Secretariat of the Pacific Community.](#)

This document provides guidance for implementing a community-based ecosystem approach to fisheries management (CEAFM), which is the management of fisheries, within an ecosystem context, by local communities working with the government and other partners.

IndiSeas

<http://www.indiseas.org/>

Useful comparative tool illustrating the status of different regions based on ecological, climatic, and socioeconomic indicators, outlining indicator selection criteria.

Ecosystem Approach Sourcebook Database

<https://www.cbd.int/ecosystem/sourcebook/search/>

[CBD.](#)

Provides examples of lessons learned and outcomes, outlining tools and approaches used, principles, and operational guidance.

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Getting results

05



Getting results

EBA approaches need commitment over the long term in order to get results and realise the maximum possible benefits for adaptation. Adaptation is a continuous process of learning to live with change and making decisions in the context of uncertainty. Monitoring and evaluation are critical to the success of adaptation efforts, both for informing ongoing adaptive management and to enable learning and sharing of experience to promote wider application and mainstreaming of successful approaches.

Why monitoring EBA actions is important

Monitoring and evaluation (M&E) activities form an important component of the implementation strategy for an EBA option. M&E provides an understanding of the extent of progress against objectives, allowing managers to identify gaps or barriers to progress and to adjust the adaptation option and/or its implementation accordingly. M&E thus supports iterative planning or adaptive management by highlighting whether a particular activity is on track to achieve its adaptation objectives or needs to be modified in order to better achieve them, or whether resources can be redirected to another activity that is having more positive results. It should include performance monitoring – assessment of whether planned activities to implement the EBA option are successfully being carried out, and evaluation of whether intermediate objectives are being met and of whether the measure ultimately will reduce the vulnerability of people and ecosystems to climate change. Evaluation also needs to consider changes to the context of the EBA measure, including the development context and environmental conditions such as climate. It is especially important in the latter respect for managers to think about whether EBA efforts will maintain their effectiveness under significant future change. Such

assessment is also important in order to learn lessons about what implementation activities and approaches are most effective to help improve practice and enhance achievements next time a similar adaptation action is implemented (see Learning and sharing results section below).

In addition to collecting information, the M&E process needs to ensure that information is properly evaluated and reviewed in order to support adaptive management. A clear process or mechanism for reviewing and discussing M&E information, and then determining next steps, should be incorporated into an M&E plan. Including multiple stakeholders in these discussions will provide more comprehensive feedback on what is, and is not, working.

How to carry out effective M&E

Monitoring can be resource- and time-intensive, so careful consideration is recommended in deciding what to measure and how, and which indicators will be used to serve this purpose. The M&E process should also include elements to ensure accountability and transparency (for example, regular performance assessments, and the participation of stakeholders). Equally important is considering the availability of information for monitoring,



Protective stone wall by the roadside, Seychelles

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BOX 5: PRACTICAL QUESTIONS FOR CONDUCTING M&E OF EBA EFFORTS

Developing an M&E plan, including selecting indicators, should take account of both the feasibility (technical/expense) of the methods of measurement and the availability of information to calculate baselines and for monitoring. Linking to ongoing monitoring efforts in the area of interest can help to supplement the limited resources usually available for monitoring. The following questions should be considered when developing an M&E plan:

- Is there a baseline? Effective M&E requires a baseline of information regarding the current situation, in order to monitor changes. If there is no baseline, then the collection of this information needs to be incorporated into your M&E plan.
- How will information be collected? The methodology including secondary sources to be used, the process for collecting primary information, how the baseline will be established, and how the information will be documented and stored.
- When will information be collected? The frequency and timing of information collection and information processing, taking into account whether the primary data collection needs to take place at a particular time of year.
- Where will the information be collected? I.e. at which location(s) and at what scale?
- By whom? Who is responsible for information collection and for analysis?
- For whom? Who will use the information? And who should receive the information?
- Feedback/evaluation? How and by whom will the monitoring information be evaluated?
- Cost? What resources are needed? Are the costs sustainable or does the monitoring plan need to be adjusted? Are there ongoing, similar data collection processes that can be built upon?

These questions can most likely be answered during the formulation of an M&E plan; however, answering some questions may require a process of consulting more widely with partners and stakeholders, e.g. to identify who should be involved in monitoring or synergies with other data collection processes.

For further information on how to design and implement effective M&E for EBA options, please see the section on 'Useful resources' below. This includes links to some case studies of existing EBA projects.

Source: Adapted from: table 8, page 51, Ayers, J. et al. (2012). Participatory Monitoring, Evaluation, Reflection and Learning for Communitybased Adaptation: PMERL Manual – A manual for local practitioners, CARE International; and Coastal EBA Decision Support Tool: http://www.care.org/sites/default/files/documents/CC-2012-CARE_PMERL_Manual_2012.pdf

including opportunities for making use of existing sources of information and already-established processes, and how this may change during implementation. Box 5 below provides some more information about these and other practical questions to consider when designing an M&E plan.

Monitoring EBA actions generally requires formulating and tracking indicators that measure the adaptation outcomes, that is, the positive and negative impacts of the intervention on the resilience and adaptive capacity of the ecosystem services and on the human communities that rely on them. In addition to such outcome indicators, M&E should include context indicators that track external parameters that influence ecosystem service supply (including climate), as well as indicators that track the

progress of implementing activities, including those directed at the enabling environment (e.g. to enhance governance). Overall, indicators should address several key aspects of a well articulated theory of change for the measure being implemented (see Constructing theories of change for Ecosystem-based Adaptation projects: a guidance document within the Useful resources section). Indicators selected for monitoring EBA should contribute to measuring changes in the resilience and adaptive capacity of ecosystems and communities, as well as reductions in vulnerability. Such indicators might focus, for example, on the capacity of coral reefs to recover from bleaching events, and the ability of the reef to attenuate wave energy, providing further information about the provision of a key ecosystem service for coastal communities. Monitoring subsequent changes

BOX 6: PRINCIPLES OF EFFECTIVE MAINSTREAMING OF CLIMATE CHANGE ADAPTATION

Finding entry points and making the case:

- Define climate change adaptation in terms that are relevant to the goals of other sectors.
- Identify targets (sectors, policies, organizations) where mainstreaming of adaptation is likely to have the largest impact.
- Be clear about what trade-offs exist and enter into discussion on how they can be dealt with.
- Ensure engagement with key ministries (e.g. environment, finance, planning sectors) and other non-governmental actors (e.g. representatives of communities and the private sector).
- Increase awareness among sectors that national development goals and key sector strategies (e.g. agriculture, health, energy, tourism) can be affected by climate change, that poor people are likely to be the most affected by climate change and that national development and sectors can in turn affect the climate change vulnerability of the country.
- Analyse and understand the changing motivations and opportunities of each sector, including the effects of globalization, as well as differential power dynamics between sectors and how these can be managed.
- Implement activities in collaboration with finance and planning, or relevant sector, ministries.
- Mainstream climate change adaptation into policy processes:
 - Use existing national, sectorial or local analytical/planning processes as far as possible, rather than attempt to run special 'adaptation' processes.
 - Collect country-specific evidence on the costs and benefits of climate change and adaptation (e.g. vulnerability and impact and adaptation assessment, socioeconomic analysis, demonstration projects).
 - Work to include consideration of adaptation within targeted policy processes and the working and policy documents they produce (e.g. documents and policies related to economic policy reforms, poverty reduction strategy papers, relevant sector or subnational plans).
 - Work to ensure that climate-proofed and specific adaptation policy measures are included within budgets of finance and planning or sector ministries and subnational bodies.

Meet the implementation challenge:

- Integrate adaptation-related indicators into existing national monitoring systems.
- Increase budget allocations and public expenditures for adaptation policy measures within non-environment ministries and subnational bodies.
- Establish adaptation mainstreaming as standard practice in government and administrative processes, procedures and systems (e.g. systematic inclusion of adaptation in public expenditure reviews).
- Encourage sustained behavioural change within individuals, institutions, and society and in both public and private domains.

Source: Adapted from: UNDP-UNEP Poverty-Environment Initiative (2011). Mainstreaming Climate Change Adaptation into Development Planning: A Guide for Practitioners. UNDP-UNEP Poverty-Environment Facility, Nairobi; Huntley, B.J. and K.H. Redford (2014). Mainstreaming biodiversity in Practice: a STAP advisory document. Global Environment Facility, Washington, DC., USA; IIED (2013). Entebbe Statement on Biodiversity in Development Planning. NBSAPs 2.0: Mainstreaming Biodiversity & Development. IIED, London, United Kingdom. August 2013; Dalal-Clayton, B. and S. Bass (2009). The challenges of environmental mainstreaming: Experience of integrating environment into development institutions and decisions. Environmental Governance No. 3. IIED, London, United Kingdom.

in the impacts of waves and storm surges on coastal communities will then provide more information about effects of coral reef conservation/restoration on the vulnerability of people to climate change impacts in the area.

Monitoring EBA actions, and the indicators used to do so, may share some similarities with monitoring approaches for tracking ecosystem-based management, i.e. conservation or ecosystem management projects that are not specifically related to climate change adaptation.

However, there are key differences to consider to ensure that the monitoring of EBA action is actually delivering information on adaptation and resilience outcomes. For example:

- Not all ecosystem functions or services are important for resilience or the adaptation of ecosystems and human communities to climate change. Monitoring for EBA should focus on tracking changes in those services that have been identified as important through a vulnerability and impacts assessment process (for more information see Munroe et al. 2015 in the Useful resources section below).
- Monitoring for EBA should also consider the resilience of the EBA action itself to climate change impacts. Even if an action achieves clear improvements in ecosystem function or benefits for a community reliant on such functions, if the gains are short-term and are reduced or negated in the future by the changing climate, then effective adaptation may not be achieved.
- EBA is about facilitating the adaptation of people, as well as ecosystems, to climate change. Therefore, EBA actions need to demonstrate that they are improving the resilience or reducing the vulnerability of communities, through the enhancement or maintenance of key ecosystem services. Monitoring for EBA must also take into account the results of the actions for target communities, rather than for the ecosystem or its components only.

Sample indicators (and examples of monitoring methods for each indicator) for an EBA option involving the conservation and/or restoration of coral reefs are outlined in Table 4. These relate to ‘questions’ formulated to guide the process of indicator development and clearly define what information is desired.

Learning and sharing results

Improving outcomes and further uptake of EBA are dependent on effective learning from results and sharing this information with relevant At the project level, outcomes can be improved if adjustments are made as a result of such learning. Adaptive management facilitates the collection, evaluation and review of results, in order to learn from implementation experiences and inform subsequent adjustments needed for the adaptation option and its implementation. For more information on adaptive management and how it can assist implementers in learning from their coastal EBA results, please refer to the Coastal EBA Decision Support Tool (DST) available online here <http://web.unep.org/coastal-eba/coastal-EBA-DST>.

Additionally, although adaptation activities are to some degree site- and context-specific, the management factors that determine success are applicable across projects more broadly. For this reason, once results and lessons learned have been collected under a project, sharing and communicating these to relevant stakeholders can help in improving EBA knowledge and effectiveness more broadly among the adaptation practitioner community. Currently, little information is available on exactly which adaptation options work most successfully in which contexts. Consolidating the information gathered through M&E will help to improve the adaptation process over the long term, and help replicate/scale-up effective adaptation activities. If such information is shared with other countries, then the overall evidence-base for EBA and other adaptation options will be enhanced, enabling more evidence-based decisions on adaptation policy and implementation. Such information will also help researchers and donors to identify where additional research and funding may be needed to help overcome challenges. Equally, a more developed evidence-base will help to convince those investing in adaptation measures to continue funding EBA actions.

Effective adaptation communication and mainstreaming

A wide range of stakeholders affect and are affected by EBA actions and outcomes. Tailoring communication on EBA to specific relevant audiences is more likely to result in successful EBA planning and implementation. Those audiences will include stakeholders from several contexts and scales, from the local level (e.g. local government, local communities, businesses and vulnerable groups), to the national level (e.g. various government ministries) and even the global level (e.g. UN agencies/organizations, international banks and development organizations). One good way to facilitate exchange of information on EBA is through capacity building workshops. Other examples include meetings and seminars, community consultations, presentations and information brochures and leaflets. More information on factors to consider when communicating EBA to different types of stakeholders and on undertaking capacity building workshops can be found in the Coastal EBA DST.

Sharing results and information with stakeholders is part of the answer to the complex challenge of mainstreaming of EBA into other sectors and policies. Mainstreaming of EBA is the informed inclusion of EBA concerns into the decisions of institutions that drive relevant international, national, local and sectoral policies, rules, plans, investment and action. The experiences of development agencies and nation states in mainstreaming adaptation,

biodiversity and the environment into predominantly development and economic sectors have helped to highlight several principles that can support effective mainstreaming of climate change adaptation (see Box 5 below). In any mainstreaming effort, it is important to ensure that the process is under the full ownership of the country or locality in question.

Communities, planning processes, sectors and countries can learn from the experience of implementing EBA to help with their overall integration and implementation of adaptation actions. Presenting positive experiences, as well as challenges and obstacles, can help other organizations or departments avoid undertaking activities which undermine the EBA options being implemented.

Useful resources

Constructing theories of change for Ecosystem-based Adaptation projects: a guidance document.

http://www.conservation.org/publications/Documents/CL_IKI-ToC-Guidance-Document.pdf

Conservation International. 2013.

A document considering how adaptation options relate to each other in order to achieve an overall outcome. It also provides information on developing indicators for EBA.

Annex C2: Resources that aid in linking activities to outcomes' in Ecosystem-based adaptation guidance: Moving from principles to practice ('EBA Decision Support Framework').

Travers et al. 2012. UNEP Working document. An EBA guidance resource annex covering linking activities to outcomes, and the utility of different tools to help do so.

'Annex C3: Ecosystem-based indicators' in Ecosystem-based adaptation guidance: Moving from principles to practice ('EBA Decision Support Framework')

http://www.unep.org/climatechange/adaptation/Portals/133/documents/Ecosystem-Based%20Adaptation/Decision%20Support%20Framework/EBA%20Guidance_WORKING%20DOCUMENT%2030032012.pdf

Travers et al. 2012. UNEP Working document.

An EBA guidance resource annex providing sample indicators against impact types and adaptation options.

Reef Resilience Program

<http://www.reefresilience.org/>

The Nature Conservancy.

A partnership led by The Nature Conservancy that builds the capacity of reef managers and practitioners to address local impacts on coral reefs from climate change

and other stressors. Website provides case studies on selected reef projects; e.g. Disturbance Response and Monitoring Program in Action in the Florida Keys.

Global Climate Change Alliance+

<http://www.gcca.eu/>

Global Climate Change Alliance (GCCA). 2012.

The GCCA+ Intra-ACP Programme, funded under the 10th European Development Fund (EDF) financial framework, supports the 79 member countries of the African, Caribbean and Pacific (ACP) Group of States in their adaptation and mitigation responses. Includes case studies of projects: for example, Reducing climate vulnerability in São Tomé and Príncipe.

Restoring Guyana's Mangrove Ecosystem

<http://www.mangrovesgy.org/home/>

Mangroves Project. 2014.

Project website for the Guyana Mangrove Restoration Project, funded by a partnership between the Government of Guyana and the European Union. The project started in February 2010 and is working in the areas of administrative capacity development, research, community development and capacity building, mangrove restoration (replanting), monitoring and awareness and education. The website includes project documents, a section on monitoring and enforcement, project activity reports, etc.

Guidance on Integrating Ecosystem Considerations into Climate Change Vulnerability and Impact Assessments to Inform Ecosystem-based Adaptation

http://www.undp-alm.org/sites/default/files/downloads/viag_guidance.pdf

Munroe et al. 2015.

Provides information and advice on how to integrate consideration of ecosystems and their services into a climate change Vulnerability and Impact Assessment (VIA), through a step by step process. Each step describes key questions to be answered, outlines the process of carrying out the step, identifies relevant outputs and refers the reader to other useful materials. It also uses a fictional case study to illustrate the type of information that might be collected at each step.

Monitoring and Evaluating Adaptation

<http://www.gsdr.org/go/topic-guides/climatechange-adaptation/monitoring-and-evaluatingadaptation>

GSDR Applied Knowledge Services.

Webpage providing information on how to monitor and evaluate adaptation efforts, including useful links to additional online resources for monitoring and evaluation.

Good Practice in Designing and Implementing National Monitoring Systems for Adaptation to Climate Change

[http://www.unepdtu.org/-/media/Sites/Unepriose/News%20Item%20\(pdf\)s/National%20Monitoring%20Systems%20for%20Adaptation_Final_web.ashx?la=da](http://www.unepdtu.org/-/media/Sites/Unepriose/News%20Item%20(pdf)s/National%20Monitoring%20Systems%20for%20Adaptation_Final_web.ashx?la=da)
[Naswa et al. 2015.](#)

A detailed account of the monitoring and evaluation process for adaptation, including stages of the monitoring and evaluation process, criteria for indicators, monitoring and evaluation frameworks, challenges to monitoring and evaluation, and emerging lessons. Provides examples of existing country efforts to monitor and evaluate adaptation policies and strategies and monitoring and evaluation systems for adaptation in the Latin American region.

Adaptation Made to Measure

https://giz.de/ibt/var/app/wp342deP/1443/wpcontent/uploads/filebase/me/me-guides-manualsreports/GIZ-2013_Adaptation_made_to_measure_second_edition.pdf

[Olivier, Leiter, and Linke. 2013.](#)

A guidebook to the design and results-based monitoring of climate change adaptation projects. It also provides

a reference source for national and international organizations, NGOs and research bodies that seek a practical frame of reference for the results-based design of adaptation interventions and verification of the results achieved.

Blue Solutions

<http://www.bluesolutions.info/>

Project website of the global Blue Solutions initiative, in which GIZ, IUCN, UNEP and GRIDArendal combine their efforts to develop and bring together innovative marine and coastal management approaches and policy advice, focusing on holistic solutions for a sustainable use of marine and coastal resources. By collating best practices, improving methods, enhancing capacity and fostering knowledge exchange, action is being supported at local, sub-national, national, regional and global levels.

Blue CCA Training

<http://bluesolutions.info/climate-changeadaptation>
[Blue Solutions.](#)

The Blue Solutions initiative developed a training that provides an introduction to the theory and to the practical starting points of climate change adaptation in coastal and marine areas.

References

Conservation International. 2013. Constructing Theories of Change for Ecosystem-Based Adaptation Projects. A Guidance Document. Washington DC: Conservation International.

Munroe, Robert et al. 2015. Guidance on Integrating Ecosystem Considerations into Climate Change Vulnerability and Impact Assessment to Inform Adaptation. Cambridge, UK: UNEP-WCMC.

Naswa, Prakriti et al. 2015. Good Practice in Designing and Implementing National Monitoring Systems for Adaptation to Climate Change. Copenhagen, Denmark: Climate Technology Centre & Network.

Olivier, J., T. Leiter, and J. Linke. 2013. Adaptation Made to Measure. A Guidebook to the Design and Results-Based Monitoring of Climate Change Adaptation Projects. (Second Edition). Eschborn, Germany: Climate & Development Knowledge Network.

Travers, Ailbhe, Carmen Elrick, Robert Kay, and Ole Vestergaard. 2012. Ecosystem-Based Adaptation Guidance: Moving from Principles to Practice. Working Document. Nairobi: UNEP.

Table 4: Example indicators for EBA involving coral reef protection/restoration. The examples are provided in relation to some of the key questions that monitoring and evaluation needs to address.

Questions to answer	Example indicator	Monitoring methods and information sources
What activities have been undertaken to improve resilience? Are policies and regulations being enforced?	Conservation area established, with a management plan that considers climate change being implemented	Endorsement and implementation of management plan that addresses climate change, with sufficient budget
	Number of patrols undertaken to prevent activities that are reducing resilience of reefs; patrolling results/findings	Patrol reports
Have interventions reduced the impact on the ecosystem of key threats/stressors identified as affecting its resilience?	Changes in water quality (e.g. X % reduction in pollution loadings compared to baseline)	Measurement of key parameters for water quality (e.g. nutrient load, contaminants, turbidity)
	Change in effectiveness of conservation area management	Use of Management Effectiveness Tracking Tool (METT); improvement in METT score
Are key ecosystem functions that support resilience being protected or enhanced? (How do ecosystem responses differ in those areas with and without protection activities?)	Abundance of focal species e.g. turtles, herbivorous fish, reef predators, commercially important species compared to surrounding areas	Monitoring of parrotfish abundance with fish counted for 5 minutes in 5 m x 5 m quadrats
	Area of live coral (e.g. total area or increase in area covered)	Assessment of change in % coral cover using line-intercept transects
Have key ecosystem services for climate change adaptation been maintained/enhanced?	Level of wave attenuation by reef	Wave height/energy compared to baseline (similar season/storm)
	Net erosion/accretion of beach	Beach profile and erosion transects
	Damage caused by storm surges	Damage measured in losses (USD) and compared to baseline events of similar magnitude (taking into account any coastal development)
Is there public support for the adaptation option implementation activities?	Changes in local perceptions	Survey before and after the projects have been implemented
Is the intervention sustainable over the long term?	Level of additional finance mobilised for sustainability of project activities	Value of additional finance leveraged
	Continued political support for the measures	Review of references to EBA approval in new policies, laws and regulations
Is the intervention resilient to climate change impacts?	Resilience of coral to climate change impacts Number of bleaching events and/or rate of coral loss (in relation to changes in temperature acidity) Level and rate of recovery of corals post-bleaching (ideally compared to areas with no intervention)	Use of existing coral reef monitoring and assessment networks (e.g. Global Coral Reef Monitoring Network, GCRMN) and/or protocols to provide relevant data.
Does the intervention need to be adjusted to take account of any deviation from expectation (adaptive management, e.g. due to updated information on likely sea level rise)?	Occurring climate change impacts, e.g. rate of sea level rise, sea surface temperatures, ocean acidity	Sea level gauges
Has the vulnerability of coastal communities to climate change been reduced?	Level of adaptive capacity of coastal communities, e.g. have relevant capital assets been strengthened? ('five capitals': natural, social, physical, financial and human)	Household surveys before, during and after interventions to determine changes in capital assets of communities
	Changes in community resilience to climatic events	Value of damage/loss incurred due to climate change impacts and/or natural disasters as a proportion of total asset base

Case study 1: Lauru Ridges to Reef Protected Area Network (Lauru PAN)

Introduction

About 26,000 people live in Choiseul Province, or Lauru by its local name, in the Solomon Islands. Due to its remoteness, people in Lauru depend heavily on natural resources for food and income. The area boasts the largest remaining stands of lowland rainforest and more plant and animal species than any other island in the Solomon archipelago. Its unique marine biodiversity calls for preservation – a task that the Lauru Ridges to Reefs Protected Area Network takes care of.

Project implementation

In 2008, the Lauru Land Conference of Tribal Communities (LLCTC) asked The Nature Conservancy (TNC) to assist Choiseul Province with conservation planning for the future. Subsequently, in May 2009, a participatory mapping workshop was held. Community leaders from across the Province attended and some 25 conservation features were identified and mapped. Participatory mapping was also used to identify threats to biodiversity (i.e. areas susceptible to climate change) and to map areas of conservation opportunity, such as sites that are proposed but not yet gazetted as protected areas and sites already managed by communities for some natural resources.

These data were then digitized and fed into a conservation planning analysis. The planning region encompassed all lands, waters and seas of Choiseul Province, out to the 200 meter depth contour. Based on both biodiversity and conservation features, representative ridges to reefs options were developed.

In 2009, TNC staff presented results of the Choiseul conservation planning exercise at a LLCTC meeting. Following the presentations, LLCTC participants provided their unanimous support for two recommendations put forward by TNC and the LLCTC environmental committee to: (1) establish a Lauru Protected Areas Network (LPAN); and (2) establish, for each of the 12 wards in Choiseul,

at least one marine protected area and one terrestrial protected area within the next two years. It was agreed by the LLCTC that the implementation of the LPAN will remain a community driven process that is guided by the Choiseul Ridges to Reef Conservation Plan.

To date, 26 locally-managed marine areas (LMMAs) have been established in a community-led process. The LMMA network helps to strengthen the ownership and responsibility of local communities. It provides them with a systematic approach and useful tools to develop their own conservation plans, so that they can create protected areas and achieve legal security over access rights.

The steady increase of sites within the Lauru PAN, the initial success and returns from enclosed and no-take zones, the results of initial biological monitoring and the endorsement and support from all stakeholders, including the Government, all suggest that the Lauru PAN is being implemented successfully. The benefits of the approach has been communicated by word of mouth, generating enthusiasm in other communities for starting similar conservation areas. The Lauru PAN is also a blueprint for other provinces and communities in Solomon Islands and LLCTC and the Provincial Government are working to ensure Solomon Islands national legislation reflects and enhances the Lauru PAN experience nationally.

Key findings and lessons learned

For the success of LMMAs, communities must have the lead from establishment to enforcement. It is therefore important to ensure that all groups in the community agree to engage in the LMMA project. This engagement needs to be invested in the long term and demands considerable time and human resources. Furthermore, there is a need to: (a) develop more consistent management plans for each site and (b) build capacities regarding the management planning and implementation of protected areas.

FURTHER INFORMATION:

A synthesis report entitled *Ecosystem-based adaptation and climate change vulnerability in Choiseul Province, Solomon Islands* has been produced under the project, outlining the cultural and ecosystem context of Choiseul Province, the ecosystem services provided by the coast, climate change and other threats, key vulnerabilities, adaptation options identified by communities in Choiseul, the relevance of EBA and the ridgecommunity- reef approach, and future application of results from the project.

<https://www.weadapt.org/sites/weadapt.org/files/legacynew/placemarks/files/52d3d4e19244b52ca9d55eacadchoiseul-sol-eba-synthesis.pdf>

For more information on this project, contact Jimmy Kereseka, Lauru Land Conference of Tribal Community (LLCTC), jkereseka@TNC.org and <http://solutionexplorer.org/solutions/lauru-ridges-to-reefs-protected-area-network-lauru-pan>

Case study 2: Community-based habitat restoration: The Green Coast Project

Introduction

Many coastal communities in Indonesia, Sri Lanka, India, Thailand and Malaysia were severely affected by the 2004 Indian Ocean Tsunami, as were the coastal ecosystems that they depended on for their livelihoods and other goods and services. In 2005, the Oxfam Novid (Netherlands) funded 'Green Coast' project was initiated by Wetlands International, WWF, IUCN and Both ENDS in Aceh, Indonesia with four main goals: to restore and manage damaged coastal ecosystems in the five countries, build and restore sustainable livelihoods resilient to climate change, carry out environmental education campaigns and develop village regulations for conservation (IUCN, 2009).

Project implementation

As of March 2009, more than 1,100 hectares of coastland had been rehabilitated through planting of mangroves and coastal forests and 2.5 km of sand dunes and one hundred hectares of coral reef and seagrass beds were restored and protected. Guidance was also provided by the implementing organizations to support the development of alternative livelihoods, such as fishing, aquaculture, eco-enterprises, home gardening and pastoral farming. Overall the project was considered to be successful in helping to improve resilience to climate change for 91,000 people and improve livelihoods for 12,000 households in the region.

Key findings and lessons learned

The project published an assessment of lessons learned and key factors affecting rehabilitation success (Wibisono and Sualia, 2008):

- The chances of survival varies among the species of mangrove and beach plants (survival rates for

different species are included in the report).

- Mismatches between the land's carrying capacity and the plans made for its rehabilitation can lead to seedlings being planted at too high a density or in unsuitable locations (e.g. planting mangrove on dry grassy soil, on sandy beaches, on pest prone sites or on heavily inundated beaches).
- Techniques were developed for propagation and judging the maturity of a propagule.
- Soaking the propagules and steep embankments can reduce the risk of pest attack.
- Intensive facilitation was key to successful activities.
- The presence of a particular species of plant or animal can be a biological indicator of whether or not the site is suitable for the purposes of rehabilitation.
- Training needs to be frequent, and include sufficient teaching aids and specific materials.

The project also made several recommendations, including the need to:

- Develop a mechanism for selecting group members
- Maintain or raise the level of environmental awareness
- Establish specific criteria for choosing a livelihood
- Apply a service system to support continued facilitation of funds
- Assess the more specific potentials and constraints concerning livelihoods (including present conditions and predictions for the future)
- Create a clear exit strategy to ensure the long term sustainability of the project.

FURTHER INFORMATION:

A leaflet produced by Wetlands International and WWF gives details on reforestation of fisheries using mangroves in districts in Indonesia under the Green Coast project.

<http://www.wetlands.org/LinkClick.aspx?fileticket=s5kUWEslW1A%3D&tabid=56>

GNF. (2007) Mangrove Rehabilitation Guidebook Published in the framework of the EU-ASIA PRO ECO II B Post Tsunami Project in Sri Lanka, Eds Udo Gattenlöhner, Stefanie Lampert, Kathrin Wunderlich. Global Nature Fund (GNF), Germany

http://www.globalnature.org/bausteine.net/f/6426/Brochure_Sri_Lanka_GNF.pdf?fd=0

Wibisono, I.T.C. and Ita Sualia. (2008). Final Report: An Assessment of Lessons Learnt from the "Green Coast Project" in Nanggroe Aceh Darussalam (NAD) Province and Nias Island, Indonesia, Period 2005-2008. Wetlands International - Indonesia Programme, Bogor.

Case study 3: Responding to coastline change in its human dimensions in West Africa through Integrated Coastal Area Management Project

Introduction

The Canary Current Large Marine Ecosystem is characterised by high biodiversity and a highly productive ecosystem, which faces potential threats under future West African climate change scenarios. These include increased intensity of tidal waves and storm surges, thus exacerbating anthropogenically driven erosion and sedimentation threats. Under the Integrated Coastal Area Management Project, structural and ecosystem-based approaches to adaptation were piloted in five sites between 2008 and 2012 in Mauritania, Senegal, Gambia, Guinea Bissau and Cabo Verde. The aim was to help communities increase their adaptive capacity and resilience to climate change (Project Executive Summary, GEF Council Submission, 2006). By carrying out pilots, the project aimed to show tangible benefits from climate change adaptation and thus promote integration of climate change adaptation into national policy and regional coastal management planning.

Project implementation

Specific ecosystem related activities across the five selected pilot sites consisted of:

- **Riberia Lagoon on Maio Island (Cabo Verde)**
 - Anti-salt dyke construction and establishment of plant nurseries in a hybrid approach to prevent flooding and reduce sea-water
 - infiltration
 - Soil rehabilitation to reduce run-off
 - Reforestation using plant nurseries
- **Varela beach (Guinea-Bissau)**
 - Reforestation and rehabilitation of tourism
- **Tanbi Reserve (Gambia)**
 - Construction of an ecotourism camp
- **The Nouakchott shoreline (Mauritania)**
 - EBA techniques to stabilize the shoreline including nursery production of local species for dune afforestation
- **Palmarin (Senegal)**
 - Strengthening of plant cover including mangrove species *Avicennia africana* and *Casuarina equisetifolia*

The project, which was carried out under a collaboration between UNDP, GEF and UNESCO IOC, also included capacity building initiatives, knowledge sharing, monitoring mechanisms, climate change awareness raising and regional cooperation.

Key findings and lessons learned

In 2012, a Guidebook on Adaptation Options for Local Decision Makers was developed in French, English and Portuguese summarising national experts' experiences from The Gambia, Ghana, Mauritania, Nigeria and Senegal, including information on the costs of the different approaches used. Overall they found that integrated resource management generally had fewer risks and a greater success rate when compared to hard engineering options.

Integrated resource management was also generally cheaper than the alternatives, e.g. groynes, sea walls, rock armour/boulder barriers and gabions.

FURTHER INFORMATION:

A Guide on Adaptation Options for Local Decision makers has been developed under the project and outlines a collection of summary sheets on hard adaptation options, ecosystem-based adaptation approaches (including EBA options such as dune and mangrove restoration) and integrated resource management adaptation options (including optimising land use through planning options, water resource management, protecting marine ecosystems through biological recovery, and the role of Marine Protected Areas).

http://www.accc-africa.org/sites/default/files/documents/2012/09/14/une-guide_acc_a_en_bd.pdf

The UNDP Project Document acts as a useful example of factors that should be taken in to consideration when planning an adaptation approach. It places the project in a global, national and regional context, taking climate change, past and present actions in the country into account. The document includes project strategy, the operational approach, results, budget, management arrangements, logistics, the monitoring framework for evaluation, and the legal context.

<http://www.undp-alm.org/resources/prodocs/undp-project-document-adaptation-climatechange-coastal-zones-west-africa-accc-18>

Other sources:

<http://unfccc.int/files/adaptation/application/pdf/1eba.pdf>

<http://www.accc-africa.org/news/2012/10/01/newpublication-guidebook-adaptation-options-localdecision-makers>

<http://unesdoc.unesco.org/images/0021/002179/217953e.pdf>

<http://www.canarycurrent.org/en>

Case study 4: Community-based coral aquaculture and reef restoration programme, Puerto Rico

Introduction

Coral reef ecosystems in Puerto Rico provide important services to people, including protecting shore communities from storm surges, creating and maintaining habitats for fisheries and generating income for local communities through the tourism industry. However, in recent decades, several coral populations in Puerto Rico have disappeared from places where they were previously common as a result of both human and natural factors (including land use change, pollution and climate change). Restoring coral reefs can enhance their role in reducing wave energy and height. This is increasingly important in the context of sea level rise and can help coastal communities adapt to climate change.

Project implementation

In 2003, a community-based coral aquaculture and reef restoration programme was established in Puerto Rico with the aim to restore threatened coral species in three sites: Culebra Island (since 2003), Vega Baja and Manatí (since 2008). The project is jointly implemented by two community-based NGOs (Sociedad Ambiente Marino and Vegabajeños Impulsando Desarrollo Ambiental Sustentable), and the University of Puerto Rico's Center for Applied Tropical Ecology and Conservation (CATEC).

Activities under the reef restoration programme have spanned ten years and have included restoring depleted populations of *Acropora cervicornis* and *Acropora palmata* coral species.

Key findings and lessons learned

Although the project was created before EBA became a formalised term, important lessons for EBA were demonstrated. Inclusion and engagement of communities in project planning and implementation were found to be critical to the success of the project in terms of strengthening:

- Buy-in by stakeholders to technical training and education in coral farming and reef conservation and restoration methods
- The emergency rapid response capacity at times of reef restoration emergency (e.g. following hurricanes or tropical storms)
- Communities' application of the guidance developed by the project to the management of adjacent shallow coral reef ecosystems, which provide an important defence system against storm swells and sea level rise.

A further conclusion from the project was that in order to improve ecosystem conditions, restoration efforts need to take place alongside wider management efforts that address land use patterns, water quality issues and fishing activities.

FURTHER INFORMATION:

A final report titled Expansion of the Puerto Rico Low-Tech Coral Aquaculture and Coral Reef Rehabilitation Project was produced in 2013. It outlines project methods and results, and contains a useful section on lessons learned and roadblocks to coral farming and reef rehabilitation.

https://www.academia.edu/6132083/Expansion_of_the_Puerto_Rico_Low-Tech_Coral_Aquaculture_and_Coral_Reef_Rehabilitation_Project_Subaward_MAR-SAM-110110_Final_Report_Submitted_to_The_Nature_Conservancy

Other sources:

<http://epa.gov/region2/coralreefs/>

<http://www.habitat.noaa.gov/pdf/restorationworks.pdf>

http://www.academia.edu/6132083/Expansion_of_the_Puerto_Rico_Low-Tech_Coral_Aquaculture_and_Coral_Reef_Rehabilitation_Project_Subaward_MAR-SAM-110110_Final_Report_Submitted_to_The_Nature_Conservancy

<http://www.scirp.org/journal/PaperInformation.aspx?paperID=50930#.VK0c2iusVrU>

Case study 5: Communitybased Mangrove Reforestation and Disaster Preparedness Programme, Viet Nam

Introduction

Viet Nam is vulnerable to typhoons and coastal flooding, extreme events that are likely to be exacerbated by the effects of climate change. In order to protect a 100 km sea dike and improve the protection of communities behind it, the Viet Nam Red Cross has reforested and afforested 8,961 ha of mangroves in 8 Vietnamese provinces since 1994.

Project implementation

Building on provincial commitments to reverse mangrove destruction, combinations of mangrove species were planted to provide a variation in mangrove height that could break higher waves and also act as wind breaks. The majority of the planted mangroves were *Kandelia candel*, as this species produces 'ready-to-go' seedlings that can be picked from any mature tree and planted without a need for costly purchases from nurseries. The overall programme cost USD 8.8 million and is supported by the Danish Red Cross and the Japanese Red Cross.

The programme also included community based disaster risk management, disaster preparedness and training of children.

Key findings and lessons learned

The programme evaluation specifically identified mangrove afforestation as being highly cost-effective in achieving disaster risk reduction and ecological and direct economic benefits: Typhoon damage to dikes was reduced by USD 80,000 in one of the communes; the same evaluation also identified more substantial savings due to avoided risk, with a protective impact value of up to USD 15 million. Wider economic benefits for local communities have included an increase in aquaculture (e.g. oysters) yields. Furthermore, the mangroves planted by the project are expected to contribute to climate change mitigation through absorbing about 16.3 million tonnes CO₂ by 2025.

Key factors cited for the success of the project were avoiding assumptions that the mangroves would be "there for good" and instead working to ensure long-term work on protection, future planning and awareness of costs and benefits. Secondly, exit strategies are essential to avoid financial dependence on outside support which jeopardises the sustainability of the actions.

FURTHER INFORMATION:

An impact analysis report, *Breaking the waves: Impact analysis of coastal afforestation for disaster risk reduction in Viet Nam*, was produced by the project in 2011, showing the results of an evaluation of the project between 1994 and 2010. The report examines the contribution of the project to disaster risk reduction and enhancement of livelihoods, cost effectiveness and benefits (including coastal protection, economic and ecological benefits).

http://www.preventionweb.net/files/globalplatform/entry_bg_paper~mangroveimpactreportfinalapril2011.pdf

Case study 6: Increasing community resilience to climate change through development of codependent livelihoods

Introduction

The Primeiras e Segundas coral island group stretches 150 km along the coast of Nampula and Zambezia provinces in Mozambique. The islands are globally important marine biodiversity areas and are important to the economy of Mozambique, forming part of the world's largest prawn fishery. Many people rely on agriculture for at least a portion of their livelihoods, and for some, fishing is also a source of livelihood support. However, increasing impacts of climate change, along with overfishing and coral bleaching, are putting increased pressure on these island ecosystems.

Project implementation

In 2010 the Alliance provided support to the Moma District Government in Nampula province, the District Services for Economic Activities (SDAE) and local communities to establish two experimental fish sanctuaries, managed by the Thapua and Corane communities. Artisanal fishing in spillover zones was allowed, however the sanctuaries were specified as no-take zones. The sanctuaries support the Alliance's work to "build the resilience of poor and vulnerable people in the region to rapidly changing socioecological conditions", including due to climate change.

Key findings and lessons learned

In 2014, the CARE-WWF Alliance surveyed nearly 300 households in coastal communities surrounding the sanctuaries. Sixty four percent of survey respondents believed they had benefitted from the creation of the sanctuaries, with 74.5% agreeing that the creation of more would be a positive measure. Agriculture still remains the main source of food or income for more than 90% of the households; however, although approximately the same percentage of households fish, 38% eat fish more than four times a week and can thus rely far less on agriculture for food security.

Fish abundance, size and diversity was also reported to have increased in sanctuary spill-over zones. The creation of experimental sanctuaries like these suggests that activities to improve the sustainability of fisheries can balance communities' dependence on fishing and farming for livelihoods, and thus may improve community resilience to change, particularly in times of low agricultural harvest.

FURTHER INFORMATION:

Two relevant outputs have been produced under the project. An information brief entitled Fishing for the Future: Social and Biological Aspects of No Fishing Zones in Mozambique provides more information on the project and its results. A technical paper entitled Resilience in a Changing World: Can Poor Coastal Communities Achieve Sustainable Livelihoods and Sustainable Fisheries? examines appropriate ways to invest in small-scale marine fisheries and coastal livelihoods programs and policies.

References:

Fisher, B., Bovens, D., Cremildo, A., Guernier, J., Ismael, A., Mullins, D., Robinson, D. and Skinner, A. (2014) Fishing for the Future: Social and Biological Aspects of No Fishing Zones in Mozambique. CAREWWF Alliance Technical Report.

Robinson, D., Skinner, A. and Fisher, B. (2014) Resilience in a Changing World: Can Poor Coastal Communities Achieve Sustainable Livelihoods and Sustainable Fisheries? CARE-WWF Alliance Technical Report.

Case study 7: Climate-Resilient Communities and Protected Areas in West Africa

Introduction

In West Africa, future climate change impacts will not be evenly distributed amongst regions and many subsistence-based communities that rely upon coastal ecosystems for their livelihoods are likely to be more intensely affected by disproportionate impacts. The project Climate-Resilient Communities and Protected Areas, executed by the United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC), aims to enhance livelihoods and increase socio-ecological resilience in West African coastal protected area systems to the negative effects of climate change.

Project implementation

To support this work, the project developed a practical guidebook based on mixed methods and workshop designs to carry out participatory community-based workshops that assess the vulnerability of those living in and around protected areas (PA) to climate change. The guidebook also offers guidance on how to assess communities' understanding of climate impacts and natural resource use while gathering their aspirations for future activities and developing adaptation plans.

Consequently, between 2014 and 2015 three adaptation planning workshops were carried out with communities living in Marine Protected Areas (MPAs) in the Gambia (Niimi National Park) and Senegal (Sangomar MPA). On the last day of these workshops, participants voted for their top three priority issues that emerged from the workshop activities and for three suitable alternative or supplemental livelihood activities. For each of the six activities, they then developed step-by-step adaptation action plans, receiving guidance from technical experts from relevant ministries, NGOs and the MPA.

While this project has used a community-based approach (CBA) to climate change adaptation, the majority of community priority issues had an ecosystem focus and most of the resulting adaptation action plans included EBA options in addition to traditional CBA or hard adaptation approaches, such as improving access to

potable water and electricity or constructing sea walls. To maximize both the social and ecological benefits of adaptation options within the context of the MPAs, the project is supporting a number of the nature-based community adaptation plans that complement each other and have the potential of creating multiple positive feedback loops in order to build community resilience to the many adverse effects of climate change in the longterm. These include:

- In the Gambia, community members and MPA staff are replanting mangroves and other suitable tree species that serve to reduce coastal erosion and have economic value to the communities. Both men and women will also be trained on beekeeping and the production and sale of honey and other beeswax products in order to diversify their income sources with a more climate-resilient activity that can flourish in the MPA.
- In Senegal, communities and MPA staff are also engaging in mangrove replanting in order to combat severe coastal erosion. Additionally, groups of women oyster collectors will be trained on sustainable harvesting techniques and they will be equipped with sustainable stoves in order to reduce their impact on the natural environment upon which they depend. They will also receive entrepreneurial training in order to increase their sales.

Key findings and lessons learned

The implementation of actions is currently underway, but by building on local strengths as the basis for prioritizing and planning adaptation initiatives, community ownership and empowerment are high and have created the trust and commitment needed to achieve long-term, sustainable outcomes. Furthermore, the active engagement of MPA staff, as well as other relevant national ministries and NGOs in the process should ensure the feasibility and support of community plans.

Further information:

For more information on this project, please contact sylvia.wicander@unep-wcmc.org

Case Study 8: Community-based ecosystems approach to fisheries management (CEAFM) in the face of climate change

Introduction

The Pacific Island region is among the world's most vulnerable regions in the face of climate change. Recent research highlighted impacts of climate change that are expected to add to the already existing local threats to mangroves, coral reefs, seagrasses and intertidal flats, resulting in declines in both quality and area of all habitats.

The regional Coping with Climate Change in the Pacific Island Region (CCCPIR) programme, implemented by the Secretariat of the Pacific Community (SPC) and the German cooperation agency Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), aims to strengthen the capacities of Pacific member countries and regional organisations to cope with the impacts of climate change.

Project implementation

Projections show a climate change related progressive decline in productivity of all components of coastal fisheries. The community-based ecosystems approach to fisheries management (CEAFM), as one component of the CCCPIR programme, tackles this challenge by raising awareness on different fishing practices, developing community owned management and conservation measures and by introducing nearshore Fish Aggregating Devices (FADs) in a number of communities in the Federated States of Micronesia, Samoa and the Solomon Islands.

Communities are supported to develop and implement fisheries management plans. They analyse their fishing practices and develop community owned plans to introduce appropriate actions and conservation measures. This is accompanied by awareness raising programs as well as technical advice.

The strategy is based on three principles: maximum participation; motivation rather than education; and demand-based processes. Communities therefore have

the primary responsibility to manage their own marine environment. To alleviate pressure on vulnerable coral reefs and coastal fisheries resources, the deployment of nearshore FADs is promoted. Due to the easy accessibility of reefs, mangroves and lagoons, coastal fisheries resources are highly susceptible to overfishing. FADs attract pelagic fish to a certain offshore area, and therefore facilitate offshore fisheries, providing alternative livelihoods for the local community. Communities receive in-depth training on the construction, maintenance and monitoring of these devices.

Furthermore, SPC offers a number of regional and capacity building programmes for national and state government officials as well as community representatives. These teach management and specific skills at all levels of expertise. This process supports the sustainability of the CEAFM projects.

Key findings and lessons learned

Local knowledge has often been underestimated. Most communities, however, have an acute awareness of and concern for their marine environment and resources. These views should be considered when developing management strategies. The success of community consultations for the development of a community-owned management plan highly depends on the facilitators. Facilitators should be equipped with the appropriate skills; neutrality is of key importance.

Monitoring of FADs is crucial to actually assess the impacts and expected changes in the use and management of coastal resources. Monitoring should therefore be conducted by the communities or linked to ongoing monitoring programmes e.g. from conservation NGOs.

Further information:

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