Potential EbA measures

Ecosystem-based Adaptation (EbA) for Reducing Community Vulnerability to Climate Change in Northern Pacific Small Island Developing States (SIDS)

Contents

Approach to implement the EbA measures

The ecosystem-based adaptation measures considered for the project will follow, when applicable, the guidelines and the standard of practices defined by the FAO and other institutions as a contribution to the United Nations Decade on Ecosystem Restoration.[1] The practices indicate that the restoration process should be divided in five components (Figure 1).

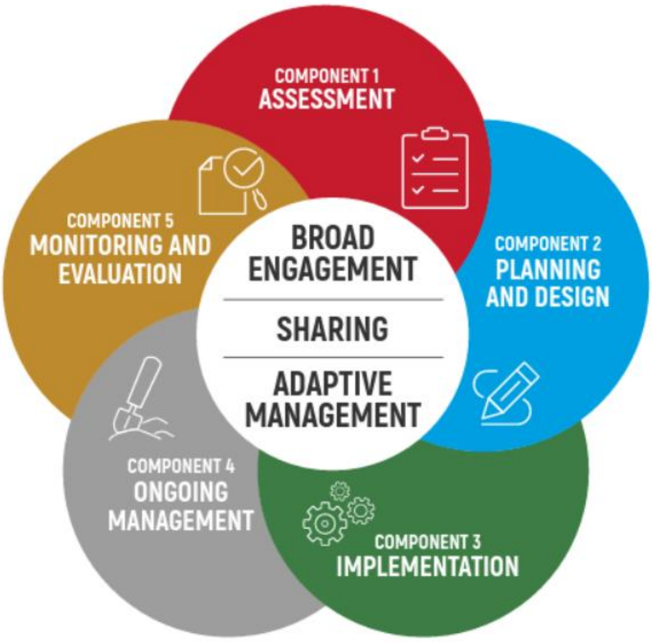


Figure 1. The five components of the restoration process along with cross-cutting subcomponents that apply throughout the restoration process.

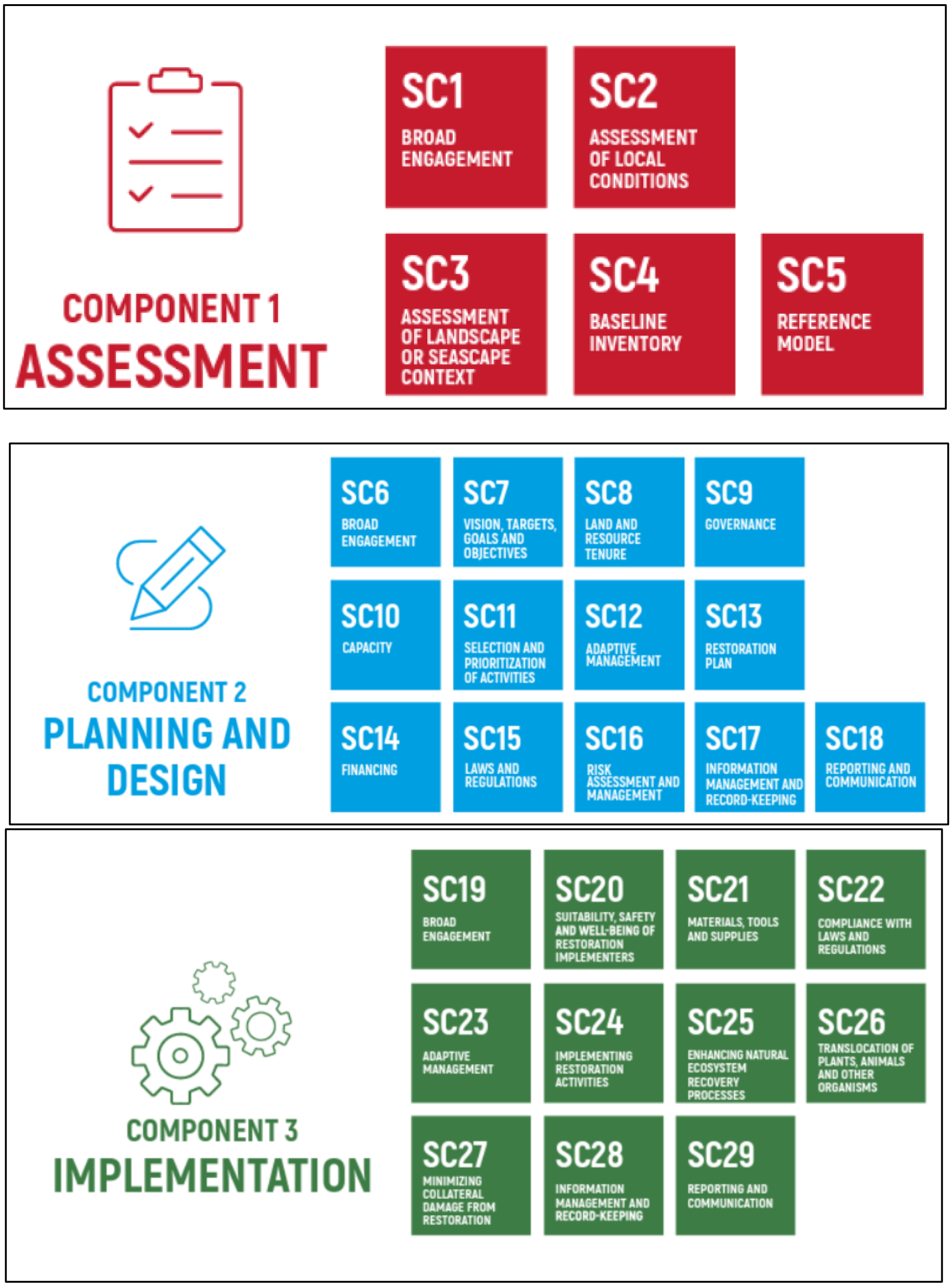
The restoration process is not a linear one, therefore, some component and subcomponents and practices may be conducted simultaneously or in a different order than the one presented and may be revisited during the process.

Figure 2 below summarizes each component and its subcomponents to assist the restoration community with developing successful projects that will result in restoration benefits.

> *"The assessment component includes the identification and evaluation of the extent and scale of degradation, considering the site and its context within the land- and seascape. Degradation is defined as the cumulative degree to which an ecosystem's physical condition, composition, structure and function have been adversely affected by anthropogenic factors. Planning and design focuses on determining appropriate restoration activities given the ecological, socioeconomic and cultural contexts, as well as financial constraints. Restoration targets are defined, and specific goals and objectives for the restoration project are developed based on consultations with stakeholders, right holders and experts. Planning foreshadows all the onsite work that will be undertaken during the project's implementation, whereas ongoing management considers short- and long-term site needs*

[1] FAO, SER & IUCN CEM. 2023. Standards of practice to guide ecosystem restoration. A contribution to the United Nations Decade on Ecosystem Restoration. Summary report. Rome, FAO. Available at: https://www.fao.org/3/cc5223en/cc5223en.pdf

following the completion of planned implementation activities. Finally, the monitoring and evaluation component focuses on measuring progress towards the recovery of the restoration targets and achievement of the project's goals and objectives, enables adaptive management for possible course corrections, and provides an opportunity to share lessons learned". (FAO, SER & IUCN CEM, 2023), page 2).[2]



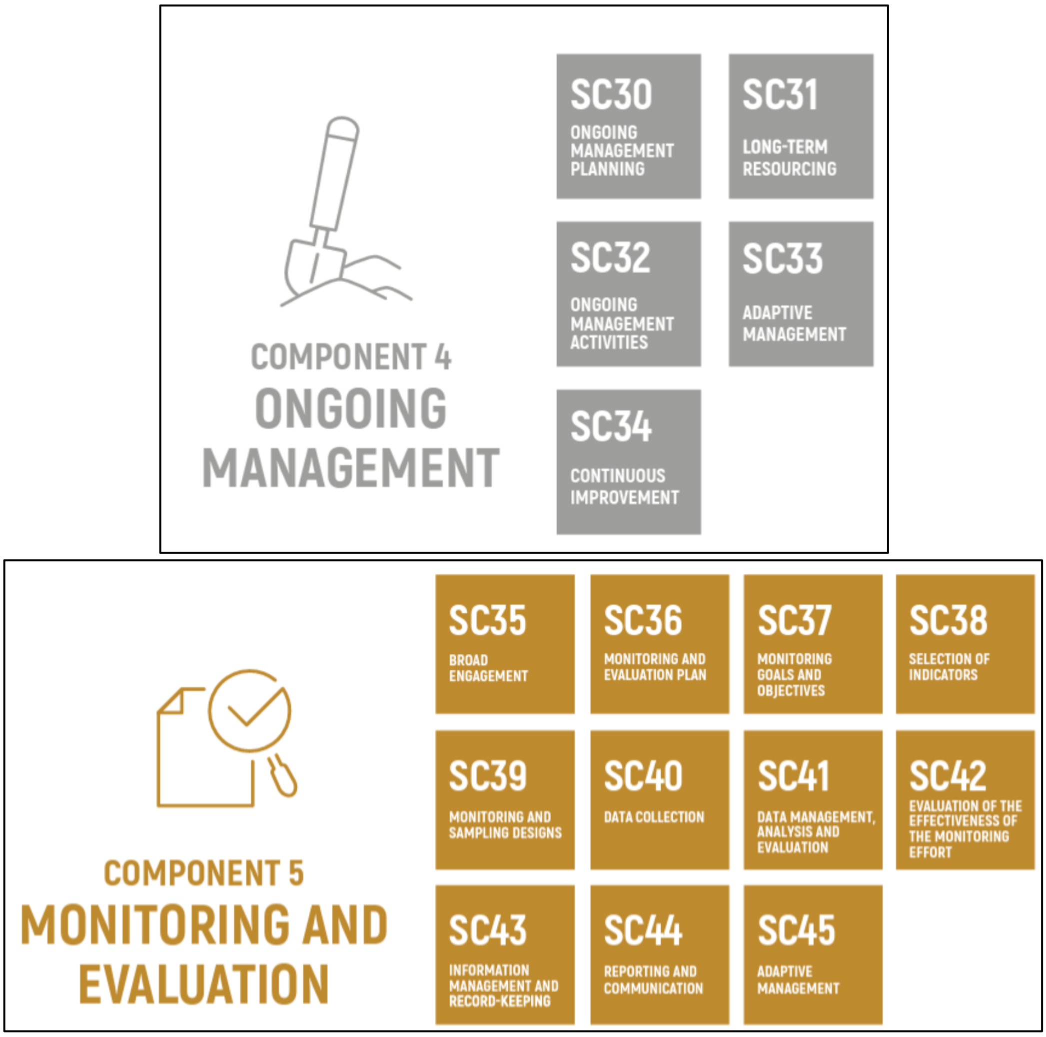


Figure 2. Components and subcomponents from the Standard of Practices to Guide Ecosystem Restoration,[2]

A series of EbA interventions to strengthen ecosystem services in each participating nation are presented below.

EbA Opportunity 1: Mangrove Conservation and restoration to improve coastal community resilience.

1.1. Description

Mangrove areas in some Pacific Islands are high relative to their coastlines (31.9% of Micronesia and 29.55% of Palau, and 0.25% of RMI's coastline), and they provide significant social, economic, and cultural benefits for the people of the Pacific Islands. [3,4] On average, the carbon stock of one hectare of mangroves, including soil carbon, is approximately 1,000 tonnes, more than twice the carbon storage of upland forests and

[2] FAO, SER & IUCN CEM. 2023. Standards of practice to guide ecosystem restoration. A contribution to the United Nations Decade on Ecosystem Restoration. Summary report. Rome, FAO. Available at: https://www.fao.org/3/cc5223en/cc5223en.pdf

[3] Bunting P, Rosenqvist A, Hilarides L, Lucas RM, Thomas N, Tadono T, Worthington TA, Spalding M, Murray NJ, Rebelo L-M. Global Mangrove Extent Change 1996–2020: Global Mangrove Watch Version 3.0. *Remote Sensing*. 2022; 14(15):3657. https://doi.org/10.3390/rs14153657

[4] https://www.iucn.org/regions/oceania/our-work/deploying-nature-based-solutions/water-and-wetlands/completed-projects/pacific-mangroves-initiative

five times that of savannah meaning that mangroves are among the most carbon-rich forests in the tropics.

The problem to solve relates to reduced mangrove area often increasing the threat to human safety and shoreline development from coastal hazards such as erosion, flooding, and storm waves and surges. Mangrove loss will also contribute to decreased coastal water quality, biodiversity, eliminating fish and crustacean nursery habitat and releasing large quantities of stored carbon.

To address the above problem, 'Community-based ecological mangrove restoration (CBEMR)', is a holistic, multi-stage approach that includes local stakeholders and other groups from the outset.[5] The CBEMR approach works to restore underlying hydrological conditions and considers adjustments to a disturbed area's topography, so that mangroves may regenerate naturally. The use of CBEMR leads to more successful restoration efforts, as well as the regeneration of a more natural forest, and proper integration of local communities and necessary stakeholders into a conservation area.


1.2. Climate rationale

The restoration of "blue carbon stores" (mangroves, wetlands, and seagrass meadows) often provides effective ways to remove carbon dioxide from the atmosphere and at the same time to protect atolls / islands from the impacts of storms and sea-level rise and protect biodiversity and livelihoods.

Mangrove forests have commonly been shown to provide multiple provisioning services that increase the economic and food security of local communities such as timber, fuel wood, medicinal, animal feed and human food resources (fish and shellfish provision etc). Fish is the primary food source in the Pacific islands, with reliable fish supplies essential for the regional food security.

In Pohnpei, epiphytes grow on mangrove trees as a result of the equatorial climate, where they can obtain regular water from rainfall. In mangrove areas with lower or

[5] https://www.wetlands.org/publications/community-based-ecological-mangrove-restoration/

seasonal rainfall they do not occur, and their abundance in Pohnpei mangroves is an important part of the ecosystem biodiversity and uniqueness. Reduced rainfall would impact diversity and abundance of these mangrove epiphytes during drier ENSO years particularly on the leeward side, which would impact inland mangrove species that rely on freshwater outflow, such as inland mangrove zones. Epiphytes play a key role in the rainforest ecosystem. They provide nectar, pollen, fruit and seed for harvest, and their moisture and nutrient retaining properties are essential to many of the terrestrial invertebrates and lower vertebrates.

Regulating services such as wave attenuation, erosion control, sediment accretion and, more recently, carbon sequestration and storage have become very important as these regulating services are critical at very large scales (across the Pacific). This is particularly important for the destructive winds and storm surge associated with cyclones in the Pacific.

Mangrove forests also provide a broad suite of cultural ecosystem services to coastal populations living close to mangrove forests, ranging from the tangible (tourism, recreation, education) to the intangible (cultural heritage, aesthetics, sense of place). There are strong spiritual links between mangrove forests and local communities in the Pacific in particular, often with deities and legends associated with different components of the mangrove ecosystem.

1.3. Benefits

- Increased biodiversity and water quality
- Increases nutrient transfers to other habitats affecting adjacent ecosystem health.
- Increased resilience to disease and climate change
- More protection for coastlines
- More sustainable, long-lasting restoration efforts.

1.4. Scope

- Intervention Areas: Biodiversity management, mangrove restoration and restoration of “blue carbon stores” (mangroves, wetlands, and seagrass meadows); protection of islands from the impacts of storms and sea-level rise and protection of biodiversity and livelihoods.
- Impact spheres: environmental, adaptation and economic
- Grant sizes: regular grants: between USD 10,000 – 50,000 and large grants: between USD 50,000 – 200,000
- Duration: 2-5 years

1.5. Key issues that affect success

- Anthropogenic pressures (coastal development/pollution etc)
- Climate change pressures (increased storm frequency and severity etc)
- Site and ecosystem characteristics (mangrove forest width, tidal hydrology, poor supply of natural seedlings etc)

- Socio-economic pressures such as high incidence of poverty in many areas. E.g. in Pohnpei, high levels of poverty could lead to the potential reliance on subsistence economy and required use of natural resources such as mangroves.
- Maximum biophysical thresholds (burial by sediment/uprooting by high winds etc)
- Timeframes
- Ongoing management (weak regulations in place or absence of important legislation for increased mangrove resilience etc). Local studies highlight that mangrove protection legislation needs to be more effective at local levels.
- On the ground implementation capacity (local community involvement).

1.6. Eligibility criteria

- Grant should include more than one community-based organization within a mangrove landscape.
- Interventions must comply with local level and regional land-use plans.
- Grantee must have the capacity to implement the full scope of the grant.

1.7. Complementary Practices

- Awareness-raising and capacity building at the local level
- Training of local people and long-term community management and monitoring plans to ensure project sustainability.

1.8. Cost and materials

CBEMR requires both lower-cost biophysical approaches and greater attention to socio-cultural-political approaches common in sustainable development and coastal resource management programs. Biophysical adaptations include use of low-cost biophysical assessment methods, reliance on manual labour, strategic breaching of aquaculture ponds and dike walls, manual construction of tidal channels, and human assisted propagule dispersal. Socio-political adaptations include land tenure settlement, increased use of training of trainers programmes, gender assessments and sensitisation, enhanced community organising, coordination with numerous government agencies and participatory monitoring.[6] For comparison purposes, a CBEMR project in Indonesia had a total cost of USD 1388/ha and in Asia, the cost varies between $1,000 and $67,670 per hectare.

- Small scale infrastructure and equipment
- Mangrove ecosystem service for planning and adaptation, implementation and management
- Training/capacity building, research and monitoring
- Operational costs

[6]https://journals.openedition.org/sapiens/1589#:~:text=The%20total%20cost%20of%20425,USD%20590%2C000%20or%20%241388%2Fha.

- Consumables (seedlings etc)

The cost of mangrove restoration varies widely due to the techniques used, costs of material and labour, site accessibility, training and monitoring of activities.

1.9. Methodology/approach

Ecological restoration of mangroves requires a prior assessment of on-site conditions, and the activities are selected considering the local context and mangrove species. Degraded mangrove locations needing rehabilitation can be identified through forest survey assessment, spatial analysis evidence of forest decline, citizen science monitoring and consultation with local community knowledge. The strategy must focus on planning restoration actions specific to each site according to the local and regional conditions. The approach's components include:

- Convening a technical workgroup and delimiting the site to be restored
- Conducting a diagnostic and ecological analyses of the site
- Formulating the restoration plan and actions
- Monitoring the progress and success of the actions. Monitoring is repeat checking of the condition of mangroves, to allow any degradation or adaptation needs to be identified. Community volunteers in citizen science programmes could provide an extensive workforce for the collection of data on greater spatial and temporal scales than otherwise achievable.
- Establishing linkages and socialization

Five critical steps are necessary to achieve successful mangrove restoration:

1. Understanding the mangrove species at the site; in particular the patterns of reproduction, propagule distribution, and successful seedling establishment.
2. Understanding the normal hydrologic patterns that control the distribution and successful establishment and growth of targeted mangrove species.
3. Assessing modifications of the original mangrove environment that currently prevent natural secondary succession (recovery after damage).

Designing the restoration programme with communities This approach involves a more methodological ecosystem approach than the usual monoculture restoration efforts, incorporating natural mangrove dispersal and ecological recovery. Here, it is important to consider delegating power to local communities to make mangrove legislation effective, and make management decisions.

1.10. Proven Methods

A successful mangrove ecological restoration is based on understanding the ecology of this ecosystem, which means knowing the interplay between geomorphology, hydrology and the structural and functional characteristics of the mangrove at different spatial and temporal scales. All sectors must be represented and involved in the restoration process, including local communities, scientific-technical groups, economic players, government institutions and funding stakeholders. Assessment of components of vulnerability can allow targeted adaptation. This approach has been trialled in Tanzania, Fiji and Cameroon, and used subsequently to assess mangrove areas in China, Madagascar, Ternerife atoll, Mozambique, Yucatán and the Marshall Islands. Ong and Ellison adapted vulnerability assessment methods to a resilience assessment ranking method, demonstrated by application to some mangrove areas in Asia, and Enipein Marine Park in Pohnpei.[7]

Community based ecological mangrove restoration engages communities in the restoration process, empowering them to be stewards of their environment and enabling them to regain the livelihoods lost when the mangroves were destroyed.

The following steps were taken during recent restoration project in Sokehs (Lewetik) and the Pohnpei State Forestry:

1) Community awareness of importance of mangroves
2) Identification of species of mangroves to replant. "Climate smart" species are those with the highest adaptive capacity, those that have wider ranges of tolerance than others. These are the best to choose for rehabilitation.
3) Direction on where propagules can be collected.
4) Instruction on using a transect to plant propagules (and the density on which to replant)
5) Monitoring progress indicators

Some villages in Pohnpei reported that mangroves have improved in condition over the last several years owing to effective management, such as community designation of a mangrove protected area at Peidie, and use of a traditional management system at Palikir. Management activities included raising awareness, monitoring, clean up and restricting dredging. Other villages have prevented dredging, and organised trash cleanups. Villages of Depenhk/ Takaiou and Pohras and Palikir also noted a traditional management system that is beneficial and functional.

1.11. Key studies

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[7] Ellison, J.C. 2021. Mangrove vulnerability assessment for Pohnpei, Federated States of Micronesia., School of Geography, Planning and Spatial Sciences, University of Tasmania, Australia.

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- Lewis & Brown. 2014. Ecological Mangrove Rehabilitation. Available at: https://ocean.floridamarine.org/chimmp/Resources/Lewis%20and%20Brown%2020014%20Ecological%20Mangrove%20Rehabilitation.pdf
- Micronesia coral-reef monitoring website providing data trends for adjacent reefs (corals, fishes, algae, and macroinvertebrates. Available at: https://micronesiareefmonitoring.com//
- Moudingo J.H.E., et al., 2018. Enhancing resilience of vulnerable coastal areas and communities: Mangrove rehabilitation/restoration works in the Gambia. In: Hussain C. (eds) Handbook of Environmental Materials Management. Springer, Cham, 1-44. Available at: https://doi.org/10.1007/978-3-319-58538-3_68-1
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EbA Opportunity 2: Sustainable Forest and agro-forest management for climate resilient agriculture

2.1 Description

The problem to solve relates to the need to simplify the use of monoculture, which affects the landscape and climate regulation in a watershed area (or similar) as well as also the hydrological water cycle within that defined topographic area.

These are natural resource management approaches that integrate planting of trees and agricultural crops and / or use of animals (in a scientifically and ecologically desirable manner), which is feasible and socially acceptable by both farmers and other beneficiaries, in a way that maximizes the benefits of ecological interactions and as a result, attains measurable economic results.[8]

[8] https://www.scielo.br/j/cerne/a/cPT5pVGq46Sp9FLMRX9GpVf/?format=pdf&lang=en

2.2 Climate Rationale

Characteristics of agroforestry systems is that these strengthen the resilience of ecosystems and communities as reduces impacts to drought events and extreme rainfall, reducing losses and damage to crops.

General agroforestry systems and climate-resilient agriculture conserve soil moisture, improve the microclimate conditions and increase biodiversity that gives greater stability to production systems best suited to the climate. The production of energy forest species in these systems allows production and sustainable consumption of firewood that defines a neutral role of carbon balance.

2.3 Benefits

Agroforestry and climate-resilient agriculture can provide four main benefits in terms of ecosystem-services: i) climate change mitigation through carbon sequestration; ii) biodiversity conservation; iii) soil health enrichment and iv) air and water quality improvement.[9]

2.4 Scope

- Intervention Areas: conservation agriculture, grazing management, fire management.
- Impact spheres: adaptation and economic
- Grant sizes: large grants: between USD 100 – 200,000
- Duration: 3 years

2.5 Eligibility criteria

- Grant should include more than one CBO within a landscape
- Interventions must comply with local level and regional land-use plans
- Grantee must have the capacity to implement the full scope of the grant
- Measures must comply with local-level land use plans.

2.6 Complementary Practices

- Planting of leguminous species native trees
- Incorporation of residues of branches to the ground
- Incorporation of manure as organic fertilizer

2.7 Cost and Materials

[9] https://oxfordre.com/environmentalscience/view/10.1093/acrefore/9780199389414.001.0001/acrefore-9780199389414-e-195

- Variable depending on crops used etc (essentially low cost)

- Large and small scale infrastructure and equipment
- Services for planning, implementation and management
- Training, research and monitoring
- Operational costs
- Consumables (seeds, crops etc)

2.8 Methodology/Approach

Within each agroforestry practice there are many options available to landowners depending on their own goals. The type of Agroforestry systems include:

- Plantation-based cropping system
- Scattered trees on farms, parklands
- Shelterbelts and windbreaks
- Boundary planting and live hedges
- Woodlots for soil conservation
- Horti-pastoral
- Plantation crops with pastures
- Home gardens
- Aqua forestry

The following steps have been used in agroforestry initiatives:

1) Set initial steps and priorities according to multiple uses of the property and objectives (i.e., improve environmental conditions, increase yields, diversify livelihoods, etc.).
2) Evaluate existing assets to analyse the best suited options for the land (i.e., available planting materials, equipment, manpower).
3) Identify current land uses and map areas suitable for agroforestry development.
4) Climate assessment will determine what is suitable for the area and develop a seasonal calendar for production.
5) Monitor progress indicators.

2.9 Proven methods

Forestry management and agroforestry system have demonstrated sustainability in preventing loss of soil fertility, soil erosion and conserving available water, thus ensuring food and livelihood security for communities. Agroforestry systems have been used as a buffer against stress from both abiotic and biotic, they offer greater resilience in the face of extreme weather events and climate change.

USAID- Climate Adaptive Agriculture and Resilience Project (CAAR) project proved that restoration agroforestry has great potential for regreening degraded lands in a less expensive and participatory way, creating a basis for improved livelihoods, water provision and sustainable food production and has tested models that will be replicated and scaled up in the present GCF pogramme.

2.10 Key studies

- Bishaw, B., Soolanayakanahally, R., Karki, U. et al. Agroforestry for sustainable production and resilient landscapes. Agroforest Syst 96, 447–451 (2022). Available at: https://doi.org/10.1007/s10457-022-00737-8
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EbA Opportunity 3: Watershed Management and Soil Conservation/management Measures

3.1 Description

Challenges related to sustainable watershed management measures, including the need for improved soil conservation, water supply, land restoration, vegetation planting (vetiver grasses etc.) all helping to support climate change adaptation and disaster risk management policies.

Reversing soil degradation trends needs identification and implementation of site-specific strategies. The choice of strategies depends on biophysical (climate, geography, soil type, vegetation, etc.) and human dimension factors (demography, infrastructure, land tenure, etc.).

Watersheds provide many important water-related functions and services to a wide range of stakeholders who are directly or indirectly affected by changes in the quantity and quality of water available. Watershed management incorporates the improvement of three main elements:[10]

- Natural resources management
- Local development management by local governments
- Management of externalities inherent in every catchment (for example erosion from hill farming)

[10] Gonzalez, F. & Smyle, Jim & Dalton, J. & Kerr, J. & Kiersch, Benjamin & Tucker, S.P. (2002). Improving watershed management programs. 41. 399-405. https://www.researchgate.net/publication/292385435_Improving_watershed_management_programs/link/574f65dc08ae10b2ec055f62/download

- Implementation of activities identified within community PAs plans.

The watershed management process includes the implementation of land use and watershed management practices to protect and improve the quality of water and other natural resources within a watershed by managing the use of those resources in a comprehensive manner.

Conserving and managing soils help improving soil organic matter which in turn affects soil humidity, soil fertility and reduces soil erosion. The adoption of soil conservation/management-effective measures sustains and improves soil and ecosystem C pools, enhances soil quality, and increase net primary productivity.

3.2 Climate Rationale

Improvement in soil quality would enhance resilience against climate change by dampening the effects of extreme events, moderating fluctuations in microclimate, reducing diurnal/annual variations in soil temperature and moisture and mitigating climate change. Watershed management is thus an important measure to make a significant contribution to meeting the intertwined global challenges of protecting and restoring terrestrial ecosystems (SDG 15), combating climate change and its impacts (SDG 13), ensuring sustainable water management (SDG 6), ending poverty (SDG 1), and achieving food security, improved nutrition, and sustainable agriculture (SDG 2).

3.3 Benefits

- Helps increase production of crops
- Reduces mismanagement and over-exploitation of water and natural resources
- Soil erosion control
- Enhancing ecosystem functions and services
- Increase and conserve biodiversity
- Create positive plant-soil feedback with positive impact on the biosphere.[11]

3.4 Scope

- Intervention Areas: contour agriculture, grazing management, soil conservation measures.
- Impact spheres: adaptation and economic
- Grant sizes: large grants: between USD 100 – 200,000
- Duration: 3 years

[11] Lal, R. (2014). 'Soil conservation and ecosystem services'. *International Soil and Water Conservation Research*, 2 (3), pp. 36–47. doi: https://doi.org/10.1016/S2095-6339(15)30021-6.

3.5 Eligibility Criteria

- Grant should include more than one CBO within a watershed landscape.
- Interventions must comply with local level and regional land-use plans.
- Grantee must have the capacity to implement the full scope of the grant.

3.6 Complementary Practices

- Awareness-raising at the local level
- Training of local people and long-term agro-business community management and monitoring plans to ensure project sustainability.

3.7 Cost and Materials

Variable depending on scale of watershed and techniques adopted etc (essentially low cost)

- Small scale infrastructure and equipment
- Sustainable Land Management services for planning, adaptation and implementation
- Training, research and monitoring
- Operational costs
- Consumables (fencing/vertiver grasses etc)

3.8 Methodology/Approach

Soil and water conservation is an integral part of watershed management. The activities are based on:

- Prevention or reduction of soil erosion, compaction, salinity
- Conservation or drainage of water
- Maintenance or improvement of soil fertility

These activities are to be selected and implemented according to the respective local conditions, which means that the strategy must be adapted at the local level.

Soil and water conservation measures to be implemented may include: (a) In situ conservation, (b) adopting soil conservation practices like contour bunding, terracing, (c) construction of check dams, gully control structures, (d) providing farm ponds and (e) digging wells to collect and utilize the water for supplemental irrigation.

The GEF Ridge to Reef project in Tuvaly developed a training manual of integrated land management techniques that sumarises proven methodoloquies, approaches and lessons learnt that are applicable to the present programme. These are available here.

Also the USAID- Climate Adaptive Agriculture and Resilience Project (CAAR) project, in Yap, developed and scaled-up sustainable land and soil conservation practices in selected pilot sites.

3.9 Key Studies

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- UNDP. 2017. Sustainable Land Management Training Manual for local farmers in Tuvalu. R2R-GEF. Available at: https://www.pacific-r2r.org/sites/default/files/2020-08/SLM%20Training%20manual%20final.pdf

EbA Opportunity 4: Introducing "Buffer Zones" to help facilitate the management / enforcement of PAs

4.1. Description

Protected Areas (Pas) are areas set aside to protect marine and terrestrial ecosystems. They are an example of an area-based management measure relevant to EBA; others including integrated coastal management (ICM) and marine spatial planning (MSP). MPAs have a clearly defined geographical space, which is recognised, dedicated and managed (through legal or other effective means) to achieve long term conservation of nature, along with associated ecosystem services and cultural values. In order to be a successful adaptation option, PAs need agreed governance and management approaches and the capacity to implement management plans and to carry out monitoring and evaluation. With such structures and capabilities in place, PAs are well positioned to support EBA.

Improve the creation of “buffer” zones (i.e.: conservation of habitat surrounding PAs, reforestation of degraded areas, increasing and enforcement of key habitat cover within PAs). This may require new policies that encourage improved coordination of conservation actions/partnerships, incorporation of ‘Other Effective area-based Conservation Measures’ (OECMs) etc. Supporting the creation of “buffer zones” increase the connectivity of PAs to facilitate climate-driven redistribution of species. This may include measures that establish new habitat “migration” corridors, improving landscape (or seascape) connectivity by permanent protection of virtual “steppingstones” across States or Nations. This could be designed to watershed protected areas to provide more wildlife habitats to help absorb storm surges and flood events.

This may also need measures that incorporate conservation partnerships among lands inside and outside protected areas to increase connectivity and reduce land-use impacts, while building on the interconnections among terrestrial, freshwater, coastal and marine ecosystems. Such strategies require raising awareness of biodiversity values among local communities, and cross-sectoral planning and policy at both island, regional and trans-boundary scales. These lend to private-public partnerships (PPPs), increasing the potential of solutions reaching beyond protected areas boundaries and affecting socio-political change.

4.2. Climate Rationale

PAs are the foundation of modern-day conservation approaches. Their importance in protecting biodiversity has been demonstrated across the globe. A clear scientific consensus has emerged that expanding the PA network is critical for maintaining and restoring intact natural ecosystems6, for protecting biodiversity, supporting ecosystem services, and for achieving scalable natural climate solutions.[12]

PA management, through helping to reduce non-climate pressures, can help to increase the resilience of ecosystems (and the services they provide) to temperature rise. Where PAs protect ecosystems that help to attenuate waves, they can help reduce wave inundations as sea levels rise. PA management, through helping to reduce non climate pressures, can help to increase the resilience to acidification of ecosystems and the services they provide. Where PAs protect ecosystems that help to attenuate storm waves, they can help reduce associated coastal flooding and erosion.

4.3. Benefits

The positive ecological impacts MPAs (as an example) can have on fisheries, such as increased biomass, species density, species richness and size, can lead to spill-over of adult species into surrounding areas, in particular from no-take zones therefore benefitting coastal economies through increased catch and catch per unit effort. MPAs can lead to improvements in coral cover, reef ecology and structural integrity by limiting practices of destructive fishing on reefs.

PAs can contribute to diversified livelihoods and they can also help people build their resilience by offering alternative sources of livelihoods and income. Alternative livelihood options within MPAs could include climate change-resistant agricultural activities, raising

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[12] Dobrowski, S.Z., Littlefield, C.E., Lyons, D.S. *et al.* Protected-area targets could be undermined by climate change-driven shifts in ecoregions and biomes. *Commun Earth Environ* **2**, 198 (2021). https://doi.org/10.1038/s43247-021-00270-z

livestock, aquaculture, mariculture, seaweed farming, beekeeping, handicrafts, or tree nurseries.

- It is a highly effective and low-cost conservation model
- Increased participation and engagement of local communities contribute to strengthen their support for conservation and sustainability of the measures.
- Positive impact on livelihoods and community development

4.4. Scope

- Intervention Areas: Biodiversity management, reef/mangrove restoration and restoration of “blue carbon stores” (mangroves, wetlands and seagrass meadows); provision of effective ways to remove carbon dioxide from the atmosphere and at the same time to protect atolls/islands from the impacts of storms and sea-level rise and protect biodiversity and livelihoods.
- Impact spheres: environmental, adaptation and economic
- Grant sizes: regular grants: between USD 10,000 – 50,000 and large grants: between USD 50,000 – 200,000
- Duration: 2-5 years

4.5 Key issues that can affect success

- PAs need good design and management (they can have positive effects on building the resilience of coastal communities, and can equally have the potential to reduce resilience).
- PAs need good governance which is crucial both for effective and equitable conservation and in determining the effectiveness and efficiency of PA management.
- PAs require adequate management capacity and resource availability.
- Understanding the context in which PAs operate is key.
- Policies for PAs need to recognise the interconnectivity between terrestrial and marine systems.

4.6. Eligibility Criteria

- Grant should include more than one CBO within a landscape.
- Interventions must comply with local level and regional land-use plans.
- Grantee must have the capacity to implement the full scope of the grant

4.7 Complementary Practices

- Awareness-raising and capacity building at the local level (PA management related rangers enforcement capacity etc).
- Training of local people and long-term community management and monitoring plans to ensure project sustainability.

4.8 Costs and Materials

Variable depending on scale of techniques adopted and role (scale) of buffer zones etc.

- Small scale infrastructure and equipment
- Reef/mangrove/seagrass ecosystem service for planning and adaptation, implementation and management
- Training, research and monitoring
- Operational costs
- Monitoring of outcomes

4.9. Methodology/Approach

Buffer zones are areas between core protected areas and the surrounding landscape or seascape which protect the network from potentially damaging external influence and which are essentialy transitional areas. These zones may or may not also be protected areas, depending on the form of management and recognition by the state, and they are important to connect protected areas and prevent land conversion.

Adequately understanding the interaction between human activities and species populations and the resulting dynamics is important when designing a buffer zone. Land-use management is a critical factor in the degree to which buffer zones can prove to be effective in conservation.

4.10 Proven methods

The size and limits of buffer zones must be achieved and defined based on information on minimum habitat necessary to maintain viable population.

4.11. Key Studies

- Alexandre, B. et al. 2010. How Can We Estimate Buffer Zones of Protected Areas? A Proposal Using Biological Data. *Natureza & Conservação* 8(2):165-170. Available at: https://doi.editoracubo.com.br/10.4322/natcon.00802010
- Bennett, B. and Mulongoy, K.J. 2006. Review of Experience with Ecological Networks, Corridors and Buffer Zones. Secretariat of the Convention on Biological Diversity, Montreal, Technical Series No. 23, 100 pages. Available at: https://www.cbd.int/doc/publications/cbd-ts-23.pdf
- Dudley, N. (Editor). 2008. Guidelines for Applying Protected Area Management Categories. Gland, Switzerland: IUCN. x + 86pp. WITH Stolton, S., P. Shadie and N. Dudley (2013). IUCN WCPA Best Practice Guidance on Recognising Protected Areas and Assigning Management Categories and Governance Types, Best Practice Protected Area Guidelines Series No. 21, Gland, Switzerland: IUCN. xxpp. Available at: https://portals.iucn.org/library/sites/library/files/documents/pag-021.pdf
- IUCN. Undated. IUCN Green List Components, Criteria & Indicators - IUCN Green List. Available at: https://iucngreenlist.org/standard/components-criteria/
- Nimwegen, P., Leverington, F., Jupiter, S. & Hockings, Marc. (Editors). 2022. Conserving our sea of islands State of protected and conserved areas in Oceania; Available at. https://www.iucn.org/resources/publication/conserving-our-sea-islands

EbA Opportunity 5: Ecosystems-based Fisheries Management

5.1 Description

The ocean and its capacity to support life (through marine resource protein stocks) are increasingly threatened by the scale of human-induced greenhouse gas emissions (GHGs). These GHGs continue to alter some of ocean’s underlying characteristics and hence fish stocks. Increased sea temperatures and increasing acidification are some of the consequences that impact fish supplies, and hence affect human health.[13]

Sustainable fisheries management is an integrated process that seeks to attain an optimal state that balances ecological, economic, social and cultural objectives for fisheries. Marine protection related management strategies are increasingly turning towards the ecosystem approach to fisheries management (EAFM, or ‘ecosystem-based fisheries management’, EBFM) as an alternative to species-based management in order to account for the broad range of interdependent relationships that occur within ecosystems.

5.2 Climate Rationale

Marine habitats and species are known to be important carbon stores, but vulnerable to particular anthropogenic activities and need to be protected through appropriate management measures. The open ocean is an important carbon sink and plays an essential role in regulating the global climate[14]. Furthermore, interdependence has been exhibited between coastal habitats: for instance, coastal vegetative habitats such as seagrasses and mangroves provide nurseries for the early life-stages of reef fish and are, in turn, sheltered from incoming waves by coral reefs. Thus, Ecosystem Based Fisheries Management (EFM) can complement other EBA strategies to improve the holistic resilience of coastal human and ecological systems and the availability of ecosystem services.

(NB: If climate change makes some livelihoods less reliable, access to a wide variety of livelihood options can mean people and communities may be less impacted by a reduction in any one livelihood).

5.3 Benefits

[13] Simard, F., Laffoley, D. and J.M. Baxter (editors), 2016. Marine Protected Areas and Climate Change: Adaptation and Mitigation Synergies, Opportunities and Challenges. Gland, Switzerland: IUCN. 52 pp. https://portals.iucn.org/library/sites/library/files/documents/2016-067.pdf
[14] Ibid.

Conservation of marine ecosystems may reduce the effects of climate change; consequently, the ocean is part of the nature-based solutions to climate change. Healthy marine habitats also allow marine species to adapt better to climate change.[15]

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

EBA approaches can also result in enhanced food and economic security through restoration of shellfish and coral reefs that support species of importance to subsistence and commercial fisheries.

5.4 Scope

- Intervention Areas: Marine biodiversity management, fish stock (ground) restoration.
- Impact spheres: environmental, adaptation and economic
- Grant sizes: regular grants: between USD 10,000 – 50,000 and large grants: between USD 50,000 – 200,000
- Duration: 2-5 years

5.5 Eligibility Criteria

- Grant should include more than one CBO within a marine (offshore/nearshore) landscape
- Interventions must comply with local level and regional sea-use plans
- Grantee must have the capacity to implement the full scope of the grant

5.5 Complementary practices

- Maximizing ecosystem services in degraded reefs and other marine habitats requires a portfolio of management strategies that include EAFM approaches (e.g., fish aggregation devices, herbivore management etc)
- Awareness-raising and capacity building at the local level
- Training of local people and long-term co-fisheries management and monitoring plans to ensure project sustainability

5.6 Cost and materials

Variable depending on scale of techniques adopted and role (scale):

- Small scale infrastructure and equipment

[15] Lefebvre, C. Marine Protected Areas Networks and Climate Change: A political Advocacy. https://ocean-climate.org/wp-content/uploads/2020/02/11.-MPA-networks-and-climate-change-a-political-advocacy-Scientific-notes-2016.pdf

- Marine ecosystem service for planning and adaptation, implementation and management
- Training, research and monitoring
- Operational costs
- Consumables (seedlings etc)

5.7 Methodology/Approach

The implementation of an ecosystem-based fisheries management (EBFM) involves adopting a comprehensive approach through addressing a broad range of ecosystems, socio-economic and governance issues. Stakeholder involvement, especially that of local communities, as well as inputs from a wide range of actors, e.g. government and technical agencies, is important in the process. Some of the principles to guide the approach include:

- Provide motivation
- Maximise community participation
- Make use of traditional knowledge ang respect local customs
- Use science to support community objectives
- Enlist support from government agencies
- Suggest alternatives to the overexploitation of resources

An EBFM implementation road map includes the following principles:

1. Implement ecosystem-level planning
   - Engagement Strategy
   - Fishery Ecosystem Plans
2. Advance our understanding of ecosystem processes
   - Science to Understand Ecosystems
   - Ecosystem Status Reports
3. Prioritize vulnerabilities and risks to ecosystems and their components
   - Ecosystem-Level Risk Assessment
   - Managed Species, Habitats and Communities Risk Assessment
4. Explore and address trade-offs within an ecosystem
   - Modeling Capacity for Trade-offs
   - Management Strategy Evaluations
5. Incorporate ecosystem considerations into management advice
   - Ecosystem-Level Reference Points
   - Ecosystem Considerations for Living Marine Resources
   - Integrated Advice for Other Management Considerations
6. Maintain resilient ecosystems
   - Resilience
   - Community Well Being

5.8 Proven Methods

The EBFM implementation plan for the Pacific islands highlights the following guiding principles:

1. Implement ecosystem-level planning
2. Advance the understanding of ecosystem processes
3. Prioritize vulnerabilities and risks to ecosystems and their components
4. Explore and address trade-offs within an ecosystem
5. Incorporate ecosystem considerations into management advice
6. Maintain resilient ecosystems

5.9 Key Studies

- Comeros-Raynal, M.T., Lawrence, A., Sudek, M. et al. 2019. Applying a ridge-to-reef framework to support watershed, water quality, and community-based fisheries management in American Samoa. Coral Reefs 38, 505–520 (2019). Available at: https://doi.org/10.1007/s00338-019-01806-8 (noaa.gov)
- Cuetos-Bueno, J. & Houk, P. 2018. Disentangling economic, social, and environmental drivers of coral-reef fish trade in Micronesia, Fisheries Research, Volume 199, 2018, Pages 263-270, ISSN 0165-7836, Available at: https://doi.org/10.1016/j.fishres.2017.10.010.
- Houk P, McInnis A, Benavente D, Gaag M, Maxin S, McLean M, et al. 2022. Climate change disturbances contextualize the outcomes of coral-reef fisheries management across Micronesia. PLOS Clim 1(7): e0000040. Available at: https://doi.org/10.1371/journal.pclm.0000040

- Houk P, McInnis A, Benavente D, Gaag M, Maxin S, McLean M, et al. 2022 Climate change disturbances contextualize the outcomes of coral-reef fisheries management across Micronesia. PLOS Clim 1(7): e0000040. Available at: https://doi.org/10.1371/journal.pclm.0000040

- Houk, P. et al. 2018. Linking fishing pressure with ecosystem thresholds and food web stability on coral reefs. Ecological monographs. Volume 88, Issue 1. Available at: https://doi.org/10.1002/ecm.1278
- Houk, P., Cuetos-Bueno, J., Tibbatts, B. *et al.* 2018. Variable density dependence and the restructuring of coral-reef fisheries across 25 years of exploitation. *Sci Rep* **8**, 5725 (2018). Available at: https://doi.org/10.1038/s41598-018-23971-6
- Houk, P. et al. 2017. An applied framework to assess exploitation and guide management of coral-reef fisheries. *Ecosphere*, Volume 8, Issue 3. Available at: https://doi.org/10.1002/ecs2.1727

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- Houk P, Camacho R, Johnson S, McLean M, Maxin S, Anson J, et al. 2015 The Micronesia Challenge: Assessing the Relative Contribution of Stressors on Coral Reefs to Facilitate Science-to-Management Feedback. *PLoS ONE* 10(6): e0130823. Available at: https://doi.org/10.1371/journal.pone.0130823
- Houk, P., Rhodes, K., Cuetos-Bueno, J. *et al.* 2012. Commercial coral-reef fisheries across Micronesia: A need for improving management. *Coral Reefs* **31**, 13–26 (2012). Available at: https://doi.org/10.1007/s00338-011-0826-3
- Micronesia coral-reef monitoring website providing trends in coral reefs and fisheries resources. Available at: https://micronesiareefmonitoring.com/
- Pacific Islands Fisheries Science Center & Pacific Islands Regional Office. 2019. Pacific Islands Region Ecosystem-based Fisheries Management Implementation

Plan 2018–2022. Available at: https://media.fisheries.noaa.gov/dam-migration/pir_ebfm_ip_20190425.pdf

- SPC and the Nature Conservancy. 2010. A community-based ecosystem approach to fisheries management: guidelines for Pacific Island countries. Available at: https://spccfpstore1.blob.core.windows.net/digitallibrary-docs/files/db/dbaad8dc3c3e0d5a709f3dc9bb997e15.pdf?sv=2015-12-11&sr=b&sig=ETFg1GZF2blmssGnzp7ari%2FzgNW6N5t1SskjTDffXg0%3D&se=2023-10-03T15%3A58%3A00Z&sp=r&rscc=public%2C%20max-age%3D864000%2C%20max-stale%3D86400&rsct=application%2Fpdf&rscd=inline%3B%20filename%3D%22Anon_10_EAFguidelines.pdf%22

EbA Opportunity 6: Ecosystems-based Fisheries Management

6.1 Description

Similar to EbA Opportunity 1 (mangrove rehabilitation), the degradation of coastal wetland ecosystems impacts significantly on the livelihoods of coastal communities. The problem to solve relates to the fact that reduced wetland area often increases the threat to human safety and shoreline development from coastal hazards such as erosion, flooding, and storm waves and surges.

Coastal wetlands are among the most valuable ecosystems in the world, but they suffer various anthropogenic threats that include urbanization, deforestation, and pollution. Restoration of these ecosystems aims to restore the integrity of ecological systems to sustain biodiversity, improve resilience to climate change and re-establish a healthy relationship between nature and culture.[16]

6.2 Climate Rationale

Reducing non-climate pressures (e.g. pollution) and encouraging temperature tolerant species may increase the resilience of services provided by wetlands (e.g. habitat for fish) to temperature increases.

Depending on the type, wetlands can help attenuate waves and hence, reduce wave inundation. They may also act as a water store during times of high water, reducing flooding of coastal areas. Wetlands and marshes can trap sediment and hence vertically build up soil as sea level rises. Coastal wetlands can also help manage the hydrology of the area providing a freshwater source necessary to maintain other habitats such as salt marsh and mangroves that then provide some protection against sea level rise.

[16] Cadier, C., Bayraktarov, E., Piccolo, R. and Adame, M. F. (2020). 'Indicators of Coastal Wetlands Restoration Success: A Systematic Review '. *Frontiers in Marine Science* . Available at: https://www.frontiersin.org/articles/10.3389/fmars.2020.600220.

6.3 Benefits

- Recovery of ecosystem services and functions
- Re-establishment of ecological processes such as nutrient cycling
- Increase resilience of ecosystems

6.4 Scope

- Intervention Areas: Biodiversity management, wetland restoration and restoration of "blue carbon stores" (mangroves, wetlands and seagrass meadows); provision of effective ways to remove carbon dioxide from the atmosphere and at the same time to protect atolls / islands from the impacts of storms and sea-level rise and protect biodiversity and livelihoods.
- Impact spheres: environmental, adaptation and economic
- Grant sizes: regular grants: between USD 10,000 – 50,000 and large grants: between USD 50,000 – 200,000
- Duration: 2-5 years

6.5 Key Issues that affect success

- Anthropogenic pressures, which include unsustainable land use, aquaculture, agriculture, unsustainable fisheries, tourism, urbanization, shipping industry.
- Lack of political support and local engagement

6.6 Eligibility criteria

- Grant should include more than one CBO within a broader wetland landscape
- Interventions must comply with local level and regional land-use plans
- Grantee must have the capacity to implement the full scope of the grant

6.7 Complementarity practices

- Awareness-raising and capacity building at the local level
- Training of local people and long-term community management and monitoring plans to ensure project sustainability

6.8 Cost and materials

Wetland restoration costs often depend on the scale of area being regenerated, but it often has lower maintenance costs and can be more cost-effective in the long term than structural approaches, particularly when considering the combined benefits of increased wetland value and its role in proviing flood protection. However, due to competition for coastal areas and coastal squeeze, implementation costs may increase over time, necessitating spatial valuation and planning for sustainable implementation.

- Small scale infrastructure and equipment

- Wetland ecosystem service for planning and adaptation, implementation and management
- Training, research and monitoring
- Operational costs

6.9 Methodology/Approach

A systematic approach to coastal restoration projects include five components: planning, implementation, performance assessment, adaptive management and dissemination of results. Important activities under the planning component include:

- Site selection with examination of historical or predisturbance conditions
- Definition of the level of physical effort needed
- Production of engineering designs, costing, scheduling and contingency plans
- Assessment of on-site contamination

Once the planning is concluded and the project's objectives are defined, the implementation phase starts. Activities under this component can include a wide variety of construction actions (e.g. ground enhancement, vegetation planting, dike/dam/levee building, erosion control, etc.) depending on the initial assessment during site selection.

6.10 Proven Methods

The key to select a restoration method to rebuild damaged wetland is to identify the critical factors leading to wetland ecological degradation, the degree of loss and the corresponsing impact intensity and then use the principle of limiting factor to diagnose the key process of wetland ecosystem degradation, and analyse the controllability and repairability of eco-hydrological processes and ecological environment functions. According to the relationship of hydrological connectivity and biological connectivity, the damaged coastal wetlands are repaired and adjusted with wetland reconstruction, coastline protection and restoration, plant planting, invasive species removal, hydrological restoration, isolation island reconstruction and restoration, restoration of coastal wetland plants and benthic animals, and the addition of nutrients to enhance the ecological process and ecosystem service value.

6.11 Key studies

- Cadier, C. et al. 2020. Indicators of coastal wetlands restoration success: a systematic review. *Front. Mar. Sci.*, 03 December 2020, Sec. Marine Conservation and Sustainability Volume 7 – 2020. Available at: https://doi.org/10.3389/fmars.2020.600220
- Diefenderfer H.L., Thom RM. & Adkins, J.E. 2003. Systematic approach to coastal ecosystem restoration. Battelle. Available at: http://chapter.ser.org/northwest/files/2012/08/NOAA_systematic_coastal_restoration.pdf
- Micronesia coral-reef monitoring website providing data trends for adjacent reefs (corals, fishes, algae, and macroinvertebrates). Available at: https://micronesiareefmonitoring.com/

- Shuling, Yu. et al. 2022. Research progress and development trend of coastal wetland restoration in greater bay areas, *Watershed Ecology and the Environment*, Volume 4, 2022, Pages 177-187, ISSN 2589-4714, Available at: https://doi.org/10.1016/j.wsee.2022.11.004.
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EbA Opportunity 7: Coral reef conservation and restoration

1.12. Description

Many coral reefs support herbivorous grazers such as parrotfish, which produce sand that helps to replenish beaches and thus maintain beach profiles. Sediment flow to beaches may become more important as sea levels rise and storm patterns in coastal areas exert pressure on beach ecosystems.

Common approaches for coral reef conservation include establishing protected areas or no-take zones that exclude anthropogenic disturbance of reef ecosystems. Conserving existing areas of coral reef often results in improved ecosystem service provision.

For coral reef restoration, rearing, transplanting and monitoring of coral reef fragments are possible approaches. It may be possible to rear coral larvae on a large enough scale for coral reef restoration but experts, such as specially trained coral biologists, and, possibly, large facilities will be required. Despite the potential adaptation benefits available from coral reefs, only a small number of restoration projects have been undertaken that focus on adaptation. Nevertheless, coral reef conservation and restoration represent promising options for coastal adaptation.

1.13. Climate Rationale

Regarding sea surface temperature rise, reducing non-climate pressures (e.g. pollution) and encouraging temperature tolerant species may reduce incidence of coral bleaching and increase the resilience of services provided by reefs (e.g. habitat for fish, tourism) to temperature increases.

Regarding sea level rise, reefs can attenuate (reduce the height and power of) waves. Reducing the height of waves reaching the shore can decrease wave inundation (to a certain extent). When corals grow as sea level rises this attenuation service can be maintained.

With regards to ocean acidification, reducing non-climate pressures (e.g. high nutrient pollution and overfishing of herbivorous fish) increases the resilience of reefs to climate change impacts. Services provided by reefs are more likely to be maintained if other threats are effectively managed.

Wave attenuation by reefs can also reduce the power of storm waves reaching the shore and thereby reduce coastal flooding and erosion on islands/atolls

Degradation occurs around development areas, such as recent coastal infrastructure leading to increased sedimentation of near-shore coral reefs. Outbreaks of corallivorous Crown-of-Thorns Starfish (CoTS, *Acanthaster* spp.) have caused persistent and widespread loss of coral cover across Indo-Pacific coral reefs. A major crown of thorns outbreak in 2009 in Pohnpei was reported, and a moderate bleaching event in 2013.[17] A recent assessment of hard coral communities of Kosrae found a significant linear relationship between species richness and coral cover, showing the importance of reef condition to biodiversity. [18]

In a recent study conducted in Pohnpei, Palikir people noted coral mortality owing to oil and waste from tuna fishing vessels that anchor nearby. Pesticides, petroleum-based compounds including motor oils and petrols as well as personal care products shampoos, sun-cream) affect coral reproduction. Catchment landuse change can result in increased freshwater discharge with suspended sediment, which reduced coral's algal symbiosis, and is abrasive to coral surface tissues.

1.14. Benefits

Coral reefs provide coastal protection. Corals may keep pace with sea level rise. Coral reefs serve as habitat and nursery grounds for fish, supporting fisheries and livelihoods. Coral reefs support diversified livelihoods. Coral reefs can support tourism and recreation and, importantly, coral reef restoration can be cost-effective whilst supporting diversified livelihoods (containing coral species which can be important for medicine).

Coral reefs are often adjacent ecosystems to mangroves and are bio-physically connected to mangrove forests through reciprocal services such as reefs providing protection from wave action, and a calcareous sediment supply to the mangroves. Reef health and status therefore contributes to mangrove resilience, in that if these ecosystems are in poor condition, they will increase mangrove vulnerability to change.

1.15. Scope

- Intervention Areas: Marine biodiversity management, coral restoration and restoration of “blue carbon stores” (mangroves, wetlands and seagrass meadows); provision of effective ways to remove carbon dioxide from the atmosphere and at the same time to protect atolls /islands from the impacts of storms and sea-level rise and protect biodiversity and livelihoods.
- Impact spheres: environmental, adaptation and economic
- Grant sizes: regular grants: between USD 10,000 – 50,000 and large grants: between USD 50,000 – 200,000
- Duration: 2-5 years

[17] Houk, P., Yalon, A., Maxin, S. *et al.* Predicting coral-reef futures from El Niño and Pacific Decadal Oscillation events. *Sci Rep* **10**, 7735 (2020). https://doi.org/10.1038/s41598-020-64411-8
[18] Richards, Z. The status of hard coral communities at Kosrae, Micronesia. Mar Biodiv 45, 655–666 (2015). https://doi.org/10.1007/s12526-014-0266-8

1.16. Key Issues that affect success

Anthropogenic pressures - Almost three quarters of the world's coral reefs are thought to be deteriorating as a consequence of environmental stress. Fishing and pollution in particular are chronic stressors that can prolong recovery of coral reefs and contribute to ecosystem decline.

Climate change is another challenge faced by coral reef ecosystems. Increasing sea temperatures and ocean acidification, when combined with anthropogenic pressures, are likely to result in losses of ecosystem function and services and coral bleaching.

Site and ecosystem characteristics - The degree of wave energy reduction by the reef flat is dependent on its depth, particularly at the shallowest points, and bottom roughness. Therefore, any reef degradation that increases water depth or reduces bottom roughness may reduce coastal protection benefits by increasing exposure to coastal erosion.

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

Recovery after disturbance - Healthy reefs are able to recover or self-repair to a certain degree following environmental disturbances such as tropical cyclones or multi-year fluctuations in warm oceanic currents, which are responsible for mass bleaching and mortality. However, reefs which are under anthropogenic pressure do not generally recover well from such natural disturbance events. This further emphasises the need for management practices that reduce levels of anthropogenic disturbance (e.g. high nutrient pollution and overfishing of herbivorous fish) on coral reefs and that work towards ensuring the resilience of these systems to climate change related impacts.

Also, creating an appropriate enabling environment, both in terms of the policy context and at the local level through a community-based emphasis, is needed for effective coral reef management. Often, this is not in place in many SIDS.

1.17. Eligibility Criteria

- Grant should include more than one CBO within a marine (reef) area
- Interventions must comply with local level and regional land-sea use plans (LMMAs)
- Grantee must have the capacity to implement the full scope of the grant

1.18. Complementarity practices

- Improve scientific research about marine reef habitats
- Maximizing ecosystem services in degraded reefs and other marine habitats requires a portfolio of management strategies that include EAFM approaches (e.g., fish aggregation devices, herbivore management etc).
- Awareness-raising and capacity building at the local level

- Training of local people and long-term community management and monitoring plans to ensure project sustainability

1.19. Cost and materials

Coral reef restoration often has lower maintenance costs and can be more cost-effective in the long term, particularly when considering the combined benefits of increased habitat value and flood protection. However, implementation costs may increase over time, necessitating spatial valuation and planning for sustainable implementation of reef "units" over time. There are also a broad range of techniques now internationally available, all of which command different set up and license realted costs.

- Small scale infrastructure and equipment
- Coral ecosystem service for planning and adaptation, implementation and management
- Training, research and monitoring
- Operational costs
- Consumables (reef planulae etc)

1.20. Methodology/Approach

A six-step adaptive process for planning and implementing coral restoration interventions includes:

1. Set Goal & Geographic focus
2. Identify, prioritize and select sites
3. Identify, design and select interventions
4. Develop restoration action plan
5. Implement restoration
6. Monitor and evaluate progress

Coral reef restoration methods include:

- Direct transplantation: Transplanting coral colonies or fragments without an intermediate nursery phase
- Coral gardening: Transplanting coral colonies or fragments with an intermediate nursery phase. Nurseries can be in situ (in the ocean) or ex situ (flow through aquaria).
- Substrate addition (artificial reef): Adding artificial structures for purposes of coral reef restoration as a substrate for coral recruitment, coral planting, and/or for fish aggregation
    - Electro-deposition: Adding artificial structures that are connected to an electrical current to accelerate mineral accretion.
    - Green engineering: Adding artificial structures designed to mimic natural processes and be integrated into reef landscapes (nature-based solutions, eco-designed structures, living shorelines)
- Substrate manipulation: Manipulating reef substrates to facilitate recovery processes
    - Substrate stabilisation: Stabilising substratum or removing unconsolidated rubble to facilitate coral recruitment or recovery.

  - Algae removal: Removing macro-algae to facilitate coral recruitment or recovery.
- Larval propagation: Releasing coral larvae at a restoration site, after an intermediate collection and holding phase, which can be in the ocean or on land in flow through aquaria.
  - Deployment of inoculated substrate: Deploying settlement substrates that have been inoculated with coral larvae.
  - Larval release: Releasing larvae directly at a restoration site

With increasing impacts of climate change, elevated temperatures and acidification with increase stresses on reefs. Increased storm runoff may also bring stresses from watershed discharges, particularly with sediment and toxicity in the freshwater runoff. Recommended adaptation measures recommended are: [19]

- Expand community and stakeholder engagement, to reduce watershed impacts on reefs
- Retain rainwater at individual houses and building complexes, using gutters, tanks and rain gardens
- Use sediment traps, revegetation and improvements in agricultural practices to reduce soil loss from farming areas
- Use public outreach and education of consumers to reduce toxicity in runoff from pesticides, oil compounds, and personal care products such as shampoo and sunblock
- Develop suitable metrics in coral reef monitoring, both in amount of change as well as methods of monitoring on shorter timeframes.

1.21. Proven Methods

Restoration will generaly only be succesfull if the causes of reef degradation are known and have been addressed. Restoration is therefore a kick start system recovery, but it needs to be combined with a landscape framework approach that integrates different strategies of both social and ecological adaptive capacity.

Studies have shown that reef habitats will vary considerably in their response to local management. Less effort will be required to attain conservation targets in habitats where high-wave exposure, or far distances from urban centers exist. Whereas habitats close to urban centers may require more management effort and may show less of a positive response to management than distant sites.

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EbA Opportunity 8: Seagrass conservation and Restoration

8.1 Description

Reducing wave energy can contribute to reducing flooding and erosion in coastal areas and settlements, two hazards that may increase in severity with a changing climate. Seagrass beds can trap sediment and thus raise their surface elevation. Where sedimentation and accretion rates keep pace with sea level rise, there is more chance that seagrass beds will maintain their coastal protection services in the face of climate change. The most common approach to conserving seagrass ecosystems is to reduce common threats to them (e.g., pollution, damage by boats), for example through new

regulations. Restoring seagrass ecosystems can include harvesting and transplanting seagrass plants and subsequent management and monitoring of restored sites.

Supporting seagrass ecosystems through conservation or restoration can help with the continued provision of food and income, and therefore contribute to maintaining people's resilience and capacity to adapt to climate change.

8.2 Climate Rationale

Reducing non-climate pressures (e.g., pollution) and encouraging temperature tolerant seagrass species may increase the resilience of services provided by mangroves (e.g., habitat for fish) to temperature increases.

Seagrasses can reduce current velocity, dissipate wave energy, and stabilize the sediment, most reliably in shallow waters and low wave energy environments. Reducing the height of waves reaching the shore can decrease wave inundation (to a certain extent). Stabilizing sediment can help seagrasses accrete with sea level rise under certain sedimentation and accretion rates. Seagrass meadows have been shown in some locations to have a buffering effect on pH, modifying it through photosynthetic activity. As a result, healthy seagrass beds may provide a refuge for calcifying organisms. In addition, seagrass biomass is increased by ocean acidification leading to increased carbon sequestration.

8.3 Benefits

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

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

Seagrass beds also provide carbon storage capacity in their own biomass but also through their ability to trap organic sediments thus contributing to climate change mitigation. This is why seagrasses are among the systems referred to as 'blue carbon' sinks.

Like it is the case with coral reefs, seagrass health and status therefore contributes to mangrove resilience, in that if these ecosystems are in poor condition, they will increase mangrove vulnerability to change.

8.4 Scope

- Intervention Areas: Biodiversity management, seagrass restoration and restoration of “blue carbon stores” (mangroves, wetlands and seagrass meadows); provision of effective ways to remove carbon dioxide from the atmosphere and at the same time to protect atolls /islands from the impacts of storms and sea-level rise and protect biodiversity and livelihoods.
- Impact spheres: environmental, adaptation and economic
- Grant sizes: regular grants: between USD 10,000 – 50,000 and large grants: between USD 50,000 – 200,000
- Duration: 2-5 years

8.5 Key issues that affect success

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

Site and ecosystem characteristics are key as seagrass beds reduce waves and currents in shallow areas more effectively when they occupy a higher proportion of the water column. Since some species are naturally taller and therefore occupy a greater proportion of the water column than others, it may be important to take this into account when selecting species for restoration efforts, or when prioritising management efforts for existing seagrass beds. Stiffness, biomass, density, leaf length and morphology are other species-specific characteristics that influence the coastal protection value of seagrass beds.

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

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

For seagrass restoration, since implementation success predominately depends on trial and error, employing adaptive management using native species is strongly recommended.

8.6 Eligibility criteria

- Grant should include more than one CBO within a seagrass landscape
- Interventions must comply with local level and regional land-use plans
- Grantee must have the capacity to implement the full scope of the grant

8.7 Complementary practices

- Improve scientific research about seagrass habitats
- Maximizing ecosystem services in degraded seagrass beds and other marine habitats requires a portfolio of management strategies that include EAFM approaches (e.g., fish aggregation devices, herbivore management etc).
- Awareness-raising and capacity building at the local level
- Training of local people and long-term community management and monitoring plans to ensure project sustainability

8.8 Cost and materials

Seagrass transplanting is labour intensive, and can require the use of divers in deeper water, which can result in considerable financial expenditure where volunteers are not available. Transplanting also has an ecological cost, as inappropriate harvesting can damage the source ecosystem. The recovery time depends on the species harvested.

- Small scale infrastructure and equipment
- Seagrass ecosystem service for planning and adaptation, implementation and management
- Training, research and monitoring
- Operational costs
- Consumables (seedlings etc)

8.9 Methodology/Approach

Seagrass restoration should be considered when seagrass loss, damage or degradation in an area has advanced to an extent that it can no longer be expected to recover on its own. It is critically important to always first assess the reasons for the loss and address the underlying causes before proceeding with the restoration process.

Different methods for seagrass restoration are used, they all depend on the experience and familiarity with species' growth habits and life histories.

Manual transplanting restoration methods include:

- Sediment-free: Plants are dug up using a shovel (or other device), the sediment is shaken off from the roots and rhizomes and the plants are placed in tanks, floating pens or similar, for holding until made into 'planting units'. Planting units are planted either directly into the bed (as sprigs) or anchored using a device such as a peg or a staple, attached to metal frames or woven into biodegradable mats.
- Seagrass with sediment methods: Other variations include the plug method, which uses coring devices (of metal or PVC) to extract the plants with the

sediment and rhizomes intact, or the tray method, which uses metal trays to dig and collect larger (50x50cm) sods.

- Seed-based methods: Seed-based restoration techniques have been used successfully in large-scale restoration of several seagrass species that mass-produce large quantities of seeds and/or form dense seed banks.

In an effort to scale up restoration efforts and reduce costs on a per hectare basis, a number of mechanical methods have been developed that make use of heavy equipment or machinery for collection of plant material & seeds or for planting.

8.10 Proven Methods

Common reasons for failure of seagrass restoration attempts:

- Innapropriate site selection
- Poor planning
- Damage from human activities, storms, floods or spills
- Poor water quality
- Uprooting of transplants due to strong flows, high wave energy or swell
- Sediment instability causing erosion or smothering and burial of seedlings

Selection criteria for restoration sites include:

- Habitat suitability (environmental conditions conducive to seagrass growth, including temperature, salinity, light, flow velocity, wave exposure, tidal conditions, substrate)
- Level of human disturbance (from activities or developments that affect seagrass health and survival)
- Previous experience (at similar sites)
- Advice from local area experts (or elders that know the area well)
- Practical considerations (accessibility, distance, logistical, institutional and legal considerations)
- Proximity to existing seagrass beds
- Evidence of historical seagrass presence at the site
- Recent incidental sightings of seagrass colonisation in or near the area
- Depth: seagrass restoration sites should have similar depths to nearby healthy meadows and not be subject to chronic storm damage

8.11 Key studies

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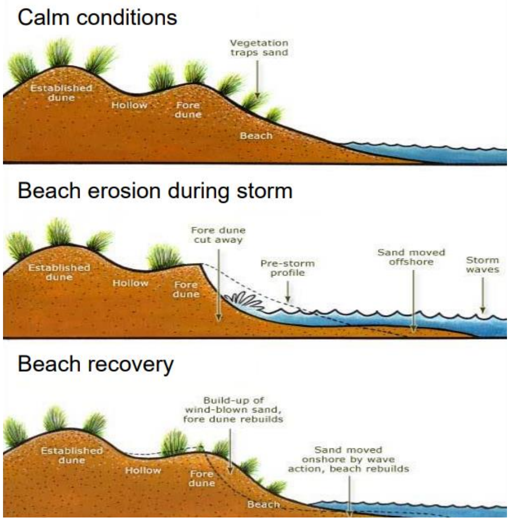
EbA Opportunity 9- Beach conservation and restoration

9.1 Description

Beaches are widely seen as a buffer between the land and sea and as providing important coastal protection and tourism opportunities. A range of conservation and restoration approaches have been developed to support these functions.

Further to minimizing disturbances, common onsite approaches include implementing physical barriers that trap sand, mechanically stabilizing dune ridges, and planting schemes using species adapted to the ecosystem to biologically fix or reforest the dune ridge. Where beaches are currently eroding, ‘beach nourishment’ has been used as an approach to maintain the beach profile, and involves depositing sand onto the beach from offshore or quarries. As beach nourishment can involve artificially building up sand on the shoreline, it can be seen as a more structural or hybrid adaptation approach.

Further to minimizing disturbances, common onsite approaches include implementing physical barriers that trap sand, mechanically stabilizing dune ridges, and planting schemes using species adapted to the ecosystem to biologically fix or reforest the dune ridge.



9.2 Climate Rationale

Reducing non-climate pressures (e.g. clearing and trampling) and encouraging plant development increases the resilience of services provided beaches.

9.3 Benefits

Beaches are a buffer between the land and sea and as providing important coastal protection and tourism opportunities. Conserving beach habitat is therefore important for this specialist flora and fauna. Sand plays an important role in water regulation and purification, as coastal dune aquifers are an important source of water extraction

9.4 Scope

- Intervention Areas: Biodiversity management, dune restoration.
- Impact spheres: environmental, adaptation and economic
- Grant sizes: regular grants: between USD 10,000 – 50,000 and large grants: between USD 50,000 – 200,000
- Duration: 2-5 years

9.5 Key Issues that can affect success

Beaches and sand dunes have been significantly damaged by human actions and as a result are in decline, mainly due to coastal development and tourism pressures. Coastal urbanization, for example, has in some cases destroyed dune systems, significantly reducing their capacity to supply sand during times of severe erosion, thereby increasing erosion risk. Additionally, dredging offshore can change beach profiles and so increase beach erosion.

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

9.6 Eligibility Criteria

- Grant should include more than one CBO within a relevant landscape
- Interventions must comply with local level and regional land-use plans
- Grantee must have the capacity to implement the full scope of the grant

9.7 Complementarity practices

- Awareness-raising and capacity building at the local level on beach restoration techniques
- Training of local people and long-term community management and monitoring plans to ensure project sustainability

9.8 Cost and materials

The success of the community-led approach for vegetation planting has had varying success and is dependent on local commitment, therefore local awareness raising campaigns may assist in promoting local efforts to protect dunes.

- Small scale infrastructure and equipment
- Mangrove ecosystem service for planning and adaptation, implementation and management
- Training, research and monitoring
- Operational costs
- Consumables (seedlings etc)

9.9 Methodology/Approach

Beach conservation and restoration include activities related to:

- Dune stabilisation: it is needed to protect other natural features, create sheltered wetland habitat, provide needed beach access for recreational use and overcome hazardous situations
- Dune management: it is necessary to achieve the balance between open, uncontrolled dune movement and selective stabilization
- Land use management: understanding the different potential land use options in dune areas is important to define how these areas will be protected and managed. Potential land use options include urban land, community services, woodland and wildlife habitat.

The six steps required to stabilise an active dune permanently include:

- Prepare the site
- Plant sand-stilling dunegrasses
- Maintain dunegrass stands
- Pland secondary grasses, legumes, shrubs or trees

- Maintain secondary plantings
- Incorporate landscape plantings

9.10 Proven Methods

The methods and best practices include:

- Manage foot traffic with delineated beach access pathways.
- Designate dune restoration areas with rope or other barriers to protect vegetation from foot traffic.
- Remove obstructions and invasive species in the restoration areas.
- Plant native vegetation to encourage sand build up over time and to stabilize dunes.
- Install sand fencing to accelerate accumulation of wind-blown sand.
- Rebuild dunes with sand from the same littoral/beach cell, if needed.

9.11 Key studies

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