Ecosystem-based adaptation for coastal regions worldwide

Working Document: Background Paper

Nico Stelljes, Grit Martinez,
Gregory Fuchs, Julia Maund,
Evgeniya Elkina

17. February 2025

Ecologic Institut

Contact

Dr. Nico Stelljes
Ecologic Institute
Pfalzburger Straße 43/44
10717 Berlin

E-Mail: nico.stelljes@ecologic.eu

Table of content

Summary

Overview

Ecosystem-based Adaptation (EbA) uses biodiversity and ecosystem services as part of an overall adaptation strategy to help people adapt to the adverse effects of climate change (CBD, 2009; FEBA, 2017) It includes the sustainable management, conservation and restoration of ecosystems to reduce the vulnerability and enhance the resilience of people and nature to climate change. EbA falls under the broader concept of nature-based solutions (NbS) (IUCN, 2020).

EbA is often characterized by:

- Reducing vulnerability to climate change while co-delivering benefits like food security, biodiversity conservation, and carbon sequestration.
- Being more cost-effective than traditional engineering solutions for climate change adaptation.
- Supporting community involvement and integrating a variety of actors (including different economic sectors, governments, civil society etc.)

This paper focusses on applications of EbA in tropical/sub-tropical coastal regions, emphasizing mangrove and coral reef restoration and was conducted as part of the project '**Ecosystem-based adaptation for coastal regions worldwide (TROPICAL ADAPT)**' supported by the German Federal Agency for Nature Conservation (BfN) with funds from the German Federal Ministry for the Environment (BMUV).

Coastal EbA refers to the use of natural ecosystems to enhance climate resilience and reduce coastal risks like erosion, flooding, and storm surges. These ecosystems act as natural buffers, reducing storm surges, preventing erosion, and mitigating flooding while also supporting fisheries, water quality, and biodiversity. For coastal communities, EbA enhances resilience by integrating nature-based solutions with local livelihoods, governance structures, and long-term climate adaptation strategies, ensuring both environmental and socio-economic benefits (Favero and Hinkel, 2024; Jones et al., 2020). For tropical and subtropical coastal regions, mangroves and coral reefs are the most addressed ecosystems regarding EbA approaches (see e.g. Giffin et al., 2020), therefore this papers focuses on these two ecosystems.

Coastal EbA overlaps with frameworks like ecosystem-based management (EBM), marine-spatial planning (MSP), and integrated coastal zone management (ICZM), which also balance ecological conservation with human needs. While these frameworks take a broader focus, EbA's specificity in addressing climate impacts ensures complementary implementation.

Policy context

The policy context for coastal EbA emphasizes the integration of biodiversity, climate, and marine policies to enhance sustainable adaptation and resilience. Coastal EbA contributes to reaching the objectives of global conventions like the Convention on Biological Diversity (CBD) and the Kunming-Montreal Global Biodiversity Framework (especially Targets 8 and 11), the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement, as well as the Convention on Wetlands (Ramsar Convention), among others, complemented by regional and international polices. Initiatives like the Mangrove Breakthrough, Global Mangrove Alliance, and Blue Carbon Initiative aim to enhance mangrove restoration, carbon sequestration, and coastal resilience.

Regional efforts adapt global targets to regional contexts, with programs like Africa's Adaptation Initiative, Southeast Asia's Coral Triangle Initiative, and the Caribbean Marine Biodiversity Program focusing on mangrove restoration, coral reef conservation, and regional collaboration. Additionally, evidence-based approaches from international guidelines outline principles for designing and monitoring EbA projects. These frameworks emphasize stakeholder engagement, adaptive management, and context-specific solutions to bolster coastal ecosystems against climate impacts while enhancing livelihoods and biodiversity.

Coastal EbA Ecosystems

Mangroves are critical ecosystems that provide vital services, including coastal protection and biodiversity support, yet they are severely threatened by climate change and human activities. Climate change impacts, such as rising sea levels, increased storm intensity, altered rainfall patterns, and temperature shifts, threaten mangrove survival and ecosystem services. Human-induced threats include deforestation, land conversion, pollution, and coastal development. Mangrove restoration efforts face challenges like environmental changes, technical errors, lack of stakeholder engagement, and inadequate long-term monitoring and funding. Despite these obstacles, successful restoration projects often involve ecological alignment, community engagement, adaptive management, capacity building, policy support, and financial investment. Case studies show that government, NGO, community-driven, and mixed approaches can all lead to successful outcomes when proper planning, stakeholder collaboration, and education are prioritized. These initiatives not only restore mangrove ecosystems but also provide alternative livelihoods, reducing human pressures on mangroves. The importance of long-term monitoring, adequate funding, and skilled staff are key elements of successful ecosystem-based adaptation (EbA) strategies, as demonstrated by projects in the Seychelles, Bangladesh, and Vietnam.

Coral reefs are vital ecosystems that provide critical services such as biodiversity support, coastal protection, and resources for millions of people. However, they face significant threats from both climate change and human activities. Ocean warming, ocean acidification, and direct anthropogenic actions like overfishing, pollution, and tourism are primary factors contributing to their decline. Warming waters lead to coral bleaching, a process that threatens coral survival. Ocean acidification weakens corals, slowing growth and making them more vulnerable to other stressors. Meanwhile, human activities, including tourism and overfishing, degrade local ecosystems, causing direct physical damage and worsening water quality.

Restoration efforts for coral reefs encounter several obstacles, including inadequate monitoring, lack of stakeholder engagement, insufficient funding, and poor management. Effective restoration requires clear objectives, ongoing maintenance, and long-term financing, which are often lacking in many projects. For example, in Indonesia, coral restoration faces challenges such as ineffective enforcement of protection laws and lack of qualified staff for management.

Successful restoration projects integrate ecological, engineering, and social approaches. Key factors include site selection, addressing local stressors, and defining clear, achievable objectives. Community engagement is essential to ensure local support and stewardship. Successful case studies, such as the Coral Triangle Initiative and the Reef Rescuers Project, highlight the importance of adaptive management, stakeholder involvement, and a focus on sustainability. These projects have demonstrated increased coral cover, enhanced biodiversity, and improved local livelihoods, proving that well-designed, community-supported restoration efforts can effectively protect coral reefs against climate change and human pressures.

Roles, financing, and outlook

Ecosystem-based Adaptation (EbA) approaches to climate change emphasize the importance of integrating community, governmental, and non-governmental actors to enhance resilience. Communities play a central role by providing local knowledge and driving adaptation strategies. By involving communities, projects become more sustainable and effective. Governments contribute by passing legislation and creating policies that protect ecosystems like mangroves and coral reefs. They also ensure long-term preservation through post-project legislation. NGOs lead and fund projects, offer expertise, and facilitate knowledge exchange. The private sector primarily supports EbA projects financially, often through partnerships with public entities.

Financing for EbA projects comes from three main sources: international public funds, private finance, and domestic public funds. International funds include those from organizations like the UNFCCC and the World Bank, while private sources include carbon markets, ecotourism, and investments. Domestic funds, such as national adaptation funds, are also important. Innovative models like debt-for-nature swaps, green bonds, and public employment programs can also finance projects. However, funding for smaller, community-based projects remains underdeveloped, and securing sufficient funding for large-scale projects can be challenging due to difficulties in quantifying their effectiveness.

The outlook for EbA includes the need for better integration of local knowledge, improved governance frameworks, and the development of scalable and transferable models. Key factors supporting EbA include:

1. **Effective Governance**: Transparency, participatory approaches, and aligning socio-economic benefits with stakeholder priorities.
2. **Context Awareness**: Tailoring approaches to local ecosystems and socio-economic contexts, particularly in vulnerable developing nations.
3. **Engagement and Adaptability**: Involving local communities, integrating traditional knowledge, and using adaptive management for long-term effectiveness.

A key challenge is overcoming the financing gap, especially for local projects. There are also knowledge gaps in assessing the socio-economic impacts of EbA, integrating it into national and international policy frameworks, and ensuring long-term monitoring and evaluation. To address these gaps, more research and coordinated efforts across local, national, and global levels are necessary. Furthermore, EbA projects must evolve to include hybrid solutions that combine ecosystem conservation with other adaptation strategies like green-grey infrastructure.

1 Background: What is Ecosystem-based Adaptation (EbA) in the context of tropical and sub-tropical coastal-marine ecosystems?

A well-known definition of Ecosystem-based Adaptation (EbA) was provided in a technical briefing by the Convention on Biodiversity (CBD, 2009, p. 10):

> *„Ecosystem-based adaptation uses biodiversity and ecosystem services in an overall adaptation strategy. It includes the sustainable management, conservation and restoration of ecosystems to provide services that help people adapt to the adverse effects of climate change."*

EbA measures are therefore specifically implemented in response to climate change and focus on the needs and quality of livelihoods of people, though they benefit both people and nature (Giffin et al., 2020; Grantham et al., 2011; Sierra-Correa and Cantera Kintz, 2015). EbA is typically multisectoral and involves government, communities, NGOs and more actors to address the pressures on ecosystem services (Sierra-Correa and Cantera Kintz, 2015). FEBA (2017) have defined five EbA criteria, stating that EbA reduces social and environmental vulnerabilities, generates societal benefits in the context of climate change adaptation, restores, maintains or improves ecosystem health, is supported by policies at multiple levels and supports equitable governance and enhances capacities.

Classification and Distinction

EbA is often discussed with other concepts and terms that also describe environmental management approaches focused on ecosystem services, such as Nature-based Solutions (NbS), ecosystem-based management (EBM), community-based adaptation (CBA), ecosystem-based disaster risk reduction (Eco-DRR), , as well as marine spatial planning (MSP) and integrated coastal zone management (ICZM) in the case of coastal EbA (Jupiter et al., 2014).

Due to their high political relevance, the links between EbA and NbS are of particular interest. While EbA focuses specifically on using ecosystems to reduce vulnerability and enhance the adaptive capacity of people and ecosystems in response to climate change, NbS is a broader concept. NbS aim to address a variety of societal challenges - not limited to climate adaptation - such as climate change mitigation, disaster risk reduction, food and water security etc., while always providing benefits for both human well-being and biodiversity (Kozban et al., 2023). EbA can thus be considered a subset of NbS, with a targeted emphasis on climate change adaptation. Both EbA and NbS are increasingly taken up in international policy. The term "ecosystem-based approaches to adaptation", which can be regarded as equivalent with EbA, has been officially established under the Convention on Biodiversity (CBD) in 2009, as part of COP10 Decision X/33. In 2014, the very first session of the United Nations Environment Assembly (UNEA 1) adopted a Resolution on Ecosystem-based Adaptation (Resolution 1/18), further promoting the concept. Thus, the United Nation Environment Programme is now looking back on "A decade of ecosystem-based adaptation" (UNEP, 2024). In contrast, the first internationally agreed definition for NbS was adopted only in 2022 by UNEA 5 (Resolution 5/5) and has been taken up by the Ramsar Convention on Wetlands (Decision XIV.17) in the same year.

Some of the aforementioned concepts and terminologies overlap or can work together, while others were developed and adapted from another. For instance, ICZM was a precursor of EBM, and coastal EbA approaches can be used in conjunction with related marine concepts, such as marine spatial planning (MSP) (Sierra-Correa and Cantera Kintz, 2015). Coastal EbA is closely linked to ICZM and Marine Spatial Planning MSP, as both provide governance frameworks for sustainable coastal management. ICZM integrates ecological, social, and economic factors in coastal planning, making it an ideal approach for embedding nature-based solutions that enhance resilience. MSP, on the other hand, organizes human activities in marine and coastal areas, ensuring that Coastal EbA is spatially prioritized to protect ecosystem functions. Together, ICZM and MSP create the necessary conditions for scaling up Coastal EbA by integrating it into broader climate adaptation and development strategies (see e.g. Giffin et al., 2020; Nalau et al., 2018).

Coastal EbA is often discussed in contrast to traditional, or hard coastal engineering infrastructure, such as sea walls and groins, however EbA solutions can also be used in combination with hard or hybrid infrastructure (Nalau et al., 2018). For instance, vegetation can be planted around hard coastal infrastructure to improve both coastal protection and aesthetic value (Nalau et al., 2018). EbA is often more cost-effective than hard engineering solutions to coastal management, requiring fewer materials, often implemented at the community or local level, and presenting fewer risks than traditional engineering methods (Giffin et al., 2020).

Since EbA is specifically designed to address climate adaptation using ecosystems and their services, this makes co-benefits (e.g., food security, carbon sequestration) an inherent part of its approach. Among these co-benefits, economic opportunities stand out, offering both direct and indirect contributions to livelihoods, disaster cost reduction, and sustainable development. For instance, Nalau et al (2018) report about a coastal afforestation project in Bangladesh creating employment for over 12,000 people, demonstrating the potential of EbA to generate direct economic opportunities (Nalau et al., 2018). Economic benefits can also arise more indirectly, for instance through the coastal protection provided by mangroves and coral reefs, thereby reducing infrastructural damage to communities as a result of storms. Other benefits include food security, carbon sequestration, reduced erosion, increased resilience in the face of future threats and climate change, and biodiversity conservation (Nalau et al., 2018).

Coastal EbA

In the context of coastal tropical and sub-tropical ecosystems, EbA is usually applied as a conservation, restoration, or natural resource management strategy. According to the literature, the most pressing climate change impacts in terms of vulnerability of tropical and sub-tropical coastal ecosystems and communities are increased environmental hazards (e.g. storm surges) and sea-level rise, both of which are expected to intensify (Sierra-Correa and Cantera Kintz, 2015). Therefore, coastal EbA projects focus primarily on alleviating direct climate change impacts such as coastal flooding or erosion. But coastal EbA can also include development of ecotourism industries to support and diversify local livelihoods in the face of climate change, or designation of marine protected areas to ensure longevity of food supply (Giffin et al., 2020). Also, the IPCC (2022) refers to coastal EbA in the sixth assessment report as one example of combination of climate adaptation and mitigation measures.

In Giffin et al.'s (2020) overview of applied EbA approaches in marine ecosystems in Asia and Oceania, most projects targeted a single ecosystem, with mangroves being the most commonly addressed, followed by coral reefs. Mangrove ecosystems primarily focused on shoreline protection, while coral reef projects emphasized food security as the key benefit. The study (ibid.) categorised project activities into three main types: 31% of projects implemented a conservation action, with the most common action being community awareness campaigns; 31% implemented a management and planning activity, with socio-ecological assessments being the most common type of activity; and 38% implemented a restoration process, e.g.

restoring mangroves. Overall, mangrove restoration was the most frequently implemented approach.

Conditions that support EbA approaches

For successful implementation of EbA approaches, several factors need to be considered prior to execution. A primary factor is creating the right conditions for effective governance measures. Attributes of effective governance include accountability, participatory approaches, transparency and clear alignment between policy, legislation and practices (Nalau et al., 2018). An example of aligning governance with stakeholder priorities is making the socio-economic benefits of implementing EbA evident to stakeholders to increase buy-in (Nalau et al., 2018). Nalau et al (2018) also advocate for implementation of EbA at the local level, as Giffin et al. (2020) point out that the benefits of EbA strategies are often felt most at the community level. Grantham et al. (2011) discuss the importance of community-based management, with close collaboration between different levels of government, tribal leaders, and local stakeholders, linking those efforts with national programmes, such as establishment of marine protected areas.

Many authors (e.g. Nalau et al., 2018) highlight the suitability of EbA to developing and less developed nations, as demonstrated by Giffin et al.'s (2020) review of EbA projects in Asia and Oceania, where most case studies are situated in such context. This is explained by the heightened vulnerability of these nations to climate change impacts due to factors such as poverty and rapid population growth. EbA approaches are both cost-effective and accessible, making them particularly useful for communities in developing nations with tropical marine environments (Giffin et al., 2020; Nalau et al., 2018).

In addition to governance measures and awareness of context, a good understanding of the biological and social systems where EbA approaches are being conducted needs to be established, with all potential drivers of change considered in the planning stage (Nalau et al., 2018). Use of monitoring and adaptive management enhance the longevity of EbA strategies by improving the evidence base and enabling adjustments over time (Nalau et al., 2018).

Engagement is another important factor to consider. Grantham et al. (2011) include community awareness in their guiding principles for effective EbA strategies, including understanding and incorporating community needs, traditional approaches, and stakeholder identification of threats during the planning and design stages. Additionally, communication strategies need to be developed when discussing the impacts of climate change. For example, there is no word in Fijian for 'resilience'. Therefore, not all concepts apply across a diversity of cultural settings, thus adapting language and concepts to the local context is necessary. Finally, stakeholder participation encourages ownership of EbA approaches and using small-scale, bottom-up processes (Grantham et al., 2011).

In general, guidance on NbS implementation can also be used to inform the implementation of EbA measures, since EbA falls under the NbS umbrella. For example, the Global Standard on NbS published by the International Union on Nature Conservation provides guidance and lists further relevant criteria, including e.g. social equity and adaptive management (IUCN, 2020).

Constraints on the implementation of EbA approaches

The widespread uptake of EbA strategies faces several constraints, including governance challenges, financial limitations, gaps in knowledge, and social and cultural barriers (Nalau et al., 2018). Governance issues arise from friction between top-down governance systems and more traditional, bottom-up approaches, as well as mismatches in the scale of governance boundaries relative to the scope of the problems being addressed (Nalau et al., 2018). Funding to implement EbA approaches can also be lacking, especially over the long-term (e.g. for monitoring), hindering the sustainability of EbA initiatives (Nalau et al., 2018). Gaps in knowledge can occur between traditional or indigenous forms of knowledge and Western scientific frameworks. Additionally, stakeholders may lack a clear understanding of EbA, especially given its overlap with related terms and concepts. Finally, uncertainty about future climate scenarios and long-terms impacts of EbA can present a challenge for decision-making and implementation (Nalau et al., 2018). Social and cultural constraints include disagreements in terms of which ecosystems are at (most) risk and the underlying reasons, as well as differing aesthetic preferences for the landscape (Nalau et al., 2018). For example, stakeholders may prioritise certain ecosystem values over others, leading to conflicts in implementation priorities.

Furthermore, Giffin et al. (2020) criticise the lack of a comprehensive overview of where, why and how EbA projects have been implemented in marine and coastal ecosystems. This lack of documentation limits the ability to learn from past experiences and identify synergies between EbA and related approaches, such as ecosystem-based disaster risk reduction. Therefore, further research is needed to explore these overlaps, especially because some literature may not be explicitly aware of the link between EbA and other nature-based solutions (Giffin et al., 2020).

Untapped potential and relevant gaps

While awareness of, and interest in, EbA is increasing in the political, managerial, and NGO spheres, an analysis of the global potential of EbA strategies (particularly in the coastal context) is lacking. Assessments of this nature have also not been incorporated with information about the co-benefits of protecting the ecosystems under consideration, threats and vulnerabilities, and their existing protections. This lack of data prevents prioritization of regions most in need of, or that would most benefit from, EbA solutions, which also obscures the ability to effectively distribute financial resources for EbA strategies (Jones et al., 2020; Sack, 2023).

EbA strategies also face uncertainty in the form of future climate conditions. It's unclear how effective EbA strategies are in different potential climate scenarios, and it's difficult to quantify levels of success due to the numerous different interactions within an ecosystem and how those elements influence provision of ecosystem services. Not only is the projection of future climate conditions uncertain, but also other pressures have an effect on ecosystem functioning, e.g. invasive species and deforestation, potentially degrading ecosystems that are the subject of EbA strategies before they have the chance to be effective (Jones et al., 2012; Lacambra S et al., 2024; Vardi et al., 2021).

Finally, while several EbA projects have been implemented in numerous case studies across the world, particularly in tropical and subtropical regions, a comprehensive and definitive evidence base has yet to be established. This exacerbates issues of lack of technical expertise and capacity, particularly in more rural or remote communities. A repository of projects that have found success on a long-term scale would help increase knowledge and awareness about EbA, better enabling new projects and project managers (Baig et al., 2015; Giffin et al., 2020). It would also allow for a better funding situation, if a clear evidence base could be established (Beeston et al., 2023).

2 Policy Context

This chapter examines the multi-level policy context of coastal EbA. A combination of biodiversity, climate, and ocean policy frameworks underscores the importance of coastal EbA for sustainable adaptation and resilience. At the global level, the CBD or the Paris Agreement, play a leading role, supported by international initiatives like the Mangrove Breakthrough and Global Mangrove Alliance. Regional frameworks, meanwhile, adapt these targets to the specific challenges and ecosystems of each area, strengthening the global push for resilient, biodiverse, and sustainable coastlines. The following sections provide an overview of key global and regional policy targets, conventions, and initiatives relevant to coastal EbA.

2.1 Global Policy Targets and Conventions

Coastal EbA contributes to reaching the objectives of a variety of Multilateral Environmental Agreements, yet only some of them explicitly promote EbA as well.

The **Kunming-Montreal Global Biodiversiy Framework (GBF)**, negotiated under the **Convention on Biodiversity,** supports EbA directly through its Targets 8 and 11, which promote “nature-based solutions and/or ecosystem-based approaches” to minimize the impacts of climate change and enhance nature’s contributions to people. Other GBF targets also align well with the EbA concept, including the restoration of 30% of degraded ecosystems by 2030, protecting 30% of terrestrial and marine areas by 2030, reducing pollution, and promoting sustainable land and sea management including aquaculture and fisheries.

The **Ramsar Convention** on Wetlands aims at the conservation, restoration and wise use of wetlands, with coastal wetlands such as mangroves, salt marshes, shallow reefs and seagrasses all falling into its scope. Its Resolutions XI.14 and XIV.17 specifically highlight the role of wetlands in addressing climate change.

Meanwhile, the **Convention on Migratory Species (CMS)** aims to protect migratory species and their habitats, including coastal areas essential for migratory birds and marine species. It highlights the links between climate change and migratory species in its Resolution 12.21, which encourages parties to take potential impacts on migratory species into account when implementing adaptation and mitigation measures in coastal ecosystems. While EbA is not explicitly mentioned in the Convention or the Resolution 12.21, EbA attempts can found in different Action Plans, for example in Action Plans for turtles or dolphins.

Under the **United Nations Framework Convention on Climate Change** (**UNFCCC)**, the **Paris Agreement** recognizes adaptation needs, including those of people, livelihoods and ecosystems, although not directly mentioning EbA and/ or NbS. **Nationally Determined Contributions (NDCs)** and **National Adaptation Plans (NAPs)** are key country-driven climate policy instruments under the UNFCCC, serving different purposes. NDCs focus on **mitigation** and, in some cases, include adaptation components. An increasing number of **Nationally Determined Contributions (NDCs)** now incorporate coastal EbA strategies, reflecting their value for reducing vulnerability and building resilience to climate impacts. Nations highly vulnerable to climate change impacts, like small island developing states (SIDS) and least developed countries (LDCs), often prioritize adaptation in their NDCs to highlight urgent needs for support (United Nations, 2024).

NAPs, on the other hand, specifically address **adaptation**, helping countries identify medium- and long-term climate risks and plan strategies to enhance resilience. NAPs are a flexible framework for integrating adaptation into national policies. Based on a study by Terton et al. (Terton et al., 2024) most NAPs address either NbS or EbA and coastal and marine ecosystems (e.g. restauration of mangroves and protection of corals) are one most often addressed ecosystems in the analysed NAPs. The **2023 Global Stocktake** also emphasizes the significance of ecosystem-based approaches, including coastal EbA, in tracking progress toward adaptation goals.

2.2 International Initiatives and Processes Relevant to Coastal EbA

The **Mangrove Breakthrough** initiative under the Sharm El-Sheikh Adaptation Agenda aims to restore and protect 15 million hectares of mangroves by 2030, emphasizing their role in carbon storage, coastal resilience, and biodiversity. The **Global Mangrove Alliance (GMA)** brings together NGOs, governments, and the private sector to increase mangrove protection and restoration, supporting EbA policies and financing. The **International Coral Reef Initiative (ICRI)** focuses on conserving coral reefs and related ecosystems, which reduce wave energy, serve as natural storm barriers, and sustain diverse marine life crucial for coastal resilience. The **Ocean Decade (2021–2030)**, a UN initiative, promotes coastal health through research, capacity-building, and projects supporting EbA. The **Blue Carbon Initiative** advocates for conserving and restoring coastal ecosystems like mangroves, seagrasses, and salt marshes for carbon sequestration on a global scale, enhancing both climate adaptation and mitigation. Lastly, the **Global Adaptation Network (GAN)**, led by UNEP, connects practitioners and policymakers to share and scale EbA and other adaptation practices in vulnerable coastal regions. These initiatives and others are compiled in more detail in Table 2 (see Annex) and examples of implemented EbA measure are displayed in Table 3 (see Annex). Some of the mentioned initiatives here and other have produced relevant guidance documents and toolboxes created to foster EbA in different contexts. **Table 1: Guidance documents** in the Annex lists guides and handbooks for EbA implementation.

2.3 Regional Policy Targets and Initiatives Complementing Global Processes

Many regional frameworks support and complement global policies like those of the CBD and Paris Agreement into localised action, tailoring them to local ecosystems and socio-political contexts. In **Africa**, the Africa Adaptation Initiative (AAI) supports coastal EbA projects, such as mangrove restoration, to enhance resilience against climate impacts, while the West Africa Coastal Areas Management Program (WACA) promotes enhanced regional collaboration to protect and restore coastlines. In **Asia and the Pacific**, the Coral Triangle Initiative (CTI) focuses on coral reef conservation in Southeast Asia and the Pacific, which aligns with EbA by ensuring coastal resilience and sustainable fisheries, and the Pacific Islands Roundtable for Nature Conservation (PIRT) promotes nature-based adaptation approaches tailored to island nations' unique vulnerabilities. In **Latin America and the Caribbean**, the Caribbean Marine Biodiversity Program works to conserve key ecosystems like coral reefs and mangroves, essential for resilience to climate impacts, and the Amazon Cooperation Treaty Organization (ACTO) includes initiatives addressing coastal areas where Amazonian rivers meet the Atlantic. In the **Middle East**, the Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERSGA) supports coral reef and mangrove conservation along the Red Sea to enhance coastal resilience.

3 Mangrove EbA

Mangroves are the most frequently cited ecosystem in tropical marine EbA literature, followed by coral reefs. Mangroves are valuable for numerous ecosystem services they provide simultaneously. They play an important role in coastal protection mainly by reducing the risk of coastal floods, sheltering the local communities from storms, and stabilising the coasts (Sunkur et al., 2023; Weaver and Stehno, 2024). Specifically, thanks to their canopy and dense roots, mangroves can attenuate wave energy, lowering wave height by 13-66% over 100 meters and by 50-99% across 500 meters, particularly for waves under 70 cm (Sunkur et al., 2023). This feature allows them to act as natural buffers protecting coastal communities not only from floodings, but also from storm debris. As a result, human casualties and economic losses and can be prevented. Mangroves' deep anchoring roots also retain sediments which helps stabilise the coast preventing erosion (Sunkur et al., 2023; Weaver and Stehno, 2024). Incoming silt gets trapped in the roots, twigs, and stems gradually increasing the ground level and speeding up sedimentation, which in its turn contributes to coast stabilisation (Chaudhuri et al., 2019; Sunkur et al., 2023). In this way, healthy mangroves support climate adaptation in coastal regions, especially amidst prognosed intensification of climate-induced disasters, such as floodings and storm surges.

In addition to stabilising shorelines and reducing wave impact, mangroves provide other valuable co-benefits such as supporting marine habitats, acting as critical nurseries for local fishes and invertebrates, filtering nutrients, and offering opportunities for commercial and recreational fishing (Jones et al., 2020; Weaver and Stehno, 2024). This high multifunctionality of mangroves makes their conservation an attractive measure to address numerous challenges simultaneously.

At the same time, mangroves are highly affected by sea-level rise (Giffin et al., 2020; Sierra-Correa and Cantera Kintz, 2015) with some estimates predicting near-total extinction of future mangrove populations within the next century if current trends persist (Sierra-Correa and Cantera Kintz, 2015). Given the number of ecosystem services mangroves provide, significantly contributing to climate adaptation in tropical and sub-tropical regions, this and other threats, described in detail below, are of major concern for the well-being of coastal communities and ecosystems.

3.1 Threats

Mangrove ecosystems face a multitude of threats, both from climate change and other human activities. Recent studies have provided deeper insights into these challenges, highlighting the urgency for effective conservation and adaptation strategies.

Climate change impacts

Mafi-Gholam and Zenner (2018) detail the negative effects of climate change on mangrove ecosystems, including storms, changes in rainfall, sea level rise, and ocean circulation patterns. A very recent book chapter reveals the critical importance of implementing resilience strategies to enhance the adaptive capacity of mangrove ecosystems due to climate change (Mohanty et al., 2024).

Storms and extreme weather such as **tropical cyclones** and **storm surges** are projected by the Intergovernmental Panel on Climate Change (IPCC, 2019) to increase in both intensity and frequency due to stronger winds and lower pressures induced by climate change. These storms can damage mangroves and erode, pollute, and toxify surrounding soil. Cyclones and flooding can also increase sedimentation and cause changes in the shoreline (Kairo and Mangora, 2020).

While global rainfall is predicted to increase in the coming years because of climate change, **rainfall** in subtropical latitudes is expected to decrease, lowering rates of survival of juvenile mangroves and seedlings, and increasing salinity, which, in turn, decreases the amount of water availability in the plants and converts tidal zones suitable for mangroves into salt flats unfit for mangrove growth.

Sea level rise, one of the greatest climate change-induced threats to mangroves, affects both sediment accretion and elevation, amongst other physical factors. Feedback mechanisms here are complex and should be examined on a case-by-case basis to determine how sea-level rise affects mangrove growth and access to nutrients.

While the effects of **temperature shifts and changes to ocean circulation** on mangroves still require further research, there is some evidence that altered currents could change seed dispersal patterns, thereby reducing gene flow and genetic diversity in mangrove communities. Additionally, temperature shifts can destabilize the delicate salinity balance in mangrove habitats, further threatening their resilience and growth.

Not only does climate change threaten the mangroves themselves, but it also affects the ecosystem services that mangroves provide. For instance, when mangrove forests diminish, so too do the fish species that use mangroves for breeding grounds, thereby affecting the livelihoods of local fishermen (Nyangoko et al., 2022). Connecting climate change to peoples' livelihoods can be a way of localizing impacts and also motivating buy-in for EbA plans from the community.

Other human-induced threats

In addition to the impacts of climate change on mangroves, more direct anthropogenic activities and their pressures (threats) are affecting mangroves. More than a third of global mangroves were lost during the 1980s and 1990s alone due to human activity (Kairo and Mangora, 2020). These activities include mangrove cutting and harvesting for timber or charcoal production; conversion of the coastline into use for other purposes, such as development and rice farming; and poor management or enforcement of natural resource protection (Kairo and Mangora, 2020; Nyangoko et al., 2022; Sunkur et al., 2023). In Mauritius, for instance, the most significant threats to mangroves include deforestation and land conversion for coastal infrastructure (including for tourism, e.g. hotels) and development for boat passage (Sunkur et al., 2023).

Pollution from human activities and settlements, including garbage, plastic, sewage, oil, and industrial effluents, poses major threats to mangrove ecosystems. A study identified that 54% of mangroves are within 20 km of sources emitting more than one ton of plastic pollution per year (Harris et al., 2021).

The degradation of mangrove forests not only threatens biodiversity but also diminishes the ecosystem services they provide. Mangroves serve as breeding grounds for various fish species, and their loss adversely affects local fisheries and the livelihoods of communities dependent on them.

3.2 Obstacles to implementation

As mangrove ecosystem have disappeared in the recent decades, quite a high percentage of that lost areas is considered as "restorable", as Beeston et al. (2023) report. However, while some restoring initiatives have achieved notable success, some "*regions still see failure rates of up to 80% due to science-based methods not being followed – most notably poor project planning and lack of local engagement, reliance on planting in unsuitable areas, or planting without also addressing hydrology, nutrient, and sedimentation requirements*" (ibid., p.18). This includes poorly executed, designed or selected techniques for planting (e.g. using incorrect seeds/species or improper preparation of the site) and failure to engage the right or all of the stakeholders (Kairo and Mangora, 2020). Beeston et al. (2023, p. 31) highlight that "*many mangrove restoration projects have failed because of a lack of community involvement, inappropriate governance structures, and a failure to align objectives and goals of external agents with those of local stakeholders.*"

In their recommendations, Sunkur et al. (2023) note that further research is required for implementing mangroves as EbA, e.g. how mangroves react to increased wave heights or strengths. Additionally, long-term monitoring of these projects in the design phase is crucial for success, yet some projects don't properly account for the resource or capacity required for monitoring. Mills et al. (2020) further explain that finding funding for long-term monitoring is a challenge. Nalau et al. (2018) confirm this in their overview of constraints to EbA, finding an absence of methods for monitoring and evaluation to be a common problem for many EbA projects.

According to the majority of community members surveyed in the Rufiji Delta, Tanzania, government management of mangrove conservation initiatives is insufficient or doesn't adequately take into account stakeholder views (i.e. regarding type of species planted and where to restore mangroves) (Nyangoko et al., 2022). The EbA South project also experienced an issue in the lack of project management capacity from government, even on a small scale. Successful EbA approaches require collaboration between departments and technical expertise, demanding upskilling and training of staff. In the Seychelles, contracting of staff for removal of invasive species for mangrove restoration was severely delayed due to changes in the government procurement's policy.

Another problem experienced in this project that is also commonly experienced in many other implementation contexts is stakeholder conflict. Stakeholders from different knowledge categories had different priorities for EbA strategies. Achieving compromise between hard engineering solutions such as seawalls and soft interventions such as increased vegetation to stabilize sand dunes, riverbanks, and mudflats required more time and managerial resource than anticipated and caused significant delays in execution of the project. Part of the reason for the extended discussions was a lack of awareness about EbA interventions, with a recommendation of including funding for educating stakeholders about EbA (Mills et al., 2020). Pearson et al. (2020) similarly note conflicts between stakeholders as a challenge of EbA, in addition to inadequate governance, a paucity of quality data, and lack of political will.

The table from Kairo and Mangora (2020) below describes the common reasons that EbA projects related to mangrove restoration fail.

Table 7. Summary of common reasons for failure of mangrove restoration projects and lesson learnt

REASONS AS TO WHY RESTORATION EFFORTS FAIL	LESSON LEARNT
- Use of inappropriate methods - Insufficient information - Failure to involve communities - Inadequate monitoring of seedlings after planting - Poor habitat selection without adequate site assessment - Faulty selection of mangrove species for replanting. - Improper planting of mangrove seedlings at a substrate depth beyond the natural range for mangroves in the area - Poor coordination among the institutions involved - Poor understanding of the ecological role of mangrove forests among policy and decision makers at different levels of government that result in weak support of restoration initiatives	- Diagnostic studies on socio-ecological aspects of mangroves - Embracing a more holistic approach - Engaging multiple experts and stakeholders - Linking local language to expertise of the scientific community - Monitoring and assessing success - Early identification of problems and taking corrective actions - Sharing knowledge and experience - Importance of mangrove valuation studies - Continued awareness and advocacy on mangrove conservation

3.3 Success Factors

Despite these challenges, many mangrove restoration projects have been successful, particularly when best practices are followed. The '*Best Practice Guidelines for Mangrove Restoration'* by Beeston et al. (2023) developed six guiding principles for successful mangrove restoration, which are paraphrased below:

1. **Safeguard nature and maximize biodiversity**: Mangrove restoration should avoid harming existing ecosystems like mudflats and seagrass beds while promoting biodiversity by restoring multiple species and natural zonation. A diverse mangrove system enhances resilience, supports various ecological functions, and provides multiple goods and services.
2. **Employ the best information and practices**: Successful restoration requires integrating scientific research with traditional and local knowledge to address the root causes of mangrove loss. A multidisciplinary approach, adaptive management, and understanding land-sea connections are essential for long-term success.
3. **Empower people and address their needs**: Local communities must actively participate in decision-making, benefit equitably from mangrove restoration, and have access to training and financial support. Sustainable livelihoods, fair governance, and prioritizing marginalized groups ensure long-term community engagement.
4. **Align to the broader context – operate locally and contextually**: Mangrove restoration must fit within national and local policies, balancing conservation with competing interests like aquaculture, infrastructure, and coastal protection. Effective governance requires resolving land tenure conflicts and fostering collaboration across sectors.
5. **Design for sustainability**: Projects should anticipate long-term risks such as climate change, political shifts, and funding gaps by ensuring local ownership and integrating restoration into broader land-sea management strategies. A long-term perspective of at least 20 years is key to success.
6. **Mobilize high-integrity capital**: Mangrove restoration requires large-scale investment beyond public funding, with private sector contributions ensuring both conservation and reduced environmental harm. Financial mechanisms must avoid greenwashing and ensure equitable access to resources.

3.4 Case studies

Kairo and Mangora (2020) provide four case studies, driven by different categories of stakeholders, of successful mangrove restoration and protection in their guidelines for mangrove restoration in the Western Indian Ocean region.

1. **Government-driven project in Mauritius**: This project involved five phases of planting seedlings between 1995 and 2001. While the first phase recorded an average survival rate of 65%, by the final phases, 95% of plants reached the four- to six-leaf stage of adulthood, with an eventual survival rate of over 80%. Prior to the project, Mauritius had 45 hectares of mangroves, with coverage increasing to 120 hectares by 2005 and 179 hectares by 2014, largely due to the continued efforts of NGOs and local stakeholders. Because of the success of the project, the government implemented laws protecting mangroves, supporting the longevity of the preservation work.
2. **NGO-driven project in Madagascar**: NGOs have driven the restoration program in Madagascar, collaborating with community organizations, local government, researchers, and the private sector to provide funding and technical support via two methods: 1) Raising public awareness and educating volunteers prior to planting and 2) Financially compensating, in collaboration with other organizations, individuals to plant and monitor mangrove restoration progress.
3. **Community-driven project in Mozambique**: In Mozambique, individuals and communities restore mangroves when they observe the need on a voluntary basis, without external support. For instance, Nhangau, a community in central Mozambique, formed a Natural Resources Management Committee (NRMC) to coordinate planting, enforce local regulations, and promote alternative streams of income, such as aquaculture and beekeeping. Other stakeholders are invited to participate in the efforts.
4. **Mixed approach project in Kenya, Tanzania, and Seychelles**: Communities, NGOs, funders, and local governments work together in this case study. Keys to success include use of local knowledge (e.g. in optimum site selection) in restoration design and technique and raising awareness about the importance of mangroves.

According to Kairo and Mangora (2020), key aspects of the success of these initiatives include the importance of awareness and public education in driving motivation for continued participate in restoration, creating a long-term, structured program rather than a short-term project, committed and knowledgeable staff or individuals, effective partnerships between stakeholders, documentation of lessons learned for future improvement, and development of alternative forms of income for mangrove cutters.

Successful projects often not only provide direct adaptive measures to climate change, but they often also provide alternative livelihoods, reducing dependence and stressors on mangroves, for instance through planting, beekeeping, aquaculture, and mangrove tourism. Restoration therefore not only bolsters the species of focus but also provides economic benefit through local employment and other ecological benefits such as protection of other species and habitats (Kairo and Mangora, 2020).

The graphic from Kairo and Mangora (2020) below provides a decision support tool for mangrove restoration projects.

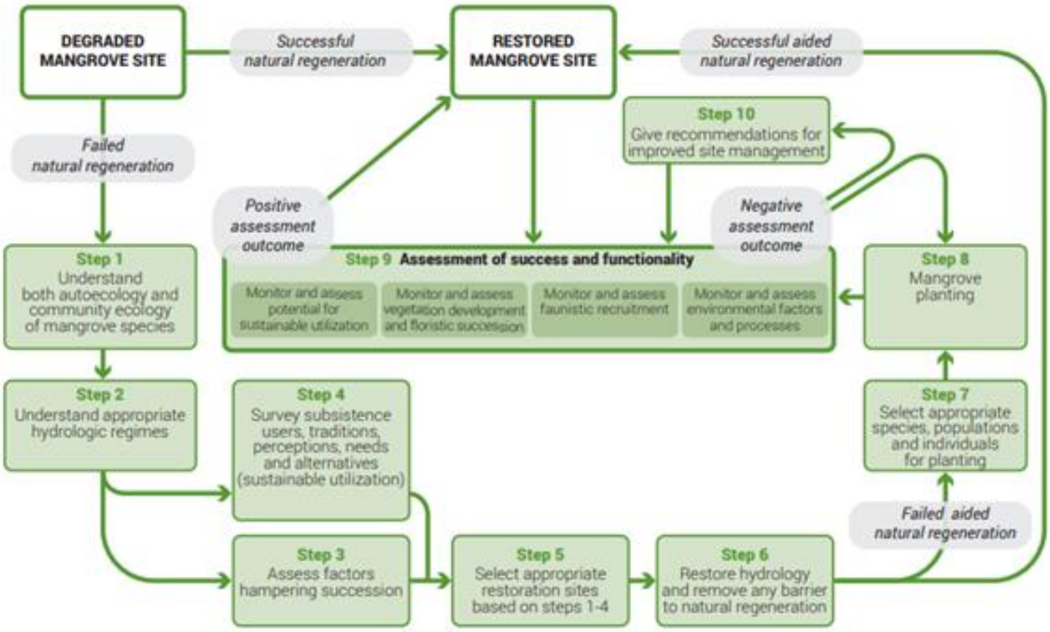

Figure 17. A 10 steps scheme depicting decision support tool for ecological mangrove restoration (Bosire *et al.*, 2008).

The "Ecosystem-based Adaptation through South-South Cooperation" (EbA South) project, which implemented land EbA strategies in Nepal and Mauritania and coastal EbA strategies in the Seychelles, ran from 2013 to 2019. In the Seychelles, the project restored over 400 hectares of wetland ecosystems (including mangroves) with the aim of mitigating flooding and sea-level rise. Lessons learned in terms of elements of a successful project include proper budgeting for the complexity of EbA projects, ensuring appropriately qualified and skilled staff have capacity, and implementing long-term monitoring and evaluation plans (Mills et al., 2020).

In Bangladesh, the Community Based Adaptation to Climate Change through Coastal Afforestation (CBACC-CF) Project is conducting coastal mangrove restoration as an EbA. The project follows the 'Forest, Fish, Fruit' (FFF) model, in which mangroves are planted alongside timber and fruit trees as well as fish nurseries. This project involves community members, who planted seeds and maintained the 9,650 hectares and 10 species of mangroves. The mangroves mitigate climate change impacts such as sea level rise, increased salinity, cyclones, erosion, and flooding while also providing alternative livelihoods for active participants (Smith School of Enterprise and the Environment, n.d.).

In Vietnam, a project scaled up mangrove EbA by identifying and maximizing synergies with other sustainability objectives. While shrimp farming is a key economic activity, the practice was also significantly contributing to mangrove deforestation. The project trained shrimp farmers in sustainable mangrove polyculture, offered certification labels for farming according to organic standards, established payments for ecosystem services (PES), and replanted 60 hectares of mangroves, The project supported the shrimp farming industry while also conserving mangroves, which protect the community from sea level rise and strong waves (IKI-eval, 2021).

4 Coral Reefs

Coral reefs are among the most frequently highlighted ecosystems in tropical marine EbA literature, alongside mangroves. These vibrant ecosystems play a critical role in coastal protection: they act as submerged breakwaters dissipating wave energy, thereby reducing the impact of storm surges and preventing coastal erosion (Beck et al., 2018; Lacambra S et al., 2024; Rottmueller et al., 2025). This reduced coastal flooding potential helps prevent economic damages amounting to tens of billions of US dollars annually worldwide (Rottmueller et al., 2025). By protecting coastlines and critical infrastructure from flood risks, healthy coral reefs help prevent flood-induced environmental pollution, e.g. sewage and petrochemical contamination (ibid.). In addition, coral reefs support the sustainability of beaches helping to replenish them with sediments after storms and hurricanes (Lacambra S et al., 2024).

Besides enhancing coastal climate resilience, coral reefs also offer a living space for marine species and ensure food security by providing food through fishing and harvesting. In total, around half a billion people depend, to varying degrees, on these coastal ecosystems for their livelihoods, food, and other resources (Eddy et al., 2021; Sobha et al., 2023).

However, coral reefs are highly vulnerable to climate change, with rising sea temperatures, ocean acidification, and other anthropogenic stressors threatening their survival (Allemand and Osborn, 2019; Hoegh-Guldberg et al., 2007). Reefs worldwide have already suffered substantial declines in living coral cover and reef structures (Beck et al., 2018).On average, coral cover decreased from 34.8% to 16.3% between 1970 and 2012 (Lacambra S et al., 2024). This decline in the state of coral reefs is alarming given the vital ecosystem services they provide (Spalding et al., 2014). By now, the capacity of coral reefs to deliver ecosystem services has decreased by half since 1950s which puts at risk the well-being of those who rely on them (Eddy et al., 2021). For these reasons, restoring coral reefs is essential for maintaining and enhancing their ecosystem services and, particularly, their role in climate adaptation amid the escalating effects of climate change.

4.1 Threats

Ocean warming

The warming climate is a significant concern for coral reefs, as they are some of the most sensitive ecosystems to temperature. Temperatures in the 18 - 30°C range discourage coral growth, and heat stress has caused coral bleaching in tropical ecosystems (Wang et al., 2020). Heron et al. (2018) found that, at current rates, 25 out of 29 World Heritage reefs will experience severe bleaching events every few years by 2040.

Ocean acidification

Ocean acidification decreases the aragonite saturation, which is what allows coral reefs to grow. In more acidic conditions, coral reefs become weaker, grow more slowly, and are less able to survive threats. Currently over half of coral reefs are in waters with subpar aragonite saturations, which can shrink and erode corals (Harrould-Kolieb and Savitz, 2009).

Direct anthropogenic activity

While coral reefs face threats from climate change, an indirect pressure from human activity, direct anthropogenic activities are responsible for much of the stress experienced by coral reefs.

Human activities such as tourism can degrade coral reefs on a local scale, with the potential to degrade ecosystems, habitats, species, water quality, and regulatory functions (Wang et al., 2020). In Wang et al.'s (2020) study, the primary damage to corals on the Weizhou Island reef was due to divers touching corals, wearing down the tissue and leading to skeleton breakage. Additionally, excess wastewater discharge from tourism increases macroalgae levels, which can affect coral calcification and reproduction.

Other pressures on coral reefs from human activity include overfishing, pollution, and coastal development (Westoby et al., 2020). In Indonesia, for example, overfishing and blast fishing are two of the most pressing threats to coral reefs. One reason for this is a lack of, or inadequate enforcement of sustainable fishing legislation (Watt-Pringle et al., 2024).

4.2 Obstacles to implementation

A lack of monitoring programs is a common issue amongst restoration projects. Without appropriately defined assessment criteria, it's difficult to measure the progress and performance of restoration projects against their objectives. This lack of data-gathering prevents standardization and frameworks for similar restoration projects (Watt-Pringle et al., 2024). Additionally, coral reef restoration faces similar challenges to other types of restoration projects, including unclear objectives and poorly designed projects that don't align with the objectives (Boström-Einarsson et al., 2020).

Citizen and stakeholder involvement is seen crucial for the success of EbA (Lucatello and Alcántara-Ayala, 2024). Without buy-in and engagement of stakeholders, local support for the conservation project will likely be lacking. Even with efforts such as education, however, buy-in is dependent upon stakeholders, who can fail to connect with conservation projects and therefore prevent long-term success. Project leaders may fail to engage stakeholders due to a lack of consideration of culture, attitudes, and norms or lack of properly established trust. Lucatello and Alcántara-Ayala (2024) stress in their study, that implementing EbA requires careful, equitable planning to prevent displacement, marginalization, and social inequalities while ensuring long-term sustainability for all stakeholders.

Long-term funding is another obstacle to implementation. Because finance packages often last between one and three years, there is not adequate funding for monitoring and management programs, a crucial part of EbA projects. A way to secure adequate funding is to ensure task plans are detailed and comprehensive when seeking financing from donors (Etongo et al., 2021; Lucatello and Alcántara-Ayala, 2024).

Another obstacle related to the long-term success of EbA projects is effective management over time (Etongo et al., 2021). Coral reefs are continuing to degrade in Indonesia because despite legislation such as MPAs to protect the efforts of EbA measures, MPAs are not effectively enforced or managed. Ineffective management can often be due to lack of financing, but it more often results from lack of qualified staff (Watt-Pringle et al., 2024).

4.3 Success factors

Coral reef restoration success relies on integrating ecological, hydrodynamic, and engineering principles at multiple scales to maximize resilience and coastal protection benefits. One critical factor is site selection and suitability (Ferse et al., 2021; Viehman et al., 2023). Effective restoration projects begin with identifying locations that exhibit suitable environmental conditions, such as stable substrates, appropriate water quality, and optimal depth to support coral growth. These sites should also align with regional risk assessments, targeting areas where restored reefs can offer significant wave attenuation and flood protection. Addressing local stressors, such as sedimentation or nutrient runoff, before restoration ensures the habitat's suitability and increases the likelihood of coral survival and growth.

Another critical factor is the definition of **clear and achievable objectives**, aligning restoration activities with ecological goals like establishing self-sustaining coral populations or enhancing reef resilience (Boström-Einarsson et al., 2020). These objectives must guide the selection of methods, coral species, and monitoring protocols. For example, the use of fast-growing coral species such as *Acropora* enhances recovery rates, while methods like coral gardening, which includes a nursery phase, improve survival rates and scalability. Additionally, adaptive management based on long-term monitoring enables practitioners to respond to unforeseen challenges, ensuring project continuity and success.

Another key success factor is the integration of ecological and engineering approaches to achieve long-term sustainability (Viehman et al., 2023). This includes using diverse coral species that reflect natural zonation and ecological resilience to maximize biodiversity and functionality. Hybrid approaches, combining artificial reef structures with planted corals, can provide immediate wave attenuation while fostering the gradual development of biogenic reefs. Monitoring and adaptive management are essential to track progress and adjust strategies in response to unforeseen challenges.

Another pivotal factor is the **integration of ecological and social dimensions**. Coral restoration is most effective when local communities are engaged, fostering stewardship and aligning restoration efforts with community needs (Boström-Einarsson et al., 2020; Le et al., 2022). Techniques such as larval enhancement or direct transplantation must consider local environmental conditions and genetic diversity to maximize ecological outcomes.

4.4 Case studies

Boström-Einarsson et al. (2020) analysed different types of restoration efforts across different case studies, finding the most common methods to be gardening (growing coral fragments in nurseries and transplanting them), direct transplantation (directly transplanting coral fragments, skipping the nursery stage), and constructing artificial reefs. Ferrario et al.’s (2014) meta-analysis of the effectiveness of coral reef restoration for disaster risk reduction demonstrated that reefs can reduce wave energy by 97%, evidence of the promise of EbA solutions in the face of growing threats from natural hazards. The following case studies indicate elements for success, lessons learned, and/or innovative measures.

The Coral Triangle Initiative on Coral Reefs, Fisheries, and Food (CTI-CFF) is both a conservation management project and tool for supporting the economic benefits that coral reefs provide. Success of the project include notable reduction in illegal fishing, increased coral cover, and improved fish abundance. Local catch rates are higher, with traditional fishing methods experiencing a revitalization, and tourism is expanding as an economic opportunity for the community. One lesson learned and demonstrated need from the project is the strengthening of continued conservation efforts and maintenance to ensure long-term staying power (Watt-Pringle et al., 2024).

The Reef Rescuers Project, conducted by the USAID/Southern Africa regional mission in partnership with the NGO Nature Seychelles, built nurseries from coral fragments and transplanted corals as part of an EbA solution. The project resulted in a fivefold increase in fish abundance, 700% increase in coral reefs, and over forty individuals trained in coral reef restoration techniques. The project used four techniques to enhance resilience: 1) transplanting corals at a large enough scale for coastal protection 2) mitigating threats such as overfishing and pollution 3) utilizing coral fragments that have demonstrated resilience and 4) incorporating monitoring and evaluation into the adaptation plan in order to understand the impacts.

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) implemented a coral reef restoration in Puerto Rico. Coral reefs provide economic benefit for the community through tourism, can reduce wave height and intensity in the event of storm surges, and provide habitat for fisheries. Elements crucial for the success of the ten-year project, focused on restoring populations of coral species, include 1) gaining buy-in from stakeholders by offering training and education (e.g. coral restoration techniques) 2) ensuring capacity for emergency response in the event, or aftermath, of crisis (e.g. hurricane) 3) community use of project-developed guidelines for continued management of coral reef ecosystems. Furthermore, successful restoration occurs alongside adequate management and improvement of other ecosystem conditions, such as water quality and land use (UNEP, 2016).

A paper focusing on coral reef restoration projects in Australia, analysed restoration activities like coral gardening, substrate stabilisation, coral repositioning, macro-algae removal, and larval-based restoration techniques (McLeod et al., 2022). With a focus on policies and projects, Razak et al. (2022) focused on coral reef restoration in Indonesia. Their findings show that Indonesia's reef restoration policy has spurred diverse efforts but lacks coordination and long-term monitoring; fostering clear objectives, robust monitoring, and global collaboration can position Indonesia as a leader in coral reef recovery.

5 Finance

Financing is crucial for EbA in tropical and subtropical coastal and marine areas as it supports the implementation of nature-based solutions that enhance resilience to climate change, protect biodiversity, and sustain livelihoods. By providing the necessary resources for planning, execution, monitoring, and community engagement, effective financing ensures the long-term success and scalability of EbA initiatives in these vulnerable regions. Different financing options are displayed in Table 4 (see Annex).

Hunzai et al. (2018) compiled a list of financing instruments for EbA measures (generally, not just for mangroves or coral reefs) into three different categories: international public funds, private financing, and domestic public funds. International public funds include several different mechanisms provided by international organizations like the UNFCCC, such as the Green Climate Fund and the Adaptation Fund, and the World Bank, the Asian and African development banks, the European Bank for Reconstruction and Development, and the Inter-American Development Bank. Private finance sources include measures such as carbon markets, in which carbon credits gained from avoiding emissions can be sold; certification schemes, for instance of food products and ecotourism services; fund mobilization from non-profits and NGOs; and private capital investments and credits, which constitute the bulk of private financing. Finally, domestic public funds usually take the form of national adaptation funds, which are often part of a federal adaptation strategy. Domestic public financing can also be generated through economic tools such as taxes, feeds, bonds, and subsidies.

As an example of a project using international public funds, the EbA South project was funded via the Global Environment Facility's (GEF) Special Climate Change Fund. Implementation and execution were conducted by a mix of international (e.g. the United Nations Environment

Programme) and national (Chinese) research bodies (e.g. the Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences) (Mills et al., 2020).

In an exemplary method for mitigating labor costs, the CBACC-CF project in Bangladesh creates participatory ownership of land behind mangrove forests through restoration projects. The model is intended to generate alternative incomes for individuals in the sectors that surround mangroves and are sensitive to the effects of climate change. Participants contribute 50% of the labor costs of land development, mostly consisting of ditch and dyke systems, in exchange for ten-year land ownership agreements. The community-centered project has also proffered important knowledge to its participants, namely that there is no substitute for mangroves in terms of their capacity to abate the effects of cyclones and storm surges, and increasing their number helps to protect fishermen's' boats and supplies from those threats (Nandy and Ahammad, 2012).

While these financing and funding options have been identified for large-scale, national, or international projects, the funding outlook for local, small-scale, or community-based projects is less clear. Financing options include microfinancing and payments for ecosystems services (PES), but broader funding schemes at the international or national scale for local projects are fairly underdeveloped (Reid, 2016). Additionally, according to stakeholders involved in the EbA South project, PES will likely be insufficient for many EbA projects. Instead, funding will need to derive from public-private partnerships (PPP), justified by detailed data on the economic benefits of ecosystem goods and services (Mills et al., 2020).

One important aspect of financing is that costs differ depending on the economic status of the nation or region. Bayraktarov et al. (2016, as cited in Westoby et al., 2020) assert that restoration can be 30 times cheaper in developing countries (rather than developed countries), often due to harnessing community efforts in the project.

As noted in the *The Mangrove Breakthrough Financial Roadmap* (Systemiq, 2023), other financing options derive from business models. This might include ventures such as ecotourism and recreation, payment for ecosystem services, carbon credits, and sustainable aquaculture.

Other options include green bonds. Green bonds are similar to standard bonds in that they are investments in projects – in this case, sustainability projects – with an offer of return on investment. For instance, the OECD (2024) reports the rise of green bonds in the Latin American and Caribbean (LAC) region, citing a jump from 9.3% to 35% issuance over the span of three years between 2020 and 2023. There are also initiatives active promoting mangroves bonds (e.g. Earth Security, 2020), however, scientific literature about mangrove bonds is scarce.

Public-private partnerships (PPPs) are increasingly used for climate mitigation and adaptation, as mentioned by Casady et al. (2024). Favero and Hinkel (2024) stress that the “essential advantage lies in efficiently allocating and sharing risks based on the parties’ ability to manage them”, however empirical evidence of successful EbA in coastal areas is stated as rather limited.

Sack (2023), in her examination of financing options for coastal and marine EbA in Southern Africa, notes that EbA projects struggle to secure financing because it’s difficult to quantify, and therefore monetarily valuate, the contributions of EbA measures to climate change mitigation. Approaching EbA projects from a holistic perspective, however, i.e. incorporating social objectives such as poverty alleviation, can help boost the profile of EbA projects for potential funders. While funding can derive from the private sector, public funds, philanthropy, and blended sources, donor funding constitutes the majority of support for marine conservation initiatives in developing countries (Sack, 2023).

Other, more innovative financing options for coastal EbA projects include debt-for-nature swap and public employment and social protection programs. Debt-for-nature swap is an exchange in which a developing nation's investment in environmental conservation allows for a percentage of its foreign debt to be forgiven. This initiative was first successfully implemented in Seychelles in 2018. In this case study, a sector of The Nature Conservancy secured loans and grants to 'buy' the debt, using the money to implement new marine protected areas. (Booth and Brooks, 2023)

Public employment and social protection programs provide temporary employment, including for youth, in the field of conservation work. For example, from 2004 to 2019, the Working for Wetlands program in South Africa rehabilitated 70,000 hectares of wetlands and created 36,000 jobs. These types of metrics also help give credence to, and evidence of, the positive impacts of EbA (Sack, 2023).

6 Outlook

6.1 Identified information requirements / knowledge gaps

Socio-economic impacts and equity dimensions: Detailed assessments of how mangrove degradation vs. their restoration affects local economies, particularly in relation to fisheries and tourism, would provide valuable insights for conservation planning. Additionally, there is limited focus on how EbA measures impact marginalized and vulnerable groups, including gender-specific impacts. Frameworks could be developed to assess equity outcomes of EbA projects.

Successful examples of large-scale financing: Because financing is often a difficulty for EbA projects, examples or roadmaps to adequate funding for large-scale projects are limited. As Sack (2023) notes, one reason why finding funding is difficult is due to a difficulty in quantifying the effectiveness of EbA projects, which would be used as evidence for financial support. At the same time, efforts to mobilize additional capital need to avoid green-washing and should ensure equitable access to funds (Beeston et al., 2023).

Quantifying success/effectiveness: There is limited empirical data on the long-term effectiveness of EbA approaches in mitigating climate change, as identifying and isolating metrics is difficult. Additionally, there is a gap in studies comparing EbA with other adaptation approaches (e.g. hard engineering or hybrid solutions).

Integration of local knowledge: While there is ample opportunity for integration of local knowledge into the design of EbA projects, there is limited evidence on how this has been conducted in case studies. Additionally, this step is missing in many guidelines and handbooks for how to implement EbA projects.

Scalability and transferability: Localized EbA practices are difficult to scale up to regional or national levels while maintaining context-specific benefits. Additionally, there is limited guidance on transferring successful EbA models across diverse ecological and socio-economic contexts.

Future climactic contexts: While climate modelling can predict some future scenarios, there is still a degree of uncertainty regarding how climactic changes will interact and unfold, how ecosystems will react to those changes in the climate, and therefore how effective EbA solutions will be over the long-term.

Policy and governance: While governance plays a crucial role in the context and longevity of ecosystem protection in EbA projects, there are gaps in integrating EbA into broader climate policies, development strategies, and governance frameworks. Additionally, more clarity and guidance could be delivered on how EbA fits within the framework of international climate agreements and national adaptation plans.

Monitoring, evaluation, and learning: While the best available guidance agrees on the importance of monitoring and evaluation in EbA projects, monitoring and evaluation frameworks can be difficult to implement in the context of developing nations with limited resources (e.g. capacity, expertise, and financing) to support program infrastructure. Additionally, there is a lack of rigorous documentation of lessons learned from past EbA projects, hindering adaptive management and iterative improvement.

Hybrid approaches: There is further opportunity for exploration of how EbA can be effectively integrated with other adaptation strategies, such as green-grey infrastructure (e.g. UNEP, 2024). More research could be conducted on trade-offs between biodiversity conservation and human adaptation needs in EbA projects.

6.2 Key questions and focus topics

1. Policy and Governance Context

- **How can we better integrate EbA into Nationally Determined Contributions (NDCs) and National Adaptation Plans (NAPs)?**
    - What are the key challenges countries face in integrating EbA into these frameworks?
    - How can guidelines and support mechanisms be enhanced to facilitate this integration?
    - What role do international and regional organizations play in this process?
- **How do regional initiatives (e.g., WACA, Coral Triangle Initiative) complement global frameworks, and where are the gaps in alignment?**
    - How can alignment between regional and global targets be improved to strengthen the implementation of coastal EbA?
    - What examples of successful coordination between regional and global initiatives exist, and what lessons can be learned from them?

2. Implementation Challenges and Opportunities

<u>Stakeholder Engagement</u>

- **How can stakeholder engagement be improved, particularly in culturally diverse or resource-limited settings?**
    - What methods have proven effective in incorporating local knowledge and operationalizing participatory approaches?
    - How can challenges like language differences, varying risk perceptions, and power dynamics be addressed to ensure meaningful engagement?

<u>Monitoring</u>

- **What are the best practices for long-term monitoring and adaptive management of EbA projects?**
    - How can barriers related to funding and technical expertise (especially in resource-limited settings) be overcome to ensure sustained monitoring?

    - How can we better track EbA's contributions to biodiversity, climate resilience, and socio-economic outcomes?
    - How can we address data limitations and methodological challenges?
    - What role can participatory monitoring and emerging technologies (e.g., remote sensing, AI) play in overcoming these challenges?
    - What tools or frameworks are available for adaptive management in EbA interventions, and how can they be scaled up?

<u>**Scaling and Communication**</u>

- **How can lessons learned from pilot projects be scaled up to national or regional levels?**
    - What mechanisms or networks exist for sharing and replication of successful approaches across contexts?
    - How can scaling efforts balance local specificity with broader applicability?
- **How can EbA strategies be better communicated to local communities, policymakers, and the private sector to increase understanding and participation?**
    - What culturally appropriate messaging strategies are most effective in engaging diverse audiences?
    - How can challenges like misinformation and apathy be overcome to foster long-term buy-in?

<u>**Financing**</u>

- **What innovative financing mechanisms (e.g., green bonds, blue carbon markets) are most viable for funding coastal EbA?**
    - What are successful examples of the mechanisms (e.g. mangrove bonds, eco-labels?)
    - How can supportive policy frameworks and capacity-building initiatives facilitate access to these mechanisms?
    - How to ensure social-ecological safeguards and avoid greenwashing?
- **How could the private sector foster coastal EbA?**
    - What are incentives for the private actors to become active in coastal EbA?
    - What are successful examples of public-private partnerships in funding EbA?

7 Literature

Allemand, D., Osborn, D., 2019. Ocean acidification impacts on coral reefs: From sciences to solutions. Regional Studies in Marine Science 28, 100558. https://doi.org/10.1016/j.rsma.2019.100558

Baig, S., Rizvi, A.R., Verdone, M., 2015. Ecosystem based adaptation : knowledge gaps in making an economic case for investing in nature based solutions for climate change. IUCN.

Beck, M.W., Losada, I.J., Menéndez, P., Reguero, B.G., Díaz-Simal, P., Fernández, F., 2018. The global flood protection savings provided by coral reefs. Nat Commun 9, 2186. https://doi.org/10.1038/s41467-018-04568-z

Beeston, M., Cameron, C., Hagger, V., Howard, J., Lovelock, C., Sippo, J., Tonneijk, F., van Bijsterveldt, C., van Eijk, P., 2023. Best Practice Guidelines for Mangrove Restoration (Executive Summary).

Booth, M., Brooks, C.M., 2023. Financing marine conservation from restructured debt: a case study of the Seychelles. Front. Mar. Sci. 10. https://doi.org/10.3389/fmars.2023.899256

Boström-Einarsson, L., Babcock, R.C., Bayraktarov, E., Ceccarelli, D., Cook, N., Ferse, S.C.A., Hancock, B., Harrison, P., Hein, M., Shaver, E., Smith, A., Suggett, D., Stewart-Sinclair, P.J., Vardi, T., McLeod, I.M., 2020. Coral restoration – A systematic review of current methods, successes, failures and future directions. PLOS ONE 15, e0226631. https://doi.org/10.1371/journal.pone.0226631

Casady, C.B., Cepparulo, A., Giuriato, L., 2024. Public-private partnerships for low-carbon, climate-resilient infrastructure: Insights from the literature. Journal of Cleaner Production 470, 143338. https://doi.org/10.1016/j.jclepro.2024.143338

CBD, 2009. Connecting Biodiversity and Climate Change Mitigation and Adaptation (Technical Series No. 41), Report of the Second Ad Hoc Technical Expert Group on Biodiversity and Climate Change. Secretariat of the Convention on Biological Diversity, Montreal.

Chaudhuri, P., Chaudhuri, S., Ghosh, R., 2019. The Role of Mangroves in Coastal and Estuarine Sedimentary Accretion in Southeast Asia, in: Sedimentation Engineering [Working Title]. IntechOpen. https://doi.org/10.5772/intechopen.85591

Earth Security, 2020. Financing the Earth's Assets: The Case for Mangroves as a Nature-based Climate Solution.

Eddy, T.D., Lam, V.W.Y., Reygondeau, G., Cisneros-Montemayor, A.M., Greer, K., Palomares, M.L.D., Bruno, J.F., Ota, Y., Cheung, W.W.L., 2021. Global decline in capacity of coral reefs to provide ecosystem services. One Earth 4, 1278–1285. https://doi.org/10.1016/j.oneear.2021.08.016

Etongo, D., Amelie, V., Pouponneau, A., Filho, W.L., 2021. Identifying and Overcoming Barriers to Climate Change Adaptation in the Seychelles, in: Oguge, N., Ayal, D., Adeleke, L., Da Silva, I. (Eds.), African Handbook of Climate Change Adaptation. Springer International Publishing, Cham, pp. 2675–2692. https://doi.org/10.1007/978-3-030-45106-6_136

Favero, F., Hinkel, J., 2024. Key Innovations in Financing Nature-Based Solutions for Coastal Adaptation. Climate 12, 53. https://doi.org/10.3390/cli12040053

FEBA, 2017. Making Ecosystem-based Adaptation Effective: A Framework for Defining Qualification Criteria and Quality Standards (No. 46), FEBA technical paper developed for UNFCCC-SBSTA. FEBA (Friends of Ecosystem-based Adaptation).

Ferrario, F., Beck, M.W., Storlazzi, C.D., Micheli, F., Shepard, C.C., Airoldi, L., 2014. The effectiveness of coral reefs for coastal hazard risk reduction and adaptation. Nat Commun 5, 3794. https://doi.org/10.1038/ncomms4794

Ferse, S.C.A., Hein, M.Y., Rölfer, L., 2021. A survey of current trends and suggested future directions in coral transplantation for reef restoration. PLOS ONE 16, e0249966. https://doi.org/10.1371/journal.pone.0249966

Giffin, A.L., Brown, C.J., Nalau, J., Mackey, B.G., Connolly, R.M., 2020. Marine and coastal ecosystem-based adaptation in Asia and Oceania: review of approaches and integration with marine spatial planning. Pac. Conserv. Biol. 27, 104–117. https://doi.org/10.1071/PC20025

Grantham, H.S., McLeod, E., Brooks, A., Jupiter, S.D., Hardcastle, J., Richardson, A.J., Poloczanska, E.S., Hills, T., Mieszkowska, N., Klein, C.J., Watson, J.E.M., 2011. Ecosystem-based adaptation in marine ecosystems of tropical Oceania in response to climate change. Pac. Conserv. Biol. 17, 241–258. https://doi.org/10.1071/pc110241

Harris, P.T., Westerveld, L., Nyberg, B., Maes, T., Macmillan-Lawler, M., Appelquist, L.R., 2021. Exposure of coastal environments to river-sourced plastic pollution. Science of The Total Environment 769, 145222. https://doi.org/10.1016/j.scitotenv.2021.145222

Harrould-Kolieb, E., Savitz, J., 2009. ACID TEST: CAN WE SAVE OUR OCEANS FROM CO2? (No. Second Edition). Oceana.
Heron, S.F., 2018. Impacts of climate change on World Heritage coral reefs: update to the first global scientific assessment.
Hoegh-Guldberg, O., Mumby, P.J., Hooten, A.J., Steneck, R.S., Greenfield, P., Gomez, E., Harvell, C.D., Sale, P.F., Edwards, A.J., Caldeira, K., Knowlton, N., Eakin, C.M., Iglesias-Prieto, R., Muthiga, N., Bradbury, R.H., Dubi, A., Hatziolos, M.E., 2007. Coral Reefs Under Rapid Climate Change and Ocean Acidification. Science 318, 1737–1742. https://doi.org/10.1126/science.1152509
Hunzai, K., Chagas, T., ‘t Gilde, L., Hunza, T., Krämer, N., 2018. Finance Options and Instruments for Ecosystem-based Adaptation. Overview and compilation of ten examples. GIZ.
IKI-eval, 2021. Aufstockung der Mangroven (EbA) im Mekong-Delta. Evaluierungsmanagement der Internationalen Klimaschutzinitiative.
IPCC (Ed.), 2022. Climate change 2022: mitigation of climate change. IPCC, Geneva.
IPCC, 2019. Summary for Policymakers, IPCC Special Report on the Ocean and Cryosphere in a Changing Climate [H.-O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, A. Alegría, M. Nicolai, A. Okem, J. Petzold, B. Rama, N.M. Weyer (eds.)]. Cambridge University Press, Cambridge.
IUCN, 2020. Guidance for using the IUCN Global Standard for Nature-based Solutions: first editions, 1st ed. IUCN, International Union for Conservation of Nature. https://doi.org/10.2305/IUCN.CH.2020.09.en
Jones, H.P., Hole, D.G., Zavaleta, E.S., 2012. Harnessing nature to help people adapt to climate change. Nature Clim Change 2, 504–509. https://doi.org/10.1038/nclimate1463
Jones, H.P., Nickel, B., Srebotnjak, T., Turner, W., Gonzalez-Roglich, M., Zavaleta, E., Hole, D.G., 2020. Global hotspots for coastal ecosystem-based adaptation. PLOS ONE 15, e0233005. https://doi.org/10.1371/journal.pone.0233005
Jupiter, S.D., Jenkins, A.P., Long, W.J.L., Maxwell, S.L., Carruthers, T.J.B., Hodge, K.B., Govan, H., Tamelander, J., Watson, J.E.M., 2014. Principles for integrated island management in the tropical Pacific. Pac. Conserv. Biol. 20, 193–205. https://doi.org/10.1071/pc140193
Kairo, J.G., Mangora, M.M., 2020. The Guidelines on Mangrove Restoration for the Western Indian Ocean Region. Published by the United Nations Environment.
Kozban, I., Kopsieker, L., Wulf, S., Hedden-Dunkhorst, B., 2023. Strengthening synergier for biodiversity and climate. Bundesamt für Naturschutz, DE.
Lacambra S, C.L., Spencer, T., Munera, C., Pizarro, V., Lozano-Rivera, P., Esquivel, C., Cardona, O.D., 2024. Coastal ecosystems contribution to climate adaptation and disasters risk management in the tropical Americas. Nature-Based Solutions 5, 100112. https://doi.org/10.1016/j.nbsj.2024.100112
Le, (Jenny) Dung, Becken, S., Curnock, M., 2022. Gaining public engagement to restore coral reef ecosystems in the face of acute crisis. Global Environmental Change 74, 102513. https://doi.org/10.1016/j.gloenvcha.2022.102513
Lucatello, S., Alcántara-Ayala, I., 2024. Sustainable Synergy: Strengthening disaster risk reduction in Latin America and the Caribbean through nature-based solutions. International Journal of Disaster Risk Reduction 113, 104860. https://doi.org/10.1016/j.ijdrr.2024.104860
Mafi-Gholam, D., Zenner, E., 2018. A Review of Climate Change Impacts on Mangrove Ecosystems. International Journal of Environmental Monitoring and Protection 5, 18.
McLeod, I.M., Hein, M.Y., Babcock, R., Bay, L., Bourne, D.G., Cook, N., Doropoulos, C., Gibbs, M., Harrison, P., Lockie, S., Oppen, M.J.H. van, Mattocks, N., Page, C.A., Randall, C.J., Smith, A., Smith, H.A., Suggett, D.J., Taylor, B., Vella, K.J., Wachenfeld, D., Boström-Einarsson, L., 2022. Coral restoration and adaptation in Australia: The first five years. PLOS ONE 17, e0273325. https://doi.org/10.1371/journal.pone.0273325
Mills, A.J., Tan, D., Manji, A.K., Vijitpan, T., Henriette, E., Murugaiyan, P., Pantha, R.H., Lafdal, M.Y., Soule, A., Cazzetta, S., Bégat, P., Vlieghe, K.E.P., Lavirotte, L., Kok, J.T., Lister, J., 2020. Ecosystem-based adaptation to climate change: Lessons

learned from a pioneering project spanning Mauritania, Nepal, the Seychelles, and China. PLANTS, PEOPLE, PLANET 2, 587–597. https://doi.org/10.1002/ppp3.10126
Mohanty, A., Mohapatra, A.G., Mohanty, S.K., 2024. Climate Change Impacts on Mangroves: Need for Resilience Mechanisms, in: Padmakumar, V., Shanthakumar, M. (Eds.), Mangroves in a Changing World: Adaptation and Resilience. Springer Nature Switzerland, Cham, pp. 45–70. https://doi.org/10.1007/978-3-031-67691-8_4
Nalau, J., Becken, S., Mackey, B., 2018. Ecosystem-based Adaptation: A review of the constraints. Environmental Science & Policy 89, 357–364. https://doi.org/10.1016/j.envsci.2018.08.014
Nandy, P., Ahammad, R., 2012. Navigating mangrove resilience through the ecosystem based adaptation: lessons from Bangladesh. IUCN, Gland, Switzerland with Mangroves for the Future, Bangkok, Thailand.
Nyangoko, B.P., Berg, H., Mangora, M.M., Shalli, M.S., Gullström, M., 2022. Community perceptions of climate change and ecosystem-based adaptation in the mangrove ecosystem of the Rufiji Delta, Tanzania. Climate and Development 14, 896–908.
OECD, 2024. The surge of Green, Social, Sustainability and Sustainability-linked (GSSS) bonds in Latin America and the Caribbean (No. 56), Development Policy Papers. OECD Publishing, Paris.
Pauleit, S., Zölch, T., Hansen, R., Randrup, T.B., Konijnendijk van den Bosch, C., 2017. Nature-Based Solutions and Climate Change – Four Shades of Green, in: Kabisch, N., Korn, H., Stadler, J., Bonn, A. (Eds.), Nature-Based Solutions to Climate Change Adaptation in Urban Areas: Linkages between Science, Policy and Practice. Springer International Publishing, Cham, pp. 29–49. https://doi.org/10.1007/978-3-319-56091-5_3
Pearson, J., McNamara, K.E., Nunn, P.D., 2020. iTaukei Ways of Knowing and Managing Mangroves for Ecosystem-Based Adaptation, in: Leal Filho, W. (Ed.), Managing Climate Change Adaptation in the Pacific Region. Springer International Publishing, Cham, pp. 105–127. https://doi.org/10.1007/978-3-030-40552-6_6
Razak, T.B., Boström-Einarsson, L., Alisa, C.A.G., Vida, R.T., Lamont, T.A.C., 2022. Coral reef restoration in Indonesia: A review of policies and projects. Marine Policy 137, 104940. https://doi.org/10.1016/j.marpol.2021.104940
Reid, H., 2016. Ecosystem- and community-based adaptation: learning from community-based natural resource management. Climate and Development 8, 4–9. https://doi.org/10.1080/17565529.2015.1034233
Rottmueller, M.E., Storlazzi, C.D., Frick, F., 2025. Coral reef restoration can reduce coastal contamination and pollution hazards. Commun Earth Environ 6, 1–14. https://doi.org/10.1038/s43247-025-02019-4
Sack, H., 2023. A Regional Assessment of Marine and Coastal EbA in SADC. South African Institute of International Affairs.
Sierra-Correa, P.C., Cantera Kintz, J.R., 2015. Ecosystem-based adaptation for improving coastal planning for sea-level rise: A systematic review for mangrove coasts. Marine Policy 51, 385–393. https://doi.org/10.1016/j.marpol.2014.09.013
Smith School of Enterprise and the Environment, n.d. Coastal mangrove restoration using a community ecosystem-based adaptation approach [WWW Document]. Nature-based Solutions case studies. URL https://casestudies.naturebasedsolutionsinitiative.org/casestudy/coastal-mangrove-afforestation-using-a-community-ecosystem-based-adaptation-approach/ (accessed 10.29.24).
Sobha, T.R., Vibija, C.P., Fahima, P., 2023. Coral Reef: A Hot Spot of Marine Biodiversity, in: Sukumaran, S.T., T R, K. (Eds.), Conservation and Sustainable Utilization of Bioresources, Sustainable Development and Biodiversity. Springer Nature Singapore, Singapore, pp. 171–194. https://doi.org/10.1007/978-981-19-5841-0_8
Spalding, M.D., Ruffo, S., Lacambra, C., Meliane, I., Hale, L.Z., Shepard, C.C., Beck, M.W., 2014. The role of ecosystems in coastal protection: Adapting to climate change and coastal hazards. Ocean & Coastal Management 90, 50–57. https://doi.org/10.1016/j.ocecoaman.2013.09.007
Sunkur, R., Kantamaneni, K., Bokhoree, C., Ravan, S., 2023. Mangroves' role in supporting ecosystem-based techniques to reduce disaster risk and adapt to climate change: A

review. Journal of Sea Research 196, 102449. https://doi.org/10.1016/j.seares.2023.102449

Systemiq, 2023. The Mangrove Breakthrough Financial Roadmap. Mangrove Breakthrough.

Terton, A., Qi, J., Jang, N., 2024. Tracking Progress on the Integration of Nature-based Solutions and Ecosystem-Based Adaptation in National Adaptation Plan Processes. NAP Global Network.

UNEP, 2024. A Decade of Ecosystem-based Adaptation: Lessons from the United Nations Environment Programme - Policy Brief. United Nations Environment Programme.

UNEP, 2016. Options for Ecosystem-based Adaptation (EBA) in Coastal Environments: A Guide for environmental managers and planners. UNEP, Nairobi.

United Nations, 2024. A deep dive into ocean-related measures in the nationally determined contributions of small island developing States 55.

Vardi, T., Hoot, W.C., Levy, J., Shaver, E., Winters, R.S., Banaszak, A.T., Baums, I.B., Chamberland, V.F., Cook, N., Gulko, D., Hein, M.Y., Kaufman, L., Loewe, M., Lundgren, P., Lustic, C., MacGowan, P., Matz, M.V., McGonigle, M., McLeod, I., Moore, J., Moore, T., Pivard, S., Pollock, F.J., Rinkevich, B., Suggett, D.J., Suleiman, S., Viehman, T.S., Villalobos, T., Weis, V.M., Wolke, C., Montoya-Maya, P.H., 2021. Six priorities to advance the science and practice of coral reef restoration worldwide. Restoration Ecology 29, e13498. https://doi.org/10.1111/rec.13498

Viehman, T.S., Reguero, B.G., Lenihan, H.S., Rosman, J.H., Storlazzi, C.D., Goergen, E.A., Canals Silander, M.F., Groves, S.H., Holstein, D.M., Bruckner, A.W., Carrick, J.V., Haus, B.K., Royster, J.B., Duvall, M.S., Torres, W.I., Hench, J.L., 2023. Coral restoration for coastal resilience: Integrating ecology, hydrodynamics, and engineering at multiple scales. Ecosphere 14, e4517. https://doi.org/10.1002/ecs2.4517

Wang, Yongzhi, Yu, K., Chen, X., Wang, W., Huang, X., Wang, Yinghui, Liao, Z., 2020. An approach for assessing ecosystem-based adaptation in coral reefs at relatively high latitudes to climate change and human pressure. Environ Monit Assess 192, 579. https://doi.org/10.1007/s10661-020-08534-5

Watt-Pringle, R., Razak, T.B., Jompa, J., Ambo-Rappe, R., Kostaman, A.N., Smith, D.J., 2024. Coral reef restoration in Indonesia: lessons learnt from the world’s largest coral restoration nation. Biodivers Conserv 33, 2675–2707. https://doi.org/10.1007/s10531-024-02897-8

Weaver, R.J., Stehno, A.L., 2024. Mangroves as Coastal Protection for Restoring Low-Energy Waterfront Property. JMSE 12, 470. https://doi.org/10.3390/jmse12030470

Westoby, R., Becken, S., Laria, A.P., 2020. Perspectives on the human dimensions of coral restoration. Reg Environ Change 20, 109. https://doi.org/10.1007/s10113-020-01694-7

8 Annex

Table 1: Evidence base guidance documents

Document Title	Publishing Organization	Year	Short Description	Relevant Region	Addressed Ecosystem
Constructing theories of change for Ecosystem based Adaptation projects: a guidance document	Conservation International	2013	"In this document we provide project managers a step-by-step guide to constructing a theory of change with examples set in the context of Conservation International (CI)'s International Climate Initiative (IKI) project that is designing and implementing EbA interventions in three countries."	Global	Not specific
Guidebook for Monitoring and Evaluating Ecosystem-based Adaptation Interventions	GIZ	2020	The Guidebook outlines a four-step process for designing and implementing effective monitoring and evaluation (M&E) for Ecosystem-based Adaptation (EbA), focusing on key considerations and guidance rather than detailed instructions. It also highlights tools and methodologies for more specific implementation and emphasizes using and communicating M&E results effectively.	Global	Not specific
A Regional Assessment of Marine and Coastal EbA in SADC	South African Institute of International Affairs	2023	This regional assessment, one of six key research outputs, reviews the state of marine and coastal EbA in SADC, highlighting implementation examples, policy integration, financing, and community partnerships. It also explores challenges and opportunities specific to Southern African communities for scaling up EbA efforts.	Southern Africa	Coastal and marine ecosystems

Guidance for using the IUCN Global Standard for Nature-based Solutions	IUCN	2020	"This Guidance for using the IUCN Global Standard for Nature-based Solutions accompanies the Global Standard to provide the scientific basis and guidance for users."	Global	Not specific
Options for Ecosystem-based Adaptation in Coastal Environments	UNEP	2016	The guide explains coastal EbA principles, showcases options with examples, and addresses implementation challenges. Alongside the online Coastal EbA Decision Support Tool, it aids decision-makers in selecting, managing, and evaluating EbA initiatives	Global	Coastal ecosystems
Ecosystem-based Adaptation	UNEP	2024	UNEP EbA webpage featuring a number of documents, toolkit, and resources.	Global	Not specific
A Decade of Ecosystem-based Adaptation: Lessons from the United Nations Environment Programme	UNEP	2024	The document summarises the key lessons from UNEP's experiences of EbA across multiple countries and ecosystems over the past ten years.	Global	Not specific
A Manager's Guide to Coral Reef Restoration Planning and Design	NOAA	2020	Provides a six-step, adaptive management planning process to assist managers in setting and meeting their restoration goals.	Global	Focus on Coral Reefs
Coral reef restoration monitoring guide: methods to evaluate restoration success from local to ecosystem scales	NOAA	2020	This Guide, alongside the Coral Restoration Database and Evaluation Tool, helps measure progress toward restoration goals, assess project performance, and identify areas for improvement, fostering better evaluation of coral restoration success.	Global	Focus on Coral Reefs

Coral Reef Restoration as a strategy to improve ecosystem services – A guide to coral restoration methods.	UNEP	2020	A guiding document, stating that coral reef restoration should prioritize goal-based planning, risk-adaptive strategies, community engagement, and long-term monitoring for adaptive management and effectiveness assessment.	Global	Focus on Coral Reefs
International principles and standards for the practice of ecological restoration. Second edition.	Article in Restoration Ecology (Vol. 27, No. S1, pp. S1–S46) by Gann et al.	2019	The second edition of the International Principles and Standards provides a framework for designing and implementing restoration projects, addressing ecosystem complexities, climate change, and land management trade-offs.	Global	Not specific
Open Standards for the Practice of Conservation. Version 4.0	Conservation Measures Partnership (CMP)	2020	The document provides a structured framework to guide conservation projects toward achieving their goals. It emphasizes adaptive management, stakeholder engagement, and evidence-based decision-making to address complex conservation challenges effectively. This version updates tools and processes to enhance project design, implementation, monitoring, and evaluation, fostering collaboration and continuous improvement in conservation practices.	Global	Not specific
Best Practice Mangrove Restoration Guidelines	Mangrove Alliance	2023	This guide offers step-by-step best practices for mangrove restoration, covering design, funding, and implementation with a focus on social, financial, and ecological impacts. It emphasizes community-based ecological restoration, integrates local and scientific expertise, and includes resources on blue carbon to align projects with climate targets or generate carbon credits. Future modules will address coastal protection, biodiversity, and fisheries.	Global	Focus on Mangroves

Making ecosystem-based adaptation effective: a framework for defining qualification criteria and quality standards	Friends of EbA network (FEBA)	2017	This paper provides a practical assessment framework for designing, implementing and monitoring EbA measures and encourages its use among practitioners and decision makers.	Global	Not specific

Table 2: Relevant networks

Project or network	**Short description**
Friends of EbA (FEBA) network	The network connects organisations that have an interest in advancing EbA approaches and concepts, promoting the exchange of knowledge, improving practical project implementation and raising awareness in politics.
The Partnership for Environment and Disaster Risk Reduction (PEDRR)	"PEDRR is the clearinghouse for knowledge, training, advocacy and practice on Ecosystem-based Disaster Risk Reduction (Eco-DRR)." It is structured into five regional networks
EbA Community of Practice (CoP)	*adaptationcommunity.net* was developed for the interested public and adaptation experts to provide information on the application of approaches, methods and tools that facilitate the planning and implementation of adaptation measures.
Reef Resilience Networks	"Since 2004, the Reef Resilience Network has served as a global leader in building the capacity of marine managers to effectively manage, protect, and restore coral reefs and reef fisheries around the world. To achieve this, we connect reef managers and practitioners with peers, experts, and the latest science and strategies, and provide online and hands-on training and implementation support. The Network is a partnership led by The Nature Conservancy that is comprised of more than 5,200 active members, and supported by dozens of partners and TNC staff, as well as 100s of global experts in coral reefs, fisheries, climate change, and communication who serve as trainers, advisors, and content reviewers."

Mangrove Alliance	“The Global Mangrove Alliance (GMA) is an unprecedented collaboration that seeks to bring together NGOs, governments, scientists, industry, local communities, and funders towards a common goal of conserving and restoring mangrove ecosystems. Since our launch at the World Ocean Summit in 2018, our collaborative approach has increased our ability to leverage funding; promote scientific research; strengthen coastal management and governance, education, disaster risk reduction, climate mitigation and adaptation related plans and policies; and accelerate the conservation and restoration of mangroves at scale.”
Global Adaptation Network	“The Global Adaptation Network (GAN) is helping the world to build resilience towards climate change by spreading adaptation knowledge. A growing number of organisations and research institutes are hastily assessing how humanity can best prepare for increasing climatic extremes. The Global Adaptation Network acts as an umbrella system across the world, linking these various organisations, many of which bear a focus towards the regions most vulnerable to the impacts of global warming. When cutting-edge solutions are developed, they must be shared with those who need them.”
Adaptation Research Alliance	“The ARA advocates for action-oriented research – or Adaptation Research for Impact – globally and its uptake for informing adaptation and resilience. We catalyse opportunities and funding for our members that generate user-driven innovations from the global to local levels. As a result, we enable better research planning and cooperation among the diversity of those in the adaptation community. Our work enables the development of new programmes that deliver resources for action-oriented research, while recognising the need to build capacity, particularly in developing countries, and to reduce risks for vulnerable communities.”
Global Climate Change Alliance+	“The Global Climate Change Alliance Plus (GCCA+) is a European Union flagship initiative which is helping the world's most vulnerable countries to address climate change. Having started with just four pilot projects in 2008, it has become a major climate initiative that has funded over 80 projects of national, regional and worldwide scope in Africa, Asia, the Caribbean and the Pacific. To be kept informed, please subscribe to our newsletter. This EU initiative helps mainly Small Islands Developing States (SIDS) and Least Developed Countries (LDCs) increase their resilience to climate change. The EU GCCA+ also supports these group of countries in implementing their commitments resulting from the 2015 Paris

	Agreement on Climate Change (COP21), in line with the 2030 Agenda for Sustainable Development and the new European Consensus on Development.”
50 Reefs Initiative	“The 50 Reefs initiative was established to identify and prioritize protection efforts on coral reefs that are least vulnerable to climate change and have the greatest capacity to repopulate other reefs over time. With the goal to catalyze the global action and investment necessary to save these critical ecosystems, the initiative released several white papers, a scientific study and a blueprint strategy for global reef conservation.”

Table 3: Relevant projects (examples)

Project	**Short description**
IUCN EbALAC Projekt	This project implements both tested and experimental EbA measures in rural Latin American communities, particularly those that are vulnerable to climate change. The project is also linked to governance, working to increase the capacity of decision-makers and incorporate EbA approaches in national plans.
The uThukela Marine Protected Area (MPA) Ecosystem based Adaptation (EbA) Project	The project aims to improve the natural environment in and around the uThukela MPA (South Africa) through a series of measures designed to make the region more resilient in the face of the devastating effects of climate change.
Scaling-up EbA Measures in rural Latin America (EbA LAC)	The aim of the project is to increase resilience to climate change in vulnerable communities and ecosystems in rural areas of Ecuador, Guatemala and Costa Rica.
CoralCarib	“This project will pioneer a new strategic approach focused on Coral Climate Refugia, with activities designed to protect, restore, and sustainably use coral reefs with high potential to survive future climate impacts. Major activities include effective management of marine areas, abatement of reef threats, coral restoration using advanced technologies, promotion of sustainable livelihoods, and a range of scaling activities to achieve region-wide impacts.”

Table 4: Financing options

Finance option	Brief Description
"Finance options and instruments for Ecosystem-based Adaptation. Overview and compilation of ten examples"	The document provided by GIZ in 2018 details practical implementation options and tools, based on case studies implemented by the GIZ and other partners.
UNEP Microfinance for Ecosystem-based Adaptation (MEbA) project	The project works with rural populations and micro-finance institutions to increase income for communities and individuals, encourage sustainable practices, and promote adoption of EbA measures.
Global EbA Fund	Financing mechanism for catalytic, innovative and inclusive projects that aim to create an enabling environment for the implementation of ecosystem-based adaptation (EbA) to improve the resilience of vulnerable communities and ecosystems to the impacts of climate change.
Caribbean Diversity Fund (CBF)	The CBF's EbA Facility finances projects that alleviate poverty and implement climate change adaptation measures.
The Mangrove Breakthrough Financial Roadmap	The guide offers pathways for financing mangrove restoration and conservation projects.
Finance Tools for Coral Reef Conservation: A Guide	A guide published by *50 Reefs initiative* and others in 2018: "The report highlights a mix of thirteen of the most compelling finance mechanisms for reef conservation. Finding the appropriate mix of funding to meet conservation objectives is

	essential and this guide presents some tried-and-true financing tools as well as those that are in early stages of implementation and testing, and even those that are still conceptual but show promise.”

Ecologic Institut

www.ecologic.eu

FB: /Ecologic.Institute

Ecologic Institut

www.ecologic.eu

FB: /Ecologic.Institute