Briefing note

9

Coastal Ecosystem-based Adaptation: How Nature Protects Our Shores

Ecosystem-based adaptation (EbA) is the utilization of biodiversity and ecosystem services as part of a strategy to aid people in adapting to the adverse effects of climate change. In coastal areas, this involves managing mangroves, coral reefs, seagrass, dunes and wetlands to strengthen the ecosystem services they provide, building their resilience to climate impacts, as well as that of nearby communities. EbA is especially important in coastal regions, as nearly 2.5 billion people (about 40 per cent of the global population) live within 100 km of the coast (United Nations Department of Economic and Social Affairs [UN DESA] 2019).

Marine and coastal ecosystems also harbour an enormous variety of the world's biodiversity, and they provide many valuable ecosystem services (Barbier *et al.* 2007), such as providing natural sea defences against coastal flooding and erosion. Fish is a key component of the diets of over 1 billion people, and it is estimated that 40–120 million people are employed in the fisheries sector alone (World Bank 2012; Food and Agriculture Organization of the United Nations [FAO] 2020). Coastal ecosystems also help sequester large amounts of carbon dioxide (Adame *et al.* 2021; Bertram *et al*. 2021), mitigating the impacts of climate change.

However, coastal ecosystem services are increasingly undermined by human activities, including fishing, aquaculture, shipping, natural resource extraction, unsustainable coastal development, and pollution (United Nations [UN] 2021), which are further exacerbated by the negative impacts of climate change. These impacts include increased water temperatures (associated with coral bleaching events), greater strength and frequency of storms (Hoegh-Guldberg *et al.* 2018), and ocean acidification due to higher concentrations of carbon dioxide in the water. In addition, sea level rise is contributing to increased flooding, storm surges and coastal salinization as seawater intrudes farther inland, harming coastal ecosystems and livelihoods, and affecting fresh water availability (Dasgupta *et al.* 2014).

GLOBAL ADAPTATION NETWORK

UN environment programme

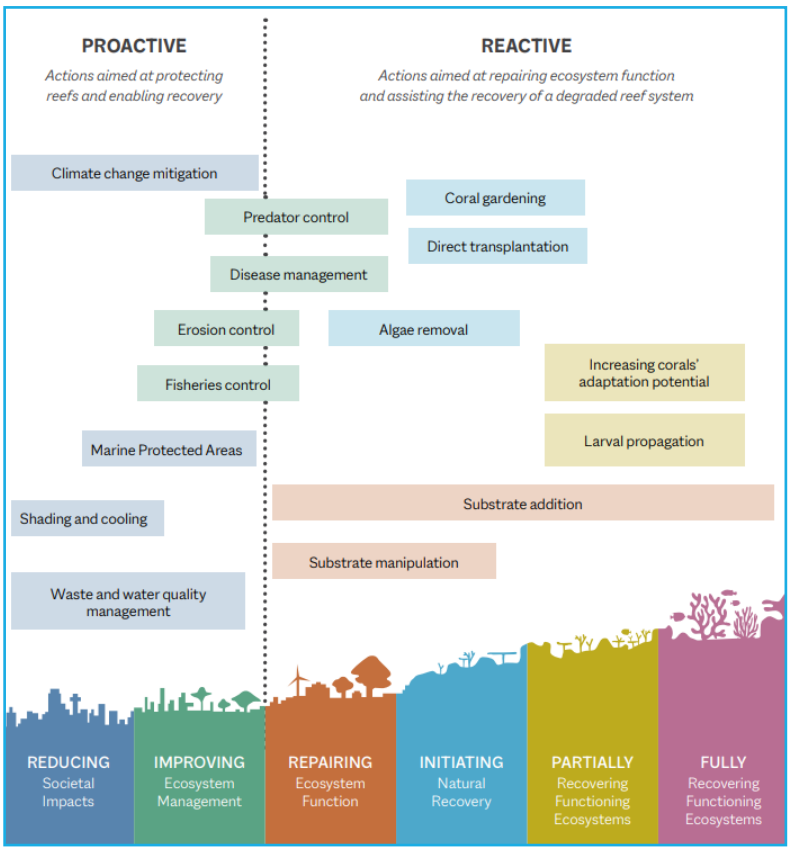
Ecosystem-based Adaptation Practices In Coastal Environments

By incorporating EbA into coastal development and adaptation plans, communities will become more resilient to climate impacts and disasters, and they can draw on ecosystem services for marine ecotourism employment, food security, and water provisioning and purification, among other benefits. Table 1 provides a list of EbA practices according to different environmental, economic and social impacts of climate change.

Table 1: Urban EbA practices for environmental, economic and social impacts of climate change

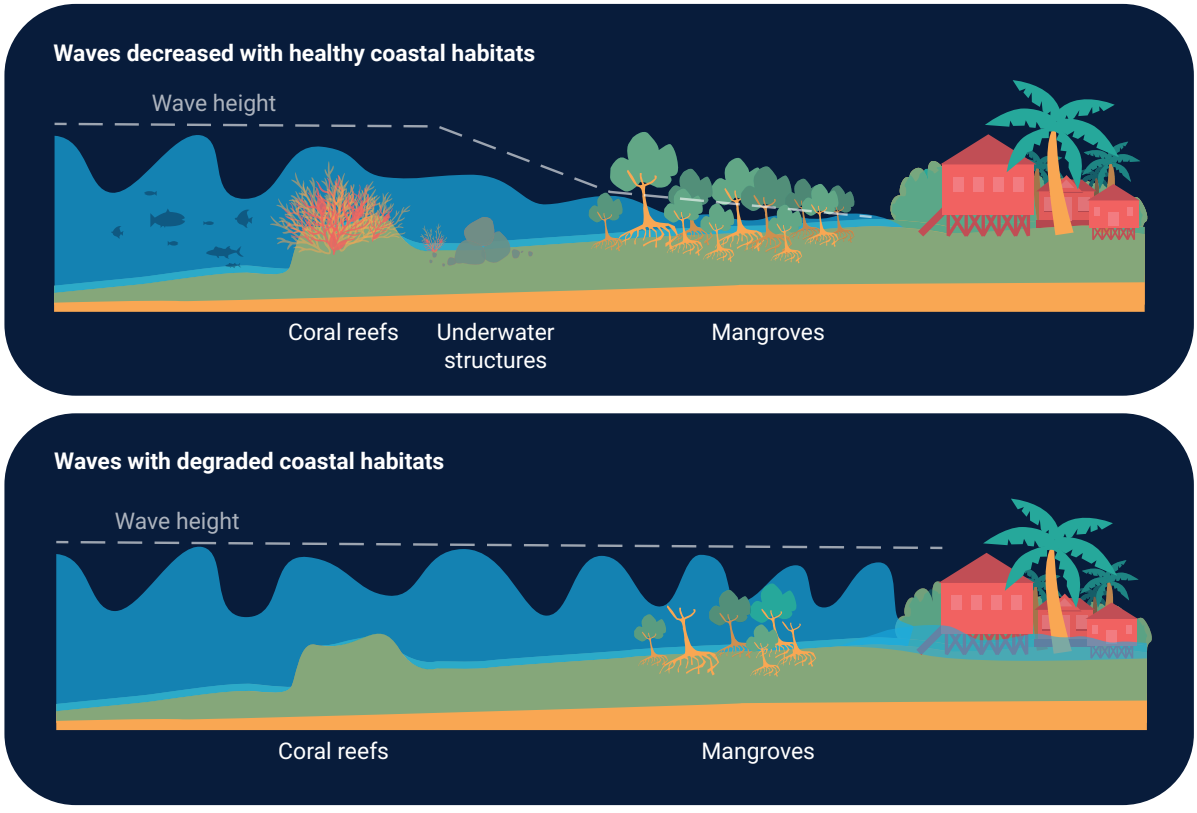
Environmental Impacts (direct hazards)
Use integrated approaches (for example, ridge-to-reef [Figure 1] and coastal zone management) to reduce cumulative pressures from overfishing, mass tourism, pollution, and unregulated coastal development - thereby helping ecosystems cope with environmental hazards below.
Coral bleaching and ocean acidification (OA)
Protect nearby ecosystems, such as mangroves and seagrasses, to provide a buffer against impacts of OA).
Provide special protection to bleaching and OA-resilient corals by including them in no-take Marine Protected Areas (MPAs).
Restore coral reefs in highly protected areas where direct drivers of degradation have been removed.
Explore interventions (Figure 2) to counter a variety of threats to coral reefs.
Reduce land-based pollution and sedimentation flowing to coastal waters: • Urban areas: Use green spaces, rainwater gardens, porous pavements, green roof, (see *Urban Ecosystem-based Adaptation Briefing Note*) composting toilets, etc. • Agriculture: Carry out wetland restoration in agricultural coastal areas, and riparian and watershed protection; use improved agricultural and forestry practices and nutrient trading schemes; employ circular use of organic waste and effluent. • Industry: Adopt circular approaches, and place stricter regulations on discharges, supported by citizen monitoring. • Plastics: Use deposit systems, circulate economy (pavements, bricks, consumer products from collected plastic), and new river cleanup technologies.

Figure 1: "Proactive" and "reactive" interventions for coral reef restoration and conservation



Source: Hein *et al.* (2020)

Figure 2: Coastal protection via coral reefs and mangroves



Adapted from Whelchel *et al.* (2016)

Sea level rise, storms and flooding
Manage and protect coastal and marine ecosystems, such as mangrove forests, wetlands, seagrasses, dunes, and oyster and coral reefs to provide coastal protection (Figure 2, see UNEP Guide).
Restore coastal ecosystems with climate-resilient species and adaptive management (see Case Study I on page 8).
Look for opportunities to implement hybrid approaches (that combine “green” and “grey” infrastructure solutions and their advantages - see Figure 3) and other innovative solutions like floating structures, for example.
Address non-climate pressures to increase the resilience of coastal ecosystems (for example, cookstoves to reduce the collection of fuelwood from mangrove forests - see Case Study II on page 9).
Incorporate climate risk, including sea level rise, flooding and storm damage into coastal planning, regulations and policies (for example, flood management, building codes, and zoning).
Strengthen early warning systems, construct multipurpose shelters for local population, develop evacuation routes and plans, and raise awareness.
Establish migration corridors for mangroves and other wetlands to migrate landward with increasing sea level rise, while supporting managed realignment needs (Figure 3).
Coastal salinization
Increase plant species variety, biodiversity, and root presence to improve soils, using salt-tolerant species for farming, landscaping, coastal parks, etc.
Draw water from coastal aquifers sustainably, build and scale up rainwater harvesting (see Case Study II on page 9), and promote water conservation with demand management approaches.
Manage, protect and restore mangroves, coastal forests and wetlands to halt salinization.
Integrate green-blue measures into existing hard infrastructure (for example, sea walls and dikes) to prevent saltwater intrusion.
See UNEP’s *Options for Ecosystem-based Adaptation in Coastal Environments* for further details.

Figure 3: Examples of coastal adaptation approaches

Minimal defence

Many communities have developed alongside the ocean, with only minimal natural defences in the form of a small strip of beach between them and the ocean.

Natural infrastructure

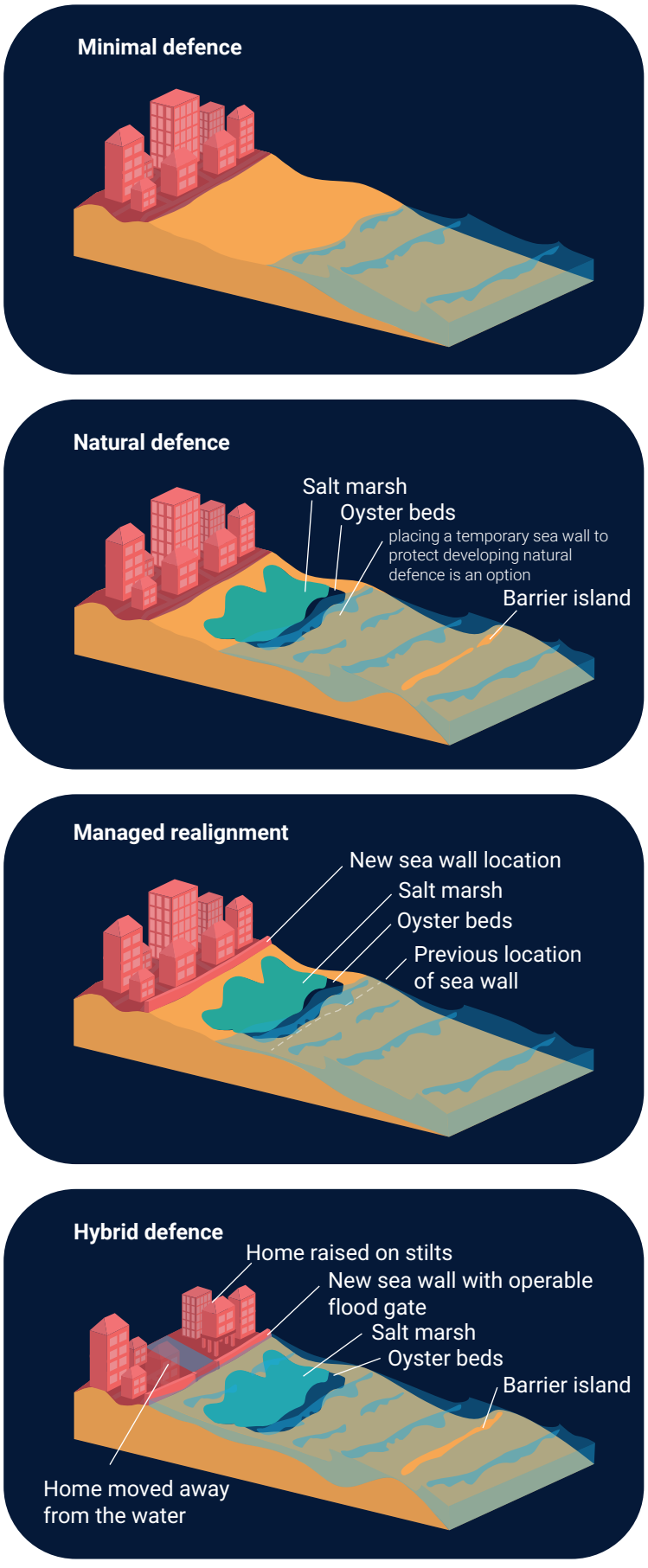
Natural habitats that can provide storm protection include salt marsh, oyster and coral reefs, mangroves, seagrasses, dunes and barrier islands. As seen in this figure, a combination of natural habitats can be used to provide more protection. Communities could restore or create a barrier island, as well as oyster reefs and salt marsh. Temporary infrastructure, such as a removable sea wall, can protect natural infrastructure while it establishes itself.

Managed realignment

Natural infrastructure can be used to protect built infrastructure in order to increase the lifespan of the built infrastructure and provide more storm protection benefits. By carrying out managed realignment, communities are moving sea walls farther away from the ocean's edge, closer to the community, and allowing natural infrastructure to establish itself between the ocean's edge and the sea wall.

Hybrid defence

In the hybrid approach, specifically built infrastructure, such as removable sea walls or openable flood gates (as shown in this figure) are installed simultaneously with restored or created natural infrastructure, such as salt marsh and oyster reefs. Other options include moving houses away from the water and raising them on stilts. The natural infrastructure provides key storm protection benefits for small to medium storms. When a large storm is expected, the built infrastructure serves as additional protection.



Adapted from: Sutton-Grier, Wowk and Bamford (2015)

Economic Impacts

Growing economic toll of climate change on homes, businesses, infrastructure and marine tourism assets (e.g., beeches and coral reefs)

Reform policies and laws that create perverse incentives to build in vulnerable areas, and use zoning to prohibit construction in these areas.

Explore resilience bonds and parametric reef and mangrove insurance to prevent and help recover from extreme weather events.

Develop Payments for Ecosystem Services schemes to encourage ecosystem conservation for coastal defence.

Changing availability of target marine species due to higher sea temperatures

Improve supply chains to reduce waste and capture added value of processed products, seeking sustainability certification with premiums to encourage better practices.

Enhance ecosystem-based fisheries management to restore flow of services such as fish spillover from no-take areas (see Case Study I on page 8).

Use revolving microloans or fisheries insurance to ease the transition to alternative economic activities or lessen the impacts of shocks to current livelihoods.

Diversify to climate-resilient livelihoods: ecotourism, sustainable aquaculture, blue "carbon farming"

Social Impacts

Climate change may exacerbate issues such as social exclusion, poverty, illegal resource use, fragile governance, forced migration, and a loss of a sense of identity

Strengthen community tenure over marine resources to ensure more sustainable use, knowledge-sharing and mutual advocacy.

Ensure participatory planning and co-management of coastal areas to provide for local needs (food, jobs, etc.).

Ensure women, indigenous peoples and other vulnerable groups participate in planning to create more robust and inclusive adaptation interventions.

Include psychological aspects of climate-induced loss of life, livelihood erosion, damages and displacement in coastal planning (especially to create buy-in for managed realignment).

Case Studies

Case Study I: Adapting to Climate Change in Madagascar With Ecosystem Restoration

UNEP is supporting the Government of Madagascar in building the resilience of coastal communities in four regions – Boeny, Menabe, Atsinanana and Vatovavy-Fitovinany – through a project funded by the Global Environment Facility's Least Developed Countries Fund. The project's main approaches are to strengthen the capacity of coastal communities to address climate change impacts through training and technical support and to protect coastal zones by restoring mangrove forests, building seawalls, introducing climate-smart farming methods and diversifying livelihoods.

To protect against frequent climate disasters such as tropical storms, sea level rise and storm surges, which are causing flooding and saline intrusion into water sources, a kilometre-long seawall, in combination with natural sea defences, will be constructed in Manakara. Existing sea-defence structures (1.1 km) in Toamasina will be stabilized through revegetation.

These climate-related disasters have impacted drinking water availability and agricultural productivity, resulting in seasonal food insecurity. As a solution to these issues, the project helps build resilience by promoting the diversification of livelihoods and use of climate-smart agricultural practices, including vegetable production, improved crop varieties, better cultivation techniques, and enhanced fish and crab production. The project is also providing Rambo (*Lepironia articulata*) seeds, a drought-resistant aquatic plant and valuable crop, to 300 community members, along with training on how to cultivate and maximize yields. In addition, communities are now benefiting from training in alternative, resilient livelihoods (beekeeping and ecotourism) that will not only support their income but also decrease mangrove deforestation.

The project is also restoring 350 hectares of mangrove forests, which are vital for coastal villages as they form a buffer against storm surges, prevent shoreline erosion, and provide a habitat for fish and crabs that are crucial for local food security and income.

The challenges faced by the project include: 1) political instability and insecurity, particularly in the Menabe region, where armed gangs cut off roads and stole livestock, making it difficult to travel to the intervention sites; 2) geographically dispersed locations; and 3) the risk of losing restored mangrove areas to disease, vandalism or other threats. These challenges have been mitigated by: 1) the recruitment of a person to ensure the security of the regional team during its travels; 2) the loan of a vehicle by the Regional Directorate of Environment to the regional team; and 3) the recommendation that the monitoring of mangroves be transferred from the NGOs in charge of mangrove restoration to communities so that the latter know how to check the health of the plants and respond in the event of a problem.

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Case Study II: Combining "Grey" and "Green" Adaptation Infrastructure in Tanzania

UNEP and the Government of the United Republic of Tanzania implemented two projects funded by the Adaptation Fund and the Global Environment Facility's Least Developed Countries Fund in Dar es Salaam and five coastal districts (Pangani, Rufiji, Bagamoyo, Mkoani and Mijni) to help protect Tanzania's coasts where sea level rise has degraded natural ecosystems, pushed saltwater into wells and damaged coastal infrastructure, affecting the livelihoods of coastal communities.

EbA was a central component of the projects and consisted of restoring mangrove and coral habitats, both of which act as natural barriers and buffers against storms and wave force. Restoration was carried out using locally available, climate-resilient species. The projects involved district and community stakeholders, including women's groups, in the implementation of project activities (the germination and planting of mangrove seedlings), strengthening ties across stakeholder groups. Overall, the projects rehabilitated nearly 1,000 hectares of mangrove habitat in Rufiji District, another 1,260 hectares across two sites in Zanzibar, and approximately 3,000 m^2 of coral reefs. Furthermore, to address the issue of mangrove deforestation for fuelwood, 3,000 cookstoves were distributed to households and a network of 87 community groups has been established in the project areas to manage the mangrove sites.

In combination with the EbA approaches, a total of 2,400 m of sea-defence structures (seawalls, groynes and dikes) were built to halt shoreline erosion and prevent saltwater intrusion and flooding of residential areas. Fruit and nut traders and other economic activity are also now returning to the coastline of Dar es Salaam.

Rising sea levels combined with changes in rainfall patterns have resulted in water scarcity and made well water too salty for use. In response, the projects constructed 10 boreholes with 15,000 litres of storage tanks, and installed rainwater harvesting devices to improve year-round water availability for local communities. In addition, over 2,300 m of drainage channels were cleaned and restored to prevent cholera and typhoid outbreaks due to flooding and stagnant water.

The projects also strengthened Tanzania's capacity to carry out climate adaptation planning and initiatives by training over 100 people in coastal and climate vulnerability mapping and producing scientific and technical knowledge on climate change vulnerability.

Key challenges with the projects included: 1) delays in the implementation of adaptation interventions due to budget limitations, and challenges in logistics and procurement, 2) human activities (for example, incompatible land use, deforestation, and drainage of untreated effluent affecting seedling survival in some sites), and 3) extreme weather conditions and security problems. These challenges were mitigated by extending the project and effectively applying adaptive management approaches (for example, adjusting project components and targets and utilizing different planting techniques to improve seedling survival rates). Overall, these challenges highlight the need for coastal EbA to be integrated as a part of a larger and long-term approach that addresses the broader issues underpinned by policy and institutional arrangements. For more information about the adaptation lessons emerging from the two projects, see *Lessons Learned: Ecosystem-based Adaptation and an Integrated Resilient Rice Model in Madagascar.*

A mangrove restoration site supported by UNEP on the east coast of Tanzania. ©*UNEP/Hannah McNeish*

Conclusion

Coasts are key areas for global biodiversity. They provide vital ecosystem services, including food, livelihoods, coastal protection, nutrient cycling, water purification, and carbon sequestration. Despite these benefits, coastal ecosystems are increasingly affected and degraded by human activities and climate change.

Implementing coastal EbA can support coastal ecosystems and communities, not only by securing ecosystems and the vital ecosystem services they provide, but also by building the social and economic resilience of coastal communities, with specific efforts made towards inclusive and participatory approaches that include women, youth and other marginalised groups, in line with UNEP's project and programme guidelines. EbA should be implemented in a manner that does not create losses for people or negative environmental effects. In some cases, traditional infrastructure solutions may be more efficient in reducing climate-related risks, as they are able to provide protection benefits as soon as they are constructed. One increasingly popular and effective approach is to use "green" EbA approaches in conjunction with "grey" infrastructure to create a hybrid solution that combines the advantages of both approaches. Promoting and scaling up EbA approaches will require effective finance mechanisms and collaboration across sectors and stakeholder groups in combination with policy and integrating EbA into broader strategies and national planning.

Further resources

- Ecosystem-based Adaptation Briefing Note Series
- Climate adaptation resources and multimedia
- Options for Ecosystem-based Adaptation in Coastal Environments
- Blue Nature-based Solutions in Nationally Determined Contributions: A Booklet for Successful Implementation
- Guidelines on Mangrove Restoration for the Western Indian Ocean Region

For more information about UNEP's work on Ecosystem-based Adaptation, contact Jessica.Troni@un.org

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