Ecosystem-Based Adaptation through South-South Cooperation
Enhancing Capacity, Knowledge and Technology Support to Build Climate Resilience of Vulnerable Developing Countries
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Protocol for Implementation of Ecosystem-based Adaptation Interventions in Coastal Wetlands of the Seychelles

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PART 1: INTRODUCTION

Seychelles context

The Seychelles, an archipelago of 115 small islands, lie in the west of the Indian Ocean. It has a large exclusive economic zone (EEZ) of 1.34 million km^2. Most islands are uninhabited, with most of the population living on the three main islands of Mahé, Praslin and La Digue. The tropical climate is influenced by alternating monsoon seasons dominated by prevailing winds. The relatively calmer, warmer and wetter northwest monsoon prevails from November to March while the stronger, cooler and drier southeast trade winds prevail from May to October.

The population is estimated at 95,000, with life expectancy of 74.8 years (NBS, 2017). The Human Development Index is relatively high (HDI: 0.797). In 2015, the Seychelles was classified as a high-income country, with a per capita GDP of US$ 15,076 in 2016 (OECD, 2017). The economy is dependent on tourism and tuna fisheries, hence the people remain highly dependent on the biodiversity and resources that support and underpin the country's economy.

The biodiversity of the Seychelles is recognised to be of international significance. It is part of the Madagascan and West Indian Ocean Biodiversity hotspot (Government of Seychelles, 2012), where 50% of the country's land mass is officially protected under the law and there are plans to designate 15% of the EEZ as no-take zones and place an additional 15% under active management, as part of the Seychelles Marine Spatial Planning (SMSP) initiative.

The effects of climate change in the Seychelles are expected to be mostly negative (SNCCC, 2009), with projected increase in sea level, storm and tidal surges, extreme sea surface temperatures, variability in rainfall patterns and coastal flooding (Government of Seychelles, 2014a) that will affect the way of life of all residents. Trends in temperatures over the past 40 years show that both maximum and minimum temperatures are increasing (Government of Seychelles, 2014a) with average warming trend of 0.33°C and 0.82°C respectively (V. Amelie *pers. comm.*). Climate change is also influencing the two seasons. Greater rain intensity but of a shorter duration is expected during the rainy season, whilst dry season is expected to be longer and wetter (Chang-Seng, 2007a, b; SNCCC, 2009). Increases in the frequency of heavy precipitation events are consistent with warming and observed increases of atmospheric water vapour (IPCC, 2007). The frequency of extreme weather events such as heavy rainfall and storm surges are expected to increase and will affect mainly the coastal areas. Analysis of sea level rise shows an upward trend of 0.66 cm per year and if the trend continues it will cause great impact in coastal areas (JICA, 2013, V. Amelie *pers. comm.*).

Climate change and climate variability are already impacting the Seychelles islands: El Nino events in 1998 destroyed 95% of corals in the Granitic Islands and subsequent coral bleaching events occurred due to a rise in sea surface temperatures (Spalding *et al.*, 2002); the tropical cyclone in 2006 resulted in flooding and habitat destruction; and various episodes of storm surges have been experienced. Human development and alteration of ecosystems have reduced the capacity of natural systems to buffer local communities against climate variability and disasters. For instance, the majority of lowland wetlands including mangroves have been fragmented, reclaimed and impacted upon through development leading to a loss of 90% of lowland wetlands since the 1900s (Gerlach, 2002). This has resulted in the current critical status of coastal wetland systems (Government of Seychelles, 2014a). Today, wetlands cover a relatively small area ca. 206 ha in the Seychelles Granitic Islands, representing about 1% of land areas (Senterre and Wagner, 2014) but play an important role and provide many ecosystem services to humans, e.g. flood control, sediment traps, water quality control, hydrological cycle regulation, freshwater supply (ground water recharge), biodiversity services (habitat for flagship species), and atmospheric carbon sequestration (Woodward and Wui, 2001; Bullock and Acreman, 2003; Zedler and Kercher, 2005). Hence, rehabilitation of natural systems should be an integral part in addressing disasters in the Seychelles.

All types of marine and coastal ecosystems are being affected, with the biggest impact thus far observed on coral reefs (Graham *et al.*, 2006; Grandcourt and Cesar, 2003; Spencer *et al.*, 2000). As a result of the extreme vulnerability of coral reefs to climate change, they have been prioritised as one of the main candidate ecosystems for ecosystem-based adaptation (EbA). Other ecosystems in which EbA interventions have focused include mangroves, sandy beaches, coastal plateaus and freshwater marshes.

The Seychelles islands consist of different terrestrial and marine ecosystems. Seven species of mangroves are found in the Seychelles. They protect shorelines by trapping sediments eroded from the land and against wave erosion. They also offer some protection to the extensive coral reef system. The complex network of coastal ecosystems has a critical role to play in maintaining the biodiversity of the archipelago. There is, however, a lack of understanding and appreciation of the typology of wetlands in the Seychelles in the sense that wetland types are not properly distinguished. Distinction is often not made between the tidal and non-tidal coastal plateau mangrove or frontshore and backshore mangrove; the terminology of mangrove is used to describe non-mangrove habitat types; and other types of wetlands such as freshwater marshes and freshwater swamps are often confused. These distinction and proper classification of wetland types are important in the management of ecosystems and in the designing and implementation of EbA interventions. Recognising and considering the interconnectedness of different ecosystems is important in the implementation of EbA interventions which needs to include and encompass different ecosystem types.

Introduction to EbA

Ecosystems are affected by climatic and non-climatic factors and have an important role to play in helping vulnerable people adapt, particularly where livelihoods are dependent on natural resources (Swiderska *et al.*, 2018). The Convention on Biological Diversity (CBD, 2010; IUCN, 2009) defined ‘ecosystem-based adaptation’ as followed: ‘Ecosystem-based adaptation is the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change.’ EbA includes the sustainable management, conservation and restoration of biodiversity and ecosystems to provide services that help people adapt to the adverse effects of climate change.



What is an ecosystem?

An ecosystem is a complex of plant, animal, and microorganism communities and the nonliving environment, interacting as a functional unit (CBD, 1992), e.g. grassland, marine, coastal, inland water, forest.

Humans are an integral part of ecosystems, and every ecosystem supports our lives in multiple ways – what we call 'ecosystem services' e.g. water, food, nutrient cycling. Ecosystem services benefit the people whose very survival depends on healthy, functional ecosystems.

What is adaptation?

Climate is changing abnormally fast and in ways that could significantly disrupt our livelihoods and security, from our economies and infrastructure to the social and ecological systems we depend on. Climate change is affecting biodiversity and ecosystem functioning and the many benefits that they provide to society. Ecosystems are vulnerable to climate change for two reasons. First, climatic impacts may be too severe for an ecosystem to withstand them e.g. heavy and sudden downpours wash away fertile soil and prolonged drought destroys soil nutrients. If these phenomena become a normal part of the local weather, soil erosion will exceed the natural rate of soil formation and degrade the land irreparably. Second, how we use the ecosystems increases their vulnerability to climate change. For instance, natural processes of soil erosion could be accelerated by the continuous and unsustainable farming practices. As a result of misuse, land can turn into a hard crust impacting water infiltration and replenishment of underground water sources. Soon, the water levels in marshes, rivers and so forth, would decline, shrink or disappear altogether.

Adaptation refers to actions taken to ensure that these negative impacts are prevented or minimised and that both people and ecosystems are equipped to withstand potential damage.

Adaptation strategies involve a range of actions, including behavioural change, technical or hard engineered solutions such as construction of sea defences and disaster reduction strategies such as the establishment of early warning systems .

What is ecosystem-based adaptation?

There is growing recognition of the role healthy ecosystems can play in adaptation, known as ecosystem-based adaptation (EbA). These so-called 'nature-based solutions' aim at strengthening the natural systems to cushion the worst impacts of climate change. We strengthen ecosystem by sustainably managing, conserving and restoring degraded ecosystem to provide the services that allow people to adapt to climate change. EbA can be described as "adaptation powered by nature", where the goal is to boost the resilience of natural ecosystems and the services and species that support them, so that they are prepared for the impacts of climate change.

Core principles of EbA

There are several principles of EbA, but the main ones are listed below.

EbA is about promoting resilient ecosystems and using nature-based solutions at the service of people, especially the most vulnerable. Healthy, intact ecosystems are more resilient to changes. It is important to understand what makes resilient ecosystems (ability of a system to recover from disturbance or withstand ongoing pressures and continue functioning). Maintaining and conserving ecosystems play a vital role in resiliency.

EbA operates at multiple geographical scales

Landscape-level approaches should be considered in EbA planning. For instance, one may want to control coastal flooding by improving hydrological flow within coastal wetlands. But the core problem is in upstream wetlands which are invaded and blocked by invasive alien species (IAS) and hence the wetlands cannot store floodwaters. There is thus a need to manage the IAS in the wetlands before attempting any interventions in the downstream coastal wetlands. It is important to take into account the landscape-level approach to avoid mal-adaptation.

EbA is based on best available science and local knowledge and fosters knowledge generation and diffusion. The best available scientific knowledge should be used in conjunction with local knowledge. There is a need to obtain information (e.g. climate modeling, data on past and current climate variability and impacts, ecological data) and to use such information to support decision making. Monitoring of various parameters at specific sites to improve ecological knowledge and formulation of adaptation measures should also be undertaken. Sharing of knowledge and dissemination of results/lessons learned help to contribute to better understanding of EbA processes.

EbA minimises trade-offs and maximises benefits with development and conservation goals to avoid unintended negative social and environmental impacts. EbA can result in multiple benefits - increased livelihood assets, increased water and food security, biodiversity conservation. This might involve the active management of ecosystems for the provision of certain services at the expense of others, e.g. managing forests for water flow regulation to provide constant water supply and prevent flooding downstream rather than harvesting of timber and non-timber forest products. Although net benefits may increase, some people or communities lose while others gain. Participatory planning recognising the needs of the poorest and most vulnerable is essential for balancing trade-offs. Strategies should balance current vulnerabilities and needs for resources. Planners should ensure that the multiple benefits of EbA are maximised and channelled effectively to the stakeholders/local communities concerned.

EbA promotes multi-sectoral approaches

Ecosystems underpin the functions of diverse sectors of society with multiple stakeholders depending on the services they provide. Ecosystem benefits and management costs are incurred by different sectors and divisions of society e.g. the Public Utility Company (PUC) managing water in a national park where the forest is managed by the Seychelles National Park Authority. Therefore, EbA should work towards ensuring cooperation across different sectors to avoid conflicts e.g. water supply, forestry, agriculture, and collaboration between sectors managing ecosystems and those benefiting from ecosystem services e.g. PUC managing water in upper Val d'En Dor vs farmers benefiting from water provisioning.

EbA is participatory, transparent, accountable, and culturally appropriate and actively embraces equity and gender issues. As with any adaptation action, EbA is context and place-specific, requiring knowledge, mobilisation and action tailored to particular conditions. Broad stakeholder inclusion in formulating strategies as well as full stakeholder participation in the process is needed. It is necessary to target the adaptation needs of those stakeholders that are likely to be most affected by climate change and most dependent on ecosystem services. EbA should aim to empower people as rightful directors of their own future in the face of climate change and development.

EbA interventions in the Seychelles

Recognising that the biggest impact of climate change will be on the Seychelles natural environment, from the coast to the mountain, the country started to integrate climate change as a cross-cutting issue in various policies and strategies. There are several legislations and policies addressing EbA and climate change.

The Seychelles Sustainable Development Strategy (SSDS, 2012 – 2020) integrates climate change not only as a thematic area with its own action plan, but also as a cross-cutting theme in all of the other thematic areas (Government of Seychelles, 2012).

The National Climate Change Strategy (SNCCC, 2009) is the main national strategic document that addresses climate change adaptation. The strategy recognises that EbA needs to be further developed to decrease Seychelles' vulnerability to climate change. In addition, the Government is in the process of preparing a Seychelles Climate Change Policy to provide the general framework for climate change adaptation and mitigation.

The National Biodiversity Strategy and Action Plan 2015 – 2020 (NBSAP, Government of Seychelles, 2014b) is the main guiding document on biodiversity conservation in the Seychelles. It addresses the threats of climate change to local biodiversity and includes many cross-sectoral projects with climate change adaptation implications in the field of sustainable tourism, watershed management, sustainable agriculture and fisheries, disaster planning, and research and support a shift toward EbA approaches to biodiversity conservation.

The Seychelles Protected Areas Policy 2013 (Government of Seychelles, 2013) provides a framework for the elaboration of legislation for the establishment and management of protected areas in Seychelles. One of the main objectives of the policy is to effectively conserve 50% of national terrestrial areas and effectively manage 20% of marine area within the EEZ, thereby reducing anthropogenic stressors to ensure that marine and terrestrial habitats within these protected areas are better able to cope with climate induced changes.

Climate change adaptation also features in the agricultural sector. The Seychelles National Agriculture Investment Plan (SNAIP, Government of Seychelles, 2014c) promotes climate-smart agriculture to reduce the impact of agriculture onto the environment as well as adapting agricultural practices to the impacts of climate change.

Ecosystem-based adaptation projects in the Seychelles

This section provides an overview of previous and current EbA or EbA-related projects in the Seychelles, as listed in Table 1.

Several projects have attempted mangrove restoration activities in the past. Various activities were implemented as part of the Mangrove for the Future (MFF) initiative. MFF activities in the Seychelles included projects on habitat restoration and biodiversity protection, as well as contributing to environmental events. Mangrove projects were implemented by NGOs and schools. Some of these were partially successful whilst others failed due to several factors like vandalism, strong currents uprooting and sweeping seedlings away but also for unknown reasons. Nature Seychelles implemented a project in the bird sanctuary where mangroves were replanted to enhance the habitat for wildlife amongst other environmental benefits. The Seychelles National Park Authority attempted several replanting activities on Curieuse Island, most of which failed for unknown reasons. To note that a lack of monitoring after planting was the main reason why it was not possible to observe and identify the cause of failure.

The Seychelles has been implementing several EbA projects. *Ecosystem-based Adaptation through South-South Cooperation (EbA South)* is a global EbA project implemented in three countries (Seychelles, Mauritania and Nepal) in collaboration with the United Nations Environment Programme (UNEP) and the UNEP-International Ecosystem Management Partnership (UNEP-IEMP) in Beijing, China. The project is funded by the Global Environment Facility (GEF) through the Special Climate Change Fund. The overall goal is to build climate resilience in developing countries by increasing their capacity to plan and implement EbA. In the Seychelles, the project is concentrated in demonstrating EbA intervention in mangrove ecosystem. EbA activities which have been implemented in mangrove ecosystem include the construction of culverts to improve hydrological flow through 300 hectares of artificially fragmented mangroves, channel desilting, mangrove rehabilitation and removal of invasive species. The project also has a substantial component related to capacity building on techniques of mangrove ecosystem restoration as well as on education and awareness.

The European Union funded *Building Capacity for Coastal Ecosystem-based Adaptation in SIDS* project was implemented by UNEP as part of their Africa Regional Climate Change Programme. The long-term goal of the project was to strengthen the resilience and adaptive capacity of communities that depend on coastal ecosystem services provided by coral reefs and associated ecosystems. The biggest component of this project was dedicated to piloting coral reef restoration within the Curieuse Marine National Park.

Ecosystem-based Adaptation to Climate Change in Seychelles is an ongoing national EbA project financed by the Adaptation Fund. The project's overall goal is to reduce the vulnerability of the Seychelles to climate change. It focuses on two key issues: water scarcity and flooding, which were chosen based on the climate change projections in the Seychelles which show that rainfall, while increasing in overall terms, will become even more erratic. Much of the precipitation is falling in sharp bursts, creating heavy flooding in the wet season, while imposing extended period of drought during the dry season. As the country does not have a large water storage capacity and the topography of the islands constrains the creation of water supply infrastructure, water supplies are heavily dependent on rainfall. Furthermore, the coastal zone is vulnerable to flooding as a consequence of rising sea surface levels, and increased storm surges from cyclonic activity in the Western Indian Ocean. The project is reducing these vulnerabilities by spearheading EbA as climate change risk management – restoring ecosystem functionality, enhancing ecosystem resilience and sustaining watershed and coastal processes in order to secure critical water provisioning and flood attenuation ecosystem services from watersheds and coastal areas. EbA activities implemented focus on restoring coastal freshwater marshes, improving water flow and water retention capacity and assessing recovery potential of coral reef sites.

The Seychelles Global Climate Change Alliance + (GCCA+) Project (supporting adaptation to climate change in coastal areas) is under implementation on La Digue Island. The objective is to support adaptation to climate change to increase coastal and flood protection in the vulnerable areas of La Digue Island. The project uses a combination of EbA approaches combined with hard engineering to address site-specific issues and create opportunities to enhance climate change resilience to coastal flooding. EbA activities being implemented include wetlands rehabilitation which also includes embankment stabilisation, desilting and deepening. Beach berm rehabilitation is also planned and will be done by artificial augmentation of beach berm with natural sand from the coastal plateau and stabilising through native coastal plants. Dedicated access pathways to the beach will also be constructed to reduce trampling. Healthy beach berms are expected to act as a barrier and prevent spill over of saltwater onto the coastal plateau by storm surges or large waves during high water spring tides, thereby limiting salt intrusion and contamination of the water table.

Table 1: Overview of projects relevant to EbA in Seychelles

Project	Grantee	Year	Funding Agency
National Biodiversity Strategy, Action Plan and the First National Report to the Convention on Biological Diversity	Ministry of Environment and Natural Resources	1997	Global Environment Facility
Improving Management of NGO and Privately-owned Nature Reserves and High Biodiversity Islands in Seychelles	Nature Seychelles	2007	Global Environment Facility
Programme for the Agulhas and Somali Current Large Marine Ecosystems: Agulhas and Somali Current Large Marine Ecosystems Project	UNOPS	2007	
Western Indian Ocean Large Marine Ecosystems Strategic Action Programme Policy Harmonisation and Institutional Reforms Project	Ministry of Environment and Natural Resources		
Building the capacity of artisanal shark fishers to participate fully and effectively in the Seychelles National Plan of Action for the Conservation and Management of Sharks	Green Islands Foundation	2009	Mangrove for the Future
Conserving turtle rookeries on Mahé through improved public awareness and community involvement	Marine Conservation Society Seychelles	2009	Mangrove for the Future
“Mangroves are a Must!” Promoting mangrove conservation awareness and education in the face of climate change in the Seychelles	Wildlife Clubs of Seychelles	2009	Mangrove for the Future
Rehabilitation and Sustainable Management of the North-East Point Marsh	Seychelles Scouts Association	2009	Mangrove for the Future
Coastal development and ecosystem modelling as a tool to enable improved local and national policy and decision-making processes	Marine Conservation Society Seychelles and Green Islands Foundation	2010	Mangrove for the Future
Building the capacity of Roche Caiman community to adapt to climate change and other threats	Roche Caiman Environment Action Team	2010	Mangrove for the Future
Where did all the soil go? Coastal monitoring as a tool for developing local capacity, raising public awareness and assessing long-term environmental change	Terrestrial Restoration Action Society of Seychelles (TRASS)	2010	Mangrove for the Future
Enhancing community participation in sustainable coastal management	Sustainability for Seychelles	2010	Mangrove for the Future
Land Rehabilitation, Research and Action	TRASS	2010	Environment Trust Fund
Praslin Degraded Land Rehabilitation (Plant propagation)	TRASS	2011	Environment Trust Fund
Replanting and enhancing community participation in rehabilitation of degraded forest lands: a demonstration project at Pt Chevalier, Praslin, Seychelles	TRASS	2011	Global Environment Facility, Small Grant Programme
Studying the impacts of climate change on hawksbill turtles *Eretmochelys imbricata* on Cousin Island Special Reserve, raising awareness, and piloting mitigation measures	Nature Seychelles	2011	Global Environment Facility, Small Grant Programme
Piloting participatory research in a fisheries co-management set-up: the case of the Praslin rabbitfish spawning aggregation fishery	Lasosiasyon Peser Praslin	2011	Global Environment Facility, Small Grant Programme

Building Capacity in Organisations and Communities for Conservation of Species and Habitats	Plant Conservation Action Group	2011	Global Environment Facility, Small Grant Programme
Rehabilitation and Sustainable Management of the North-East Point Marsh	Seychelles Scouts Association	2011	Global Environment Facility, Small Grant Programme
Securing traditional livelihoods through sustainable management of the artisanal shark fishery	Artisanal Shark Fishers Association	2011	Global Environment Facility, Small Grant Programme
Conserving marine mammals around Seychelles while maintaining sustainable use of marine resources against a background of urban development, petroleum exploration - Strategic Project	Marine Conservation Society Seychelles	2011	Global Environment Facility, Small Grant Programme
Restoring Seychelles Native Biodiversity through the Involvement of Local Communities: Rehabilitation of Endangered Glacis Vegetation	Plant Conservation Action Group	2011	Global Environment Facility, Small Grant Programme
Reducing the carbon footprint of the Bel-Ombre artisanal fishing port	Bel-Ombre Fishermen Association	2011	Global Environment Facility, Small Grant Programme
Greening the Roche Caiman and the Au Cap coastal areas for improved ecosystem services	Roche Caiman Environment Action Team	2011	Global Environment Facility, Small Grant Programme
Testing methods of human induced resilience of socio-economic important coral reef sites within the Seychelles Marine National Parks	Anba Lao	2011	Global Environment Facility, Small Grant Programme
Fishing Aggregate Device and community monitoring programme around the island of La Digue for the benefit of the local community	La Digue Fishermen Association	2011	Global Environment Facility, Small Grant Programme
Mangroves for Mankind – Rehabilitating Mangroves at the Sanctuary at Roche Caiman	Nature Seychelles	2012	Mangrove for the Future
Protecting critical habitats for the Praslin nearshore artisanal fishery	Praslin Fishers Association	2012	Mangrove for the Future
Promoting community resilience through disaster risk reduction at community level	Red Cross Society, Seychelles	2012	Mangrove for the Future
Keeping the sand in "Sun, Sea and Sand": Helping coastal communities monitor, understand and manage beach movement and erosion in Seychelles	Marine Conservation Society Seychelles	2012	Mangrove for the Future
Building Capacity and Mainstreaming Sustainable Land Management in Seychelles	Ministry of Environment and Natural Resources	2012	Global Environment Facility
Cost-Effective Techniques for the Rehabilitation of Burned/Degraded Land in Selected Sites	TRASS	2012	Global Environment Facility
Management of invasive alien creepers at selected sites in Seychelles	TRASS	2012	Global Environment Facility
Capacity Development for Improved National and International Environmental Management in Seychelles	Ministry of Environment and Natural Resources	2012	Global Environment Facility
Mapping and enhancing natural resource governance in Small Island Communities	UNEP	2013	Mangrove for the Future

Integrated Ecosystem Management Programme. Component 1: Mainstreaming Biodiversity Management into Production Sector Activities Component 2: Mainstreaming Prevention and Control Measures for Invasive Alien Species into Trade, Transport and Travel Across the Production Landscape (Mainstreaming Biosecurity Project)	Ministry of Environment and Natural Resources	2013	Global Environment Facility
Strengthening the capacity of the community organisation "Anse Kerlan Avangard" to investigate and design for counter-erosion actions in the community	Anse Kerlan Avangard	2014	Mangrove for the Future
Assessment of the scalloped hammerhead shark (*Sphyrna lewini*) population and fishery to provide a basis for its sustainable management	Artisanal Shark Fishers Association	2014	Mangrove for the Future
Mediating marine mammal depredation to enable sustainable long/drop line fisheries in Seychelles	Marine Conservation Society Seychelles	2014	Mangrove for the Future
Community-based management of the Port Launay Mangrove Ramsar site in Seychelles	Sustainability for Seychelles	2014	Mangrove for the Future
Restoration and reforestation project of public and private lands on Praslin, Seychelles	TRASS	2014	Environment Trust Fund
Rehabilitating the degraded La Hauteur watershed for long-term benefits of downstream communities: a demonstration project to replant a forest	TRASS	2014	Global Environment Facility, Small Grant Programme
Ecosystem-based Adaptation through South-South Cooperation	Ministry of Environment, Energy and Climate Change	2015	Global Environment Facility
Building Capacity for Coastal Ecosystem-based Adaptation in SIDS	Ministry of Environment, Energy and Climate Change	2015	UNEP
Climate Smart Wetlands Rehabilitation and Agro-ecology	Anse Forban Community Conservation Programme	2015	Global Environment Facility, Small Grant Programme
The use of ecosystem-based adaptation tools to rehabilitate the La Hauteur watershed to enhance the livelihoods of the farming community downstream	TRASS	2015	COMESA
First Phase forest rehabilitation in the Praslin Fond Boffay and Nouvelle Decouverte River Watersheds under the Seychelles ecosystem-based adaptation to climate change project	TRASS	2016	Adaptation Fund
Ecosystem-based Adaptation to Climate Change in Seychelles	Ministry of Environment, Energy and Climate Change	2016	Adaptation Fund
Seychelles Global Climate Change Alliance + (GCCA+) Project (supporting adaptation to climate change in coastal areas)	Ministry of Environment, Energy and Climate Change	2016	European Union
Seychelles' Protected Areas Finance Project	Ministry of Environment, Energy and Climate Change	2016	Global Environment Facility
Expansion and Strengthening of the Protected Area Subsystem of the Outer Islands of Seychelles and its Integration into the Broader Land and Seascape	Ministry of Environment, Energy and Climate Change	2016	Global Environment Facility
Increasing the resilience of farming communities on the Praslin plateau by addressing soil salinity to boost local food production	Baie Ste Anne Farmers Association, in collaboration with TRASS	2016	AusAid

Securing the coastal land in Anse Kerlan with counter erosion structure thru' community-based adaptation process while building capacity and resilience of the community	Anse Kerlan Avangard	2016	AusAid
Rehabilitation and Management Plan for the La Hauteur watershed, Baie Sainte-Anne Praslin, Seychelles: A plan to address land degradation in the watershed for long-term benefits of downstream communities	TRASS	2016	AusAid
Community-based rehabilitation of coral reef	Marine Conservation Society, Seychelles	2017	Global Environment Facility
Preparing for Tomorrow Today: Women as Agents of Change for Climate Change Action	Gender and Media Association	2017	Mangrove for the Future
Mangrove habitat rehabilitation through fostering of joint school-NGO custodianship	Green Islands Foundation	2017	Mangrove for the Future
National Biodiversity Planning to support the implementation of the CBD 2011-2020 Strategic Plan in Seychelles	Division of Environment	2018	Global Environment Facility
Second Phase forest rehabilitation in the Praslin Fond Boffay and Nouvelle Decouverte River Watersheds under the Seychelles ecosystem-based adaptation to climate change project	TRASS	2018	Adaptation Fund
A Ridge to Reef Approach for the Integrated Management of Marine, Coastal and Terrestrial Ecosystems in the Seychelles	Ministry of Environment, Energy and Climate Change	2019	Global Environment Facility

Source: MFF, 2018; GEF SGP, 2019

PART 2: GUIDELINES FOR EBA PLANNING AND IMPLEMENTATION

At the heart of EbA interventions are communities, livelihoods and ecosystems. These three aspects need to be taken into consideration in the EbA planning and implementation to achieve maximum benefits. A guide to plan and implement on-the-ground EbA interventions, based on the Seychelles experience but with a worldwide applicability, is proposed below.

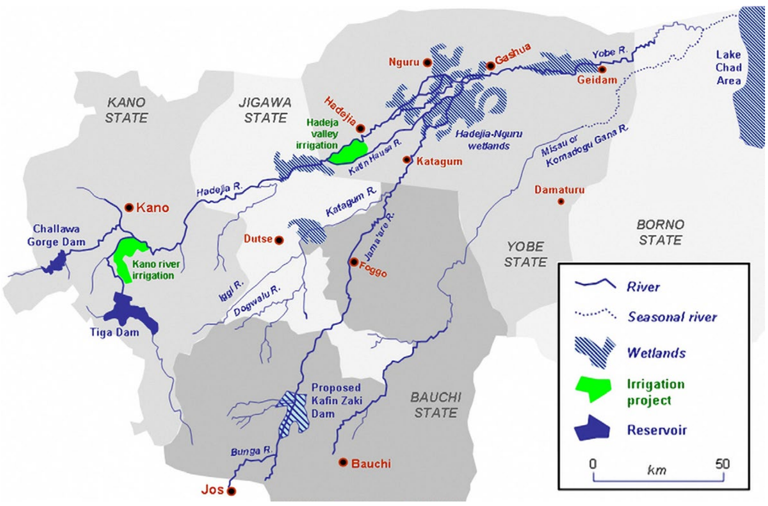
1. Understand the context

The purpose of step 1 is to collect and organise the necessary information to provide an overview of the context and to inform the design of the EbA interventions. This involves the collation of available data, review of existing literature, interviews, collection of new data through, for example, research or inventories involving community members and other stakeholders. Note that this stage involves engaging key stakeholders and communities in dialogue, which is an important element in the initial stages of the planning process. Failure to engage with key stakeholders and concerned communities may result in difficulties in implementing the EbA interventions further down the line as illustrated by a case study of the Hadejia-Nguru wetlands in Nigeria (Box 1).

Box 1 – Case Study 1: Core EbA principles in practice: the Hadejia-Nguru Wetlands of Nigeria

This case study exemplifies the following principles:

- EbA operates at multiple geographical scales
- EbA minimises trade-offs and maximises benefits
- EbA relies on best available science and local knowledge
- Importance of a participatory method in applying EbA options



The Hadejia-Nguru wetlands are located in northeastern Nigeria and comprised of permanent lakes and seasonal pools, all connected by channels. The wetlands provide essential ecosystem services - water for irrigation of export products such as peppers, staple foods such as millet and sorghum. Seasonal pools support irrigation of land outside of the wet season; livestock grazing and fishing for the majority of the 1.5 million people living in the floodplain, with fishing providing a major component of household cash income (approx. 6% of Nigeria's inland fish catch with a market value of about US$ 300,000 per annum). Diverse nature of these services ensures flexibility in resources and income, which is vital to the ability of communities to adapt to environmental shocks like drought .

Climate change resulted in water shortages, irregular water supply for irrigation and drought. Dams were constructed upstream to provide a more consistent supply of water for irrigated agriculture. These developments did not take an ecosystem-based approach and did not consider downstream effects. Decreasing volume of water downstream led to wetland shrinkage, reduced seasonal flooding and overall water supply. Water levels dropped, the velocity of water flow in the rivers decreased leading to increased siltation. Typha, a native wetland plant species, thrived and blocked waterways. These conditions prevented a natural flooding regime to occur; as a result water was not able to reach the floodplain and pools – important fish ponds dried up. The impacts were felt by fishermen, fish processors, fish wholesalers, fish retailers, fish gear dealers and boat builders. Moreover, there were flooding of productive farmland areas and grazing land upstream of the blocked channels. Farmlands, livestock, crops and natural biodiversity were lost due to changes in the river flow pattern caused by damming the rivers. The physical problems caused by the dams were compounded by insufficient consultation of directly affected people, the absence of grassroots advocacy groups and low levels of citizen participation at all levels. Upstream communities whose access to water was boosted with the construction of the dams had higher per capita income and enjoyed higher standards of living compared to communities downstream, which had lost natural resources from these developments. Hence, trade-offs were not minimised and benefits were not maximised for all.

The process to solve these many problems started with creating a knowledge base of information about the wetland basin. Local academics and researchers compiled socio-economic and environmental studies and undertook an audit of water resources in the basin. The information allowed for the creation of a Decision Support System and a Catchment Management Plan. Various stakeholders were consulted to reaffirm their interests, hope and aspirations. Restoration of the wetland ecosystems through removal of Typha and silt was undertaken. The restoration resulted in a more 'natural' flood pattern, that led to bigger and more fish catches, in addition to increased household incomes. Farmers reclaimed most of their farmlands and grazing areas and no over-flooding was experienced in the rainy season. Building on this success, the communities set up their own maintenance programme that included a substantive monitoring component to ensure the continued success of the project. This case study also exemplifies the multiplicity of benefits that EbA can provide. (FAO, 1997; Andrade *et al.*, 2011).

1.1 Establish the environmental and social conditions

The goal is to understand the current state of the environment and human aspects as well as establish a baseline situation prior to any interventions (See case study in Box 2).

- What are the ecosystems present? E.g. freshwater marsh, brackish water pool, swamp forest, mangrove, coastal forest (habitat types, size, animals and plants, physicochemical parameters, hydrological aspects, etc.)
- What are the livelihoods? Understanding the range of ecosystem-based livelihoods e.g. beekeeping, fishing, farming, nature guides
- What are the goods and services provided by the ecosystems to support livelihoods? (Goods e.g. wood for fish traps, freshwater for irrigation, crabs for crab harvesters; Services e.g. watercourse for navigation, pollinating services for agroforesters/farmers, flooding attenuation for adjacent households) Identify ecosystem services needed for livelihoods by conducting an ecosystem service mapping - map, model and evaluate the multiple flows of ecosystem services to the diverse users and sectors. Acquisition of this knowledge is to aid in understanding the role of ecosystem services in adaptation (how can ecosystem/nature be used to adapt to the impacts of climate change?).
- What services do these ecosystems provide to reduce impacts from climate change? (e.g. shoreline protection, flood attenuation, storm buffer, erosion and landslide prevention, forest fire and drought protection)
- What are the data/information gaps? Identify gaps for research and specific elements to monitor.

1.2 Analyse threats to ecosystems and livelihoods - climatic and non-climatic stressors onto the environment

To establish and understand climatic and non-climatic threats on humans, vulnerable groups, livelihoods and the ecosystems (See case study in Box 2):

- What are the historical, current and projected climate change? (e.g. trends in rainfall, temperature and climate hazards)
- What are the impacts of climate change on the ecosystems and livelihoods? (e.g. coral bleaching as a result of a rise in sea temperature which leads to reduced fish stock and decline in fish catch that affects fishermen's livelihood)
- What are the non-climatic stressors? (e.g. overharvesting/fishing, deforestation, forest fires, unsustainable agricultural practices, pollution, reclamation, drainage, road construction)
- What are the impacts of non-climatic stressors on the ecosystems and livelihoods? (e.g. drainage of marshes leading to loss of habitats for animals and loss of income for crab harvesters)
- What are the vulnerable ecosystems?
- What are the data/information gaps? Identify gaps for research and specific elements to monitor.

Box 2 – Case study 2: Analysis of environmental conditions, communities, livelihoods and threats at Cap Samy, Praslin

The sub-district Cap Samy is located in Baie Ste Anne on Praslin Island. It is primarily an agricultural area on the flat lowland coastal plateau, but there are also several businesses and residential areas. These were built in a previous floodplain and wetland area which are today fragmented by a network of roads and have been partially reclaimed for agricultural, residential, commercial and industrial purposes.

The main wetland type is the mangrove which hosts several animal species like the mangrove crab, red crab, mudskippers, land birds and waders, and several fishes including the endemic freshwater fish golden panchax (*Pachypanchax playfairii*). The main mangrove species is the white mangrove (*Avicenia marina*), but few red mangrove (*Rhizophora mucronata*) and black mangrove (*Lumnitzera racemosa*) are also present. The mangrove is fairly dense but fragmented.

The main human community of concern are the farmers who obtain their livelihood from farming the fertile floodplain and wetland soils. The farmers also obtain freshwater for irrigation from the La Hauteur River and from groundwater wells. The wetland banks provide fodder for foraging cattle. The wetland also acts as a floodwater storage for adjacent farms, businesses and households.

Predicted climate change impacts are flooding due to more intense rainfall, drought during the southeast monsoon season and saltwater intrusion from sea level rise. Non-climatic stressors onto the ecosystem and human community include road construction which fragments the wetland; land reclamation for agricultural and residential purposes which reduces the size of wetlands and their water storage capacity; impeded hydrological flow and poor drainage due to obstructed channels by the roots of mangroves, silt, rubbish, wooden debris and the small size of drainage pipes (0.7 - 0.9 m) connecting the fragmented wetland; pollution from nutrients, pesticides, fertilisers, litter from adjacent farmlands, residential and industrial estates as indicated by frequent eutrophication; stagnant waters providing breeding grounds for mosquitoes and the risk of disease like dengue and yellow fever. A granite rock quarry exists on the western side of the mangrove where red earth and sediment laden water flows into the wetland through La Hauteur River. The combination of climatic and non-climatic factors enhances flooding incidences of the community.

The farmers and residents suffered from flooding events during the northwest monsoon season, drought in the southeast monsoon season and saltwater intrusion into underground aquifer. These impacted on crop yield and income, thus affecting the farmer’s livelihood. Floodwaters also inundated several homes adjacent to the wetland. The farmers were identified as the main human community group vulnerable to the impacts of both climate change and non-climatic stressors. The mangrove was identified as the most vulnerable ecosystem since it was being impacted by development (agricultural practices, road construction, reclamation etc). Hence, measures to reduce flooding, improve hydrological flow and enhance mangrove health were identified as EbA options for implementation.

1.3 Identify relevant stakeholders and communities through exercises such as community mapping

- Who are the different communities and stakeholders in the area?
- Who are the potential winners and/or losers of specific changes in socio-ecological systems?
- Who are the core multidisciplinary teams that can be involved during any interventions?
- How can we bring stakeholders and community groups together for focus group discussions on the challenges they face and find locally-suitable solutions?

Box 3 – Case study 3: Community mapping as a tool to identify relevant communities in target areas

Cote D'Or and Cap Samy are two sites under the EbA South project. A rapid community mapping exercise (Figure 1) was conducted to identify the different communities within or in the vicinity of Cap Samy and Cote D'Or: residential (Marie-Jeanne Estate 1 and 2, Cap Samy), industrial (LOAN, UCPS), tourism (Cote D'Or Estate, Souyave Estate, Acajou Hotel, Vacanze Club). Local knowledge was combined with on-site inventory and cadastral analysis of land parcels to create the map of communities on the project sites.

The farmers and residents immediately adjacent to the wetland at Cap Samy were identified as the main losers in cases of flooding and other climatic and non-climatic stressors since there had been several complaints made to the District Administration and the Ministry of Environment, Energy and Climate Change (MEECC). Arguably, the farmers and residents would be the main winners of any EbA interventions to remediate the situation.

A dialogue began between the MEECC, the District Administrator, the Member of the National Assembly for Baie Ste Anne and the Farmers' Association to discuss and find solutions to the flooding problems of Cap Samy. Some of these dialogues were undertaken through site visits to better understand the issues at play. The process allowed for the identification of intervention measures that could be undertaken to reduce flooding events.

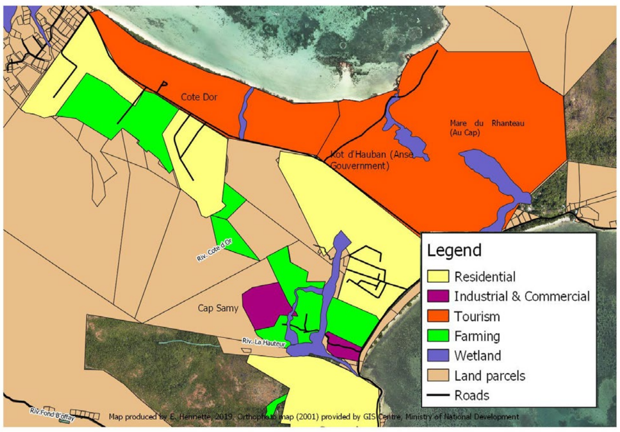


Figure 1 : Community mapping of project sites on Praslin, Seychelles

Concluding remarks on ‘Understanding the context’

To achieve the above, one needs to:

- Gather relevant expertise and data.
- Review and synthesise existing information from different disciplines and sectors on the various components: ecosystems, ecosystem services, livelihoods, climate stressors (including climate projections) and non-climatic threats, vulnerable groups.
- Complement available data with collection of new data e.g. inventories on biodiversity (species, habitat types etc.), human community mapping, identification of vulnerable groups. Data collection will establish a baseline to understand the current context as well as to establish the conditions prior to any interventions against which future changes can be measured/evaluated.
- The above data collected can either be science-based information and/or traditional/ local knowledge on past and current environmental conditions (e.g. climate variability, impacts, changes in the physical environment) to identify locally relevant solutions to the challenges presented by the stressors.

2. Identify and prioritise EbA options

Once the context has been analysed and understood, the next step is to identify, explore and prioritise effective and feasible EbA options.

2.1 Identify EbA options for vulnerable ecosystems and livelihoods

This step focuses on identifying and prioritising EbA options that strengthen the resilience of ecosystems and human communities.

There are generally three main types of EbA options (Swiderska *et al.*, 2018):

Restoration: The process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed.

Conservation: Strategies to conserve the function, structure, and species composition of an ecosystem, recognising that all components are interrelated.

Management: Managing resources in ways that promote the long-term sustainability of ecosystems and the ongoing delivery of essential ecosystem services to society.

The main EbA options can be further refined into more specific EbA activities (Table 2) and the most appropriate option is chosen for specific habitat types.

Table 2: Potential EbA options for different coastal habitat types

Coastal ecosystem/ habitat types	EbA options	Benefits
Coral reef	Coral reef rehabilitation	To partially or, occasionally, fully replace the structural and/or functional characteristics of a reef ecosystem that have been previously impacted. The rehabilitation also aims to enhance the social, economic and ecological values of the previously degraded reef.
Beach	Beach nourishment	A process by which sand, which has been lost from the beach, are replenished from other sources. The newly nourished beach can reduce storm damages, hence offering storm and shoreline protection. The process may need to be repeated several times to maintain the beach.
Sand dunes	Sand dune stabilisation through replanting	These measures to stabilise sand dunes can be found in between the beach and the coastal plateau. The dunes are revegetated or enhanced with coastal plants to reduce erosion and encourage sand accumulation. Bioengineering with fibre blankets or coconut coir rolls helps stabilise sand in place while planted vegetation takes root. Sand dune stabilisation using plants has been undertaken in several sites in the Seychelles.
Mangrove	Mangrove replanting	Planting mangroves increases the abundance, density and diversity of mangroves. The replanted mangroves buffer against flooding and storm surges by protecting the shoreline from erosion. Mangroves also provide habitats for species and aid in carbon sequestration.
Freshwater marsh	Channel profiling to improve hydrological flow	Excess accumulation of sediments is removed from the channel bed, and often the channel is widened to enhance water flow. Straightening and deepening of channels may have temporary negative effects because they destroy microhabitats (e.g. pools and ripples).
River	River bank stabilisation and erosion prevention using geotextiles, logs, coconut carpets, bamboo fences, gabions and replanting	Protect an eroding river bank from natural water flow. This involves reshaping the bank to provide a more stable slope which will be less prone to erosion. It can be combined with bioengineering which includes the installation of coconut blankets, rolls and geotextiles on the bank surface to offer protection in addition to planting. Bamboo fences and gabions can be used to prevent erosion and stabilise the bank. These methods also provide habitats for species and provision of freshwater.
Coastal forest	Coastal setback	A prescribed distance to the high-water mark or the line of permanent vegetation, within which all types of development are prohibited. Setbacks are used to adapt to coastal flooding and erosion. This provides the space for the shoreline to migrate in case of sea level rise, flooding and severe erosion.
	Invasive alien plant management	Invasive alien plants have invaded the coastal forests and encroached onto wetlands impeding their functions. Management of invasive alien species (IAS) can be done by integrating physical and chemical methods such as uprooting, cut and stump, injection and foliar spraying. IAS removal should be integrated with replanting initiatives.
	Revegetation	Used in the coastal zones to reduce erosion, improve habitat structure and ecosystem function, and to improve water quality. It also provides habitat for many species

2.2 Prioritise effective EbA options for vulnerable ecosystems and livelihoods

The prioritisation of EbA actions can be done using a multi-criteria analysis, which uses several criteria for EbA effectiveness. These priorities are not exclusive of each other, i.e. they often contribute to each other. Typically, an ecosystem needs to be healthy and climate-resilient to contribute to people's resilience. Some of these are provided below.

- Use biodiversity and ecosystem services to enhance ecosystem functioning: The EbA option uses natural measures to improve the ecosystem.
- Build resilience of ecosystems to climate change: The EbA option supports the functioning of ecosystems and enhances their ability to generate different ecosystem services. The enhancement of the ecosystem has the potential to reduce risks associated with future climate change impacts.
- Use biodiversity and ecosystem services to build people's livelihoods: The EbA option uses ecosystem services to improve resilience and livelihoods by creating new livelihood opportunities. For instance, the replanting of mangroves enhances habitats for animals particularly waders and migrants which creates an opportunity for tour guiding as an alternative livelihood. Or the rehabilitation of coral reefs strengthens coastal ecosystem resilience, enhances fish productivity and provides opportunities for ecotourism. This in turn enhances people's capacity to adapt to climate change.
- The EbA option is flexible and can easily be adapted in adaptive management approaches.
- The EbA option is inclusive of vulnerable groups and ensures the full participation of all relevant actors/stakeholders in the process of adaptation.

The evaluation process will identify the most "effective" EbA options which are most likely to produce the desired outcome.

2.3 Assess the feasibility of EbA interventions

The next step in the EbA planning is to assess the feasibility in implementing the EbA option. The cost effectiveness of EbA options can assist in making the case for EbA approaches and prioritise different EbA options. A range of criteria is proposed to assess the feasibility of the EbA options.

- Affordability (affordable ranks high; very costly ranks low)
- Technical feasibility (technically feasible ranks high; technically difficult ranks low)
- Negative environmental impact (low impact ranks high; high impact ranks low)
- Number of beneficiaries (supports large number of beneficiaries ranks high; few beneficiaries ranks low)
- Maintenance cost (low maintenance ranks high; high maintenance ranks low)
- Flexibility (flexible and can be adjusted if changes occur ranks high; inflexible ranks low)
- Ease of monitoring (easily monitored ranks high; difficult to monitor ranks low)

A case study (Box 4) illustrates the need for assessing the feasibility of EbA options.

Box 4 – Case study 4: Coastal rehabilitation options on Praslin

Invasive alien plant species pose serious threats to the biodiversity of the Seychelles. Several coastal wetlands are threatened by IAS. The encroachment of IAS onto wetlands, their ability to rapidly spread, overgrow and outcompete native plants means that the wetland and coastal areas are threatened. Under the EbA South project, 20 ha of wetland on Mahé, Praslin and Curieuse were planned for the removal of IAS and replanting with mangroves and native coastal plants.

The EbA and IAS management option chosen was the felling of IAS on the 20 ha and replanting of native species. An estimated budget was calculated by the Climate Adaptation and Management Section (CAMS) of the MEECC based on the actual cost of tree felling. The contracting of the IAS felling was done through a national tender process. Selective bidders from the tender process submitted their quotes which were in most cases more than three times the estimated cost by CAMS. The EbA option was not affordable by the project and hence unfeasible. Alternative but cost-effective EbA options were then explored. Chemical injection using herbicides, which is effective when done properly, was rejected by CAMS due to fear of wetland contamination. Selective felling of adult trees and the thinning/clearing of undergrowth was finally chosen as the revised EbA option. Negotiations with contractors were done to encourage them to take the wood free of charge and hence reduce quotation cost. This experience shows the need to carefully evaluate EbA options based on the actual market value as well as to integrate innovative ideas such as the trade-off between timber wood for a reduced operational cost.

3. Develop EbA strategies and design actions

Once the EbA options have been prioritised and selected, they can now be considered for implementation. The next step is to identify key actions to implement these EbA options.

It helps at this stage to have a site-specific intervention protocol to decide on required inputs, key actors and their responsibilities, timing of activities, potential limitations or opportunities and barriers and guide the activities (see Box 5 and Part 3).

Box 5 – Case Study 5: Wetland rehabilitation at Anse Royale, Mahé, to protect communities and infrastructures from flooding events

Overview: The Anse Royale wetland is comprised of an estuary, a mangrove, a freshwater marsh, swamp forest, 2 rivers, and riparian forests. The wetland is surrounded by agricultural land (plant and animal farms), educational facilities, health centre and commercial-business centres. Flooding is a major issue faced by the communities.

EbA options identified: Reprofiling to widen channels; removal of natural and man-made debris blocking the channels; removal of invasive alien creepers within the marsh; removal of IAS plants and replanting with native plants on the river banks, riparian and swamp forests.

Required inputs: An equipped plant nursery (nursery tools, tons of topsoil, irrigation etc.) and adequately equipped and knowledgeable contractors to propagate (nursery contractor), plant (planting team) and maintain (maintenance team) the seedlings; adequately equipped and knowledgeable contractors to reprofile the wetlands; contractors for IAS clearing; minimum two supervisors to ensure proper work progress; contractors for monitoring; volunteers from the communities to engage in various levels of on-the-ground interventions.

Key actors and their responsibilities: CAMS of MEECC was responsible to contract contractors, initiate and maintain dialogue with key stakeholders (e.g. District Administrator, drainage task force, University of Seychelles (UniSey), other project team leaders). The Adaptation Fund EbA project was responsible for most of the wetland reprofiling and IAS removal in the marsh and riparian forests through contractors; the EbA South project was responsible for the IAS removal along the river banks and the swamp forest in addition to plant propagation and planting by contractors. UniSey was in charge of mangrove monitoring on a short and long-term basis. The plant propagation contractors produced the required seedlings in the plant nursery; the planting contractors and the local communities took part in the planting and plant maintenance (weeding).

Actions identified: The EbA options chosen were:

Rehabilitating mangrove, swamp and riparian zones through biological and mechanical interventions (6 ha).

Wetland reprofiling

i. Reprofile by widening the channels and putting the excavated sediments on the banks to form a gentle sloping bank.
ii. Mechanically remove the invasive creepers in the wetland using a small excavator and dispose of in the Providence dumping site.

In the riparian zone:

i. Remove IAS in the riparian zones by cutting and uprooting *Leucaena leucocephala* and young albizia *(Falcataria mollucana*) and ring barking adult albizia.

ii. Conduct follow-up monitoring to assess the success of IAS removal and the need for any follow-up treatment.
iii. If necessary, cover the riparian zone with dead palm leaves and/or geotextile materials to reduce IAS seed germination (if replanting is not immediately done).
iv. Replant riparian zones with 5,600 native plants adapted to riverine conditions such as endemic palms and freshwater ferns.

In the mangrove community:

v. Replant at least 1,650 mangroves in gaps where IAS have been removed.

In the swamp forest:

vi. Remove IAS trees.
vii. Replant the area with 1,450 coastal species adapted to swamp areas and/or areas that are periodically waterlogged such as silverglass tree.

In the freshwater marsh:

viii. Remove invasive alien creepers using an excavator and disposal of in the Providence dumping site.

Timing of activities: Timing and coordination between activities are very important for the smooth running of the intervention. The plant nursery was established first because of the time required for plants to grow in the nursery. For the plant propagation, the timing of fruiting and seeding had to be taken into account in order to obtain the seeds, fruits, propagules and seedlings at the right time. The next activity was the removal of IAS, followed by the reprofiling of the channels and the marsh. The sediment removed from the channel bed was dumped on the banks and used to gently slope the banks. Planting and maintenance were the last activities undertaken. Considering that different zones of the wetland area were being worked on simultaneously means that sometimes more than one of the EbA options were being carried out at the same time. This process required close and good coordination among various teams.

4. Implement EbA actions on-the-ground

Once the site-specific protocol is ready, then we can start the implementation. The protocol and the EbA process need to be flexible to adapt to any unforeseen eventualities on-the-ground. Adaptive management is one element of EbA implementation needed to increase the probability of success (See Box 6 - Case study 6). Another important but often overlooked element is the participatory approach in involving various stakeholders, students and other communities (e.g. volunteer engagement) in the implementation process. Volunteer engagement is also a process of awareness raising, youth education and acquisition of skills and knowledge in nature conservation and rehabilitation (See Part 3).

Box 6 – Case study 6: Adaptive management in the EbA implementation on Praslin

Several factors are responsible for the success and failure of mangrove rehabilitation. Although very often the failures are not mentioned or recorded in rehabilitation projects, they are important information which can guide any future projects because solutions are then sought to address the challenges. This also creates an understanding of the factors contributing to the lack of success. Observing success or failure of an intervention relies heavily on regular monitoring of the actions. The regular monitoring allows the observers to detect problems with the interventions and can act as an early warning system to much bigger challenges.


Photo credit: EbA South

The first plantation of mangroves at Kot D'Hauban (Anse Gouvernement) on Praslin was carried out under the EbA South project in May 2016. During the first planting sessions, 148 propagules of red and white mangroves were planted by schoolchildren. Monitoring of the plantation was done two days after planting by the Mangrove Restoration Specialist who noted that the seedlings were being destroyed mainly by the red crabs (*Neosarmatium meinerti*) and to a lesser extent by the mangrove crabs (*Cardisoma carnifex*). The stems of 4 newly planted seedlings were cut as well as the leaves of another 5 seedlings. This was the first recorded evidence of crab predation under the project. It was clear that adaptive management measures had to be immediately implemented to protect the seedlings. The 'crab proofing' method was then used to protect some seedlings from crab predation. Four techniques were used on an experimental basis: bamboo, PVC tube, wire mesh square cage, wire mesh cylinder cage.

Bamboo and 2-inch PVC pipes were cut by saw into 20-30 cm length. 40 x 40 x 40 cm wire mesh cages and 20 cm high wire mesh cylinders were prepared. Construction of wire mesh cages and cylinders was time consuming. The preparation of PVC tubes was the fastest. Preparation of bamboo was also time consuming particularly if the bamboo was freshly cut because its high-water content made it very hard to saw. Alternatively, a chainsaw could have been used but this would create a rough finishing to the edge which may harm the protected plant when used in crab proofing. The cost-effectiveness of the four techniques can be evaluated in future trials.

A crab proofing experiment was implemented on two plots on May 21, 2016. The materials used for crab proofing were enough for only 50 seedlings. 83 seedlings were used as control whereby no protection was offered (Table 3).

Table 3: Crab proofing seedlings at Kot D'Hauban, Praslin

Date	Location	Activity	Site	Zone	Plot	Species	Protection	No. protected
21.05.2016	Kot D'Hauban	Crab proofing	Site 3	Zone D	Plot 1	*Avicenia marina*	Bamboo	5
21.05.2016							Wire mesh Cylinder	5
21.05.2016							PVC	13
21.05.2016							Wire-mesh Cage	4
21.05.2016							None	43
21.05.2016	Kot D'Hauban	Crab proofing	Site 3	Zone D	Plot 2	*Avicenia marina*	Bamboo	6
21.05.2016							PVC	13
21.05.2016							Wire-mesh Cage	4
21.05.2016							None	55

Wire mesh cages offered the best protection whereby all seedlings (100%, Figure 2) enclosed within the cages were still alive when monitored in June. Bamboo, PVC and wire mesh cylinders were also good performers (80-100%) but it was possible that the edges of the latter three techniques might cut through the stems of the seedlings if they were not smooth enough. For the cases where the bamboo or PVC was taller than the seedlings, these tended to bake the plants. 40% of the plants that were unprotected on Plot 1 were still alive whilst only 2% of the unprotected plants on Plot 2 were alive. Some seedlings had been cut, others had their bark peeled off, the base of some propagules were almost entirely eaten, and some propagules were pulled out and dragged into crab burrows.

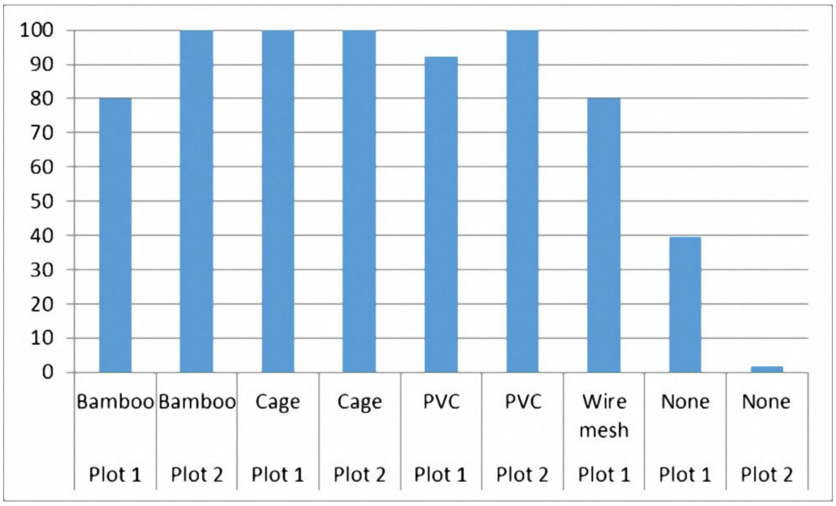


Figure 2: Monitoring results of crab proofing of mangrove seedlings, Kot D'Hauban, Praslin

The results indicated that all the four crab proofing techniques could be applied. However, other factors had to be considered to determine their feasibility, including cost, time of preparation, durability and their potential to be re-used. Bamboo is a natural material and hence ideal from an environmental perspective. Nonetheless, it is costly to prepare, and it does not last long in the field. PVC and wire mesh are durable but very costly. The preparation of wire mesh cages is also time consuming. It was cheaper to purchase and ship biodegradable plant wraps/tubes from England than to prepare an alternative locally. Whilst waiting for the plant wraps, PVC tubes were used as a temporary solution. Despite putting the measures in place, predation by crabs continued to be a problem. It was observed that during the rainy season, the level of water on the mudflat rose, covering the PVC tubes used to protect the plants and hence crabs managed to swim to the top of the tubes to eat the plants. Hence, the PVC tubes had to be replaced by the taller ones.

The PVC tubes were later replaced by the plant wraps which proved to be relatively effective although in some instances crabs burrowed under the tubes to eat the plants from below. The experiment indicated the high predation pressure by the crabs and that protective measures had to be put in place to protect future plantations. This case study showed that monitoring and constant applied management were needed to keep an acceptable level of plant survivorship.

5. Monitoring and evaluation for learning

Learning, monitoring and evaluation (M&E) should be at the centre of EbA project. Monitoring EbA actions provides vital information on the success or failure of the rehabilitation. Regular monitoring can indicate where the problems are and hence decisions can be made quickly to address these problems through adaptive management. Monitoring further provides data on how to improve the interventions. Therefore, it is important to have a document on long-term monitoring and research (LTMR) which includes various monitoring aspects in addition to the methodological approaches to be used. The LTMR should include both short and long-term indicators, identify key elements to monitor and evaluate EbA options.

The research and monitoring become more meaningful when research or educational institutions are involved. The proximity of the Anse Royale wetland to the University of Seychelles (UniSey) provides a good opportunity for UniSey students and lecturers to become engaged in the research and monitoring in the long term. Hence, involving scientific research in addition to regular monitoring is crucial for EbA and provides the opportunity for increasing the scientific evidence base for EbA.

Box 7 – Case study 7: Long-term monitoring and research by the University of Seychelles

The University of Seychelles is in close proximity to the Anse Royale wetland, where at least two EbA projects have been implemented. The rehabilitated wetland is valued as an outdoor classroom for applied research where students can implement various small projects to better apply the principles of their environmental courses. Under the EbA South project, the BSc Environmental Science programme incorporated EbA and mangrove rehabilitation into the degree courses. Various aspects of mangrove monitoring were also incorporated into the course 'Research skills and methods'. A LTMR plan was developed by UniSey for continuous monitoring of the Anse Royale rehabilitation site. The LTMR in addition to the above-mentioned courses provide the framework for supporting monitoring and research on mangrove and EbA in general, amongst the UniSey students and lecturers.

PART 3: EBA CASE STUDIES FROM THE SEYCHELLES

Two case studies from the Seychelles are presented to highlight the EbA process, share lessons learned and provide recommendations.

Case study 8: Baie Laraie mangrove (Curieuse Island) – increasing mangrove resilience

1. Understand the context

1.1. Environmental and social conditions

Baie Laraie mangrove (ca. 8 ha) was targeted under the EbA South project to increase its resilience to environmental and climate-related changes. The mangrove is highly diverse, comprising of 5 out of the 7 mangrove species found in the Seychelles: *Avicenia marina, Bruguiera gymnorhiza, Lumnitzera racemose, Rhizophora mucronate* and *Xylocarpus moluccensis*. The mangrove is protected under the National Parks and Nature Conservancy Act. Baie Laraie mangrove developed over a century behind the protection of a seawall across the bay. The seawall was built in 1909-1910 and was intended to create a pond for breeding hawksbill turtles but indirectly protected mangroves from sand encroachment .

Ecosystem present: The mangrove consists of a lagoon; tidal mangrove areas; backshore freshwater mangrove areas; sand banks colonised by coconut (*Cocos nucifera*), casuarina (*Casuarina equisetifolia*), silverglass (*Heritiera littoralis*), takamaka (*Calophyllum inophyllum*), bwadroz (*Thespesia populnea*) and Indian almond (*Terminalia catappa*) trees; freshwater marsh and wet fern and aquatic sedge dominated areas invaded by invasive plants; and small freshwater tributaries. The whole wetland is surrounded by a coastal forest where the invasive cocoplum (*Crysobalanus iccaco*) is common. A coral reef is also located beyond the lagoon.

Livelihood: The main livelihood is ecotourism.

Ecosystem goods and services supporting livelihoods: Livelihoods are supported by the following ecosystem goods and services: coral reefs support snorkelling; the lagoon and the tidal mangrove act as nursery grounds for fish and invertebrates that then populate the reefs that support ecotourism; the mangrove forest provides habitats for a variety of animal and plant species that supports nature walks; the freshwater tributaries provide freshwater for household use and irrigation for the nurseries.

Ecosystem goods and services that can reduce climate change impacts: The lagoon and mangrove can absorb and dissipate storm waters; the freshwater marsh and wet fern/sedge areas maintain the space for mangrove migration landward in the case of sea level rise in addition to reducing encroachment of the mangrove by IAS plants.

Data gaps: There was a lack of information on the factors leading to mangrove dieback (mainly *A. marina*), and on why previous rehabilitation initiatives (mainly mangrove propagation and planting) were not successful.

1.2. Climatic and non-climatic stressors

Climate related stressors: Potential sea level rise, storm surges and drought

Non-climatic stressors: IAS encroachment, erosion and sand accumulation in the tidal mangrove

Climatic and non-climatic impacts on ecosystems: In 2004, a tsunami from Sumatra almost destroyed the seawall resulting in a change in the dynamic of water circulation and sand movement patterns in the lagoon. The mangrove is not sheltered anymore. Exposure to larger waves, tidal surges and increased volume of seawater impacts the mangrove in several ways. Increased volumes of sand are deposited inland and cover the mangrove pneumatophores. The two main channels that inundate the mangrove are partially filled with excess sediments. The deposition of sand is also changing the substrate type in some areas from silty clay mud to sand. The impact is not uniform across the mangrove. Sand is deposited onto the north-eastern part of the mangrove which covers mangrove pneumatophores, thereby creating raised sand bank suitable for colonisation by grasses, casuarinas (*Casuarina equisetifolia*) and IAS. The middle seaward part of the mangrove faces erosion, resulting in root exposure, fallen trees and high mortality rate. The landward, freshwater part of the mangrove is being encroached by IAS whilst the central part is faced with mangrove dieback. Overall, the mangrove is receding landward and aging with little regeneration.

Vulnerable ecosystems: The mangrove forest, freshwater marsh and wet fern/sedge areas are vulnerable. Abundance and distribution of mangroves are expected to be affected. The freshwater marsh and wet fern/sedge areas are also expected to reduce in size due to IAS encroachment.

1.3. Stakeholders, communities and their roles and beneficiaries:

Stakeholders and communities: The main stakeholder was the Seychelles National Park Authority (SNPA) because the EbA interventions were implemented on Curieuse Island, which they manage and receive revenue from ecotourism. The tourism operators, boat operators, diving centres, fishermen are the communities benefiting from the presence of Curieuse Marine National Park. People mainly from Praslin as well as Mahé and La Digue also benefit from nature experiences.

Actors and their roles: SNPA's role was to facilitate the process by providing boat transportation and other facilities.

CAMS of MEECC was responsible for the overall coordination, management and facilitation of project activities. A National Mangrove Restoration Specialist was recruited to guide and supervise the on-the-ground interventions.

The Terrestrial Restoration Action Society of Seychelles is an environmental NGO based in Praslin reputed for mobilising volunteers in environmental activities. Its role was to recruit volunteers and to propagate mangroves and coastal native seedlings in its large nursery.

Contractors were selected to manage the IAS (felling and clearing), build a small nursery in the mangrove on Curieuse, propagate plants inside the nursery, build tortoise-proof barriers around the plantations, and plant.

Boat operators assisted with the transportation of large groups of volunteers to and from Curieuse Island.

Stakeholder engagement: SNPA was engaged early in the EbA South project and their roles defined. EbA options were also discussed and agreed with SNPA. These EbA options were eventually integrated into the Curieuse Management Plan. SNPA was periodically informed of the progress of the interventions. However, better engagement of SNPA in the direct implementation of on-the-ground intervention would have led to better results. The presence of SNPA staff who resides on Curieuse Island and their direct involvement in the project as part of their daily duties would have meant constant supervision and implementation of more and timely interventions. This would have reduced the costs of transporting other workers/teams from Praslin. Moreover, capacity building of SNPA staff in EbA implementation would have been a great achievement but was in that case a missed opportunity.

2. Identify and prioritise EbA options

EbA options

The EbA options were:

i. Re-enforcement of the stone wall
ii. Installation of bamboo fences in the tidal mangrove to reduce erosion from tidal waves, storm surges and effects of sea level rise
iii. Replanting mangroves
iv. Removal of IAS within the mangroves and from the periphery of the wetland (freshwater marsh and wet fern/sedge areas)
v. Channel profiling to improve hydrological flow
vi. Revegetation of IAS cleared areas

Table 4: Prioritisation of EbA options

EbA options	Criteria					Score (1 to 5 from low to high score)
	Use biodiversity and ecosystem services to enhance ecosystem functioning	Build resilience of ecosystems to climate change	Use biodiversity and ecosystem services to build people's livelihoods	Flexibility of the EbA option that can easily be adapted in adaptive management approaches	Inclusive of vulnerable groups, communities and all relevant actors/ stakeholders	
Re-enforcement of the stone wall	1	1	1	1	1	5
Installation of bamboo fences in the tidal mangrove	3	3	2	3	2	13

Replanting mangroves	5	5	5	5	4	24
Removal of IAS	5	5	5	5	3	23
Channel profiling	2	3	2	2	2	11
Revegetation of IAS cleared areas	5	5	5	5	4	24

EbA options chosen:

Three EbA options were chosen based on the prioritisation process:

i. Removal of IAS
ii. Revegetation of IAS cleared areas
iii. Replanting mangroves

Goal of interventions: Wetland rehabilitation to improve mangrove resilience from drought, potential sea level rise and IAS encroachment.

Feasibility of EbA options:

Several criteria were used to assess the feasibility of EbA options. Each criterion was rated from 1 (low feasibility) to 5 (high feasibility). The EbA option with the highest score was the more feasible option.

Table 5. Feasibility of EbA options

EbA options	Feasibility criteria							Total score
	Affordability	Technical feasibility	Negative Environmental impact	Number of beneficiaries	Maintenance cost	Flexibility	Ease of monitoring	
Removal of IAS	3	4	4	5	3	4	5	28
Revegetation of IAS cleared areas	5	5	5	5	4	5	5	34
Replanting mangroves	5	5	5	5	5	5	5	35

All the three EbA options were considered “highly feasible” and hence chosen for implementation.

3. EbA actions

Each EbA option had to be further detailed and activities determined.

Rehabilitating mangrove and freshwater plant species through biological strategic interventions on 3 to 4 ha consisted of removal of IAS encroaching the freshwater part of mangrove; selective removal of dense monospecific patches of coconut and casuarina trees within the mangrove; and replanting appropriate species. The specific actions were:

i. Build a nursery on the landward side of the mangrove to supply mangroves for Curieuse
ii. In Zone A, remove the IAS cocoplum (*Chrysobalanus icaco*) along the NW-NE landward side of the mangrove (1 ha), and replant with 3,300 freshwater plant species, and mangrove species like *B. gymnorhiza* and *X. moluccensis*
iii. Remove dense coconut patches from Zone B (0.7 ha) and replant with 1,000 mangrove

and coastal plant species

iv. In Zone C, remove dense coconut and cocoplum patches and replant with 2,300 mangrove and coastal plant species

v. Construct seven tortoise-proof barrages around the plantations to protect plants from being eaten by tortoises

vi. Put wraps or tubes around each plant to protect from crab predation

vii. Consider experimental replanting of *R. mucronata* in Zone D (0.12 ha) along the damaged stone wall/causeway in a trial to investigate if the mangrove can act as a protection barrier

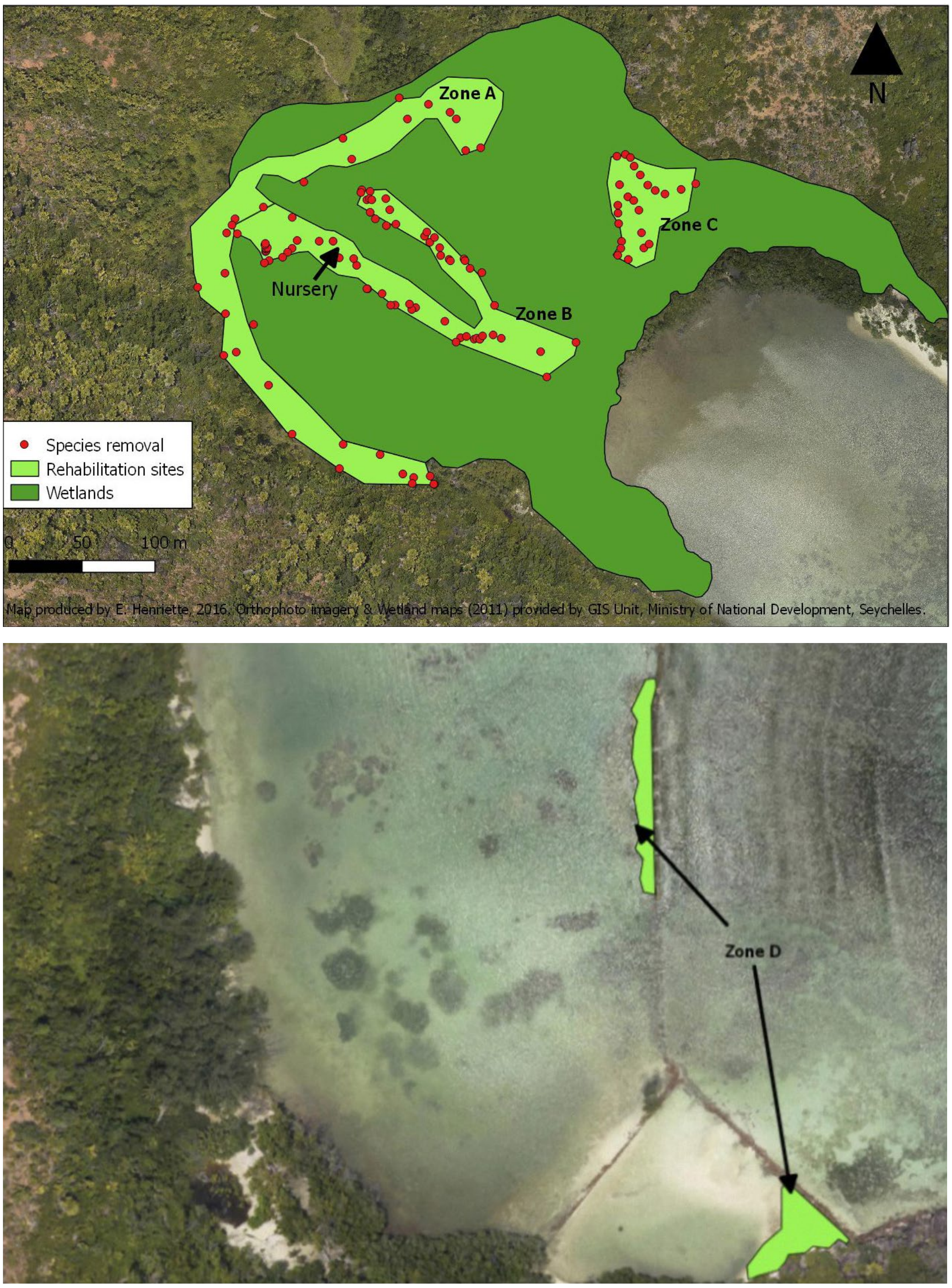


Figure 3: EbA intervention sites on Curieuse Island

4. Implementation

The EbA options were implemented accordingly but several challenges arose which required an adaptive management approach.

Outputs achieved

- Construction and maintenance of a 100 m^2 native plant nursery in the mangrove area
- Production and planting of 7,000 mangrove and native coastal plants
- Construction of seven barrages to protect part of the plantations from grazers
- Protection of seedlings using wraps against crab predation
- Delivery of 10 awareness and training activities on Curieuse
- Training and building the capacity of over 150 persons during planting on Curieuse

The expected outcome over time is improved resilience of wetland to climate change and climate-related vulnerability including sea level rise, coastal erosion, flooding and storm surges, and from the spread of invasive plant species. This will in turn benefit communities through ecotourism activities which heavily depend on the ecosystems under rehabilitation.

Limitations:

The nursery was successfully built but the large mangrove crabs managed to dig burrows under the nursery foundation to gain access. They then climbed onto the tables or on the nursery walls and ate the seedlings. One management option was to use steel tables whereby the legs are smooth and slippery preventing the crabs from climbing up. Another option was to put 5 litre plastic bottles around the legs of the tables to prevent crabs from climbing.

Crabs were responsible for eating some of the seedlings. Photosynthetic wraps (tubes) were purchased from England and put around the seedlings to crab-proof the plants. Not all seedlings could be protected due to the high numbers of seedlings being planted (i.e. not enough wraps). In some cases, however, crabs dug under the wraps into the root zone of the plant and ate the seedlings from beneath.

Giant land tortoises were another challenge because they ripped havoc in the plantations by eating and crushing the seedlings. There were major losses (few thousand plants). Seven tortoise-proof enclosures were built to prevent the tortoises from eating the seedlings. It was not possible to construct more enclosures to protect remaining plantations due to the cost, physical constraints (workforce, soft muddy conditions) and time constraints. Some of the seedlings were planted outside of the enclosures and hence would be exposed to grazing. The option of translocating few tortoises to another part of the island was proposed but SNPA did not provide any response to that matter.

Another limitation was the access to the island by boat. The SNPA boat was not always available at the required time and this severely affected the planting operations by teams coming from Praslin. Other boat operators had to be used to access the island.

Opportunities:

Considering the use of crab-proof and tortoise-proof measures, there was a good opportunity to monitor the survival of mangroves particularly in areas where previous rehabilitation attempts failed. This could help to establish if crabs and tortoises were the main responsible factors of the failed past interventions.

There was also an interesting opportunity to observe the ability of the planted seedlings in reducing and halting the spread and encroachment of IAS onto the mangrove. The enhancement of the wetland vegetation with more broad-leaved species would be beneficial to native wildlife and it might become a habitat used by the newly translocated endemic, endangered Seychelles paradise flycatcher.

Removal of IAS in the mangrove could be replicated in other parts of the mangrove ecosystem.

Recommendations:

SNPA to continue maintaining the sites and the nursery, control IAS, propagate other seedlings for replacement planting (to replace dead ones or those eaten by crabs and tortoises) and monitor the EbA intervention as part of their management plan.


Photo credit: EbA South


Photo credit: EbA South

Case study 9: Volunteer engagement in mangrove rehabilitation: a Seychelles' NGO contribution to community-based mangrove planting

The case study showcases the importance of engaging local actors and communities in mangrove rehabilitation activities. It illustrates three components of the EbA process as outlined in Part 2: Identify relevant stakeholders and communities; Develop EbA strategies and design actions, and; Implementation.

Identify relevant stakeholders, actors and communities

The Terrestrial Restoration Action Society of Seychelles (TRASS) is an environmental NGO committed to the restoration of degraded terrestrial sites of the islands of Seychelles. Its aim is to mobilise actions from interested parties for restoration, enhancement, maintenance, and safeguarding of degraded ecosystems. Its objectives are to 'Educate and raise awareness of private landowners and other local communities on forest conservation and rehabilitation'; and 'Rehabilitate degraded forest lands and engage communities in the implementation of appropriate replanting techniques'. Under the EbA South project, TRASS was identified as an important actor for the implementation of EbA options on Praslin and Curieuse on the basis of its extensive expertise in rehabilitation of degraded ecosystems, plant propagation and replanting techniques and its reputable skills in engaging a large number of volunteers in environmental activities.

TRASS objectives in the implementation of the mangrove rehabilitation were to:

- enhance awareness of the value of mangroves;
- demonstrate approaches to successful mangrove rehabilitation;
- build capacity of local NGOs and communities in mangrove propagation and planting techniques.

Develop EbA strategies and design actions

The EbA options were: the propagation of ca. 30,000 mangrove and non-mangrove native coastal seedlings; and the planting and maintenance of 30,000 seedlings on the sites identified by the EbA South project.

The specific activities for each option were:

1. Propagation of ca. 30,000 mangrove and non-mangrove native coastal seedlings
   - i. Creation of a mangrove area within the existing plant nursery
   - ii. Collection and preparation of soil medium for planting in nursery
   - iii. Filling of 30,000 polybags with soil medium
   - iv. Collection of over 30,000 plant materials for propagation
   - v. Potting of over 30,000 propagules, seeds, cuttings and seedlings
   - vi. Watering, weeding and replacement of dead seedlings in nursery
   - vii. Transportation of seedlings to the hardening area outside of the nursery for acclimatisation prior to planting
2. Planting and maintenance of 30,000 seedlings
   - i. Transportation of 30,000 seedlings to planting sites
   - ii. Planting of 30,000 seedlings
   - iii. Weeding of seedlings planted at project sites

Implementation

How does TRASS mobilise volunteers?

TRASS relies heavily on its volunteers to implement its activities. Volunteers come from various organisations like government agencies, non-governmental organisations, educational institutions, farmers association, environmental clubs (e.g. the Wildlife Clubs of Seychelles), the private sector (hotels, restaurants, tour guides), banks, as well as faith groups (e.g. the Anglican church, disabled children), and several others .

TRASS uses its Facebook page, WhatsApp and text messages to recruit volunteers for its rehabilitation activities. Social media is a useful tool to recruit volunteers and it normally gets very good responses. Word of mouth is another effective means.

Outputs:

- Two mangrove sections were built inside the main plant nursery. Blocks were used to build the structure which consisted of laying one row of blocks to form a rectangle of 8 m^2. Black plastic sheets were laid onto the floor of the structure to make it impermeable. The overhanging sides of the plastic were tucked under the row of blocks. Several truckloads of mud were collected from the Cap Samy site where the wetland was being re-profiled as part of the EbA South project. The mud was placed in the constructed mangrove area and irrigated with water to keep it waterlogged.
- Several thousand of mangrove propagules were collected mainly on Curieuse but also on Praslin. These were planted into the constructed mangrove area in the plant nursery and cared for until they were ready for out-planting at project sites.
- For the propagation of non-mangrove coastal plants, several procedures had to be taken. At least three tons of humus was collected in gunny bags from the forest floor. This was a very tedious activity since good humus is found in valley bottoms with steep slopes. The

humus was transported to the nursery and then sieved to remove debris, leaving only fine substrate. Three tons of red earth was also collected. The humus and red earth were then mixed together and used to fill polybags which were then ready to receive the plant material for propagation.

- Several thousand seeds, cuttings and seedlings of non-mangrove plants were collected and planted into the previously prepared polybags and maintained until ready. Maintenance included watering, weeding, replacing plants and treating diseased plants.
- Five species of mangroves were used in the rehabilitation: white mangrove (*Avicenia marina*), red mangrove (*Rhizophora mucronata*), black mangrove (*Bruguiera gymnorhiza*), yellow mangrove (*Ceriops tagal*) and puzzlenut mangrove (*Xylocarpus moluccensis*). Yellow mangrove was prior to the EbA South project absent on Praslin, but these were introduced from Mahé in 2016 at Kot D'Hauban (Anse Government) and in 2018 at Cote D'Or where they grew well.
- 30,000 seedlings were planted using mainly volunteers at 6 sites on Praslin and 1 site on Curieuse over 10 ha. A core planting team comprising 6 persons was responsible for technical aspects, training and coordinating the planting sessions.
- The plant propagation and planting activities provided team building and capacity development opportunities for local groups. The project's Mangrove Restoration Specialist provided training and guidance to the core team who further trained and guided volunteer groups (Train-the-Trainer).
- Training of the core team on nursery establishment, management, plant identification, propagation and planting techniques.
- Delivery of over 30 awareness programmes for schoolchildren and community members.
- Implementation of a community-based mangrove replanting campaign of over 20 planting activities in 2018.
- The targeted communities developed an interest and determination in protecting the mangrove ecosystem.

Community participation in mangrove rehabilitation spearheaded by TRASS

Activities disseminated on the social media

Volunteers assisting with nursery work

Yellow mangrove in the constructed mangrove area

Several thousands of native coastal seedlings being propagated in TRASS nursery

Using wraps around seedlings to protect against crab predation. Crabs ate newly planted seedlings and were responsible for a high mortality rate. Adaptive measures were put in place to protect the plants.

One of the trained trainers showing residents ways to plant mangroves

Schoolchildren and teachers actively contributing to mangrove rehabilitation

Before planting

8 months later

GENERAL CONCLUSIONS, LESSONS LEARNED AND RECOMMENDATIONS

Limitations

- Lack of understanding of implementing entity on EbA planning, designing and implementation
- Unclear or unsupported justification for choice of some of the intervention sites
- Project covering too many intervention sites, each with its own complexity
- Feasibility of some EbA options not adequately assessed
- Stakeholders and concerned communities not engaged early enough in the project
- Greater engagement of communities and private sector would have been more beneficial to the project
- Lack of coordination between different parties and different activities
- Insufficient personnel to supervise on-the-ground interventions
- Difficulty to get committed contractors or to get them to work within a defined timeline
- Lack of capacity to collect good data at the nursery level including appropriate labelling, e.g. date of potting, date and number of plants that died, date of planting. A lot of important information for every step of plant propagation was lost due to inconsistent data collection.
- Poor weather, including drought, led to a high seedling mortality rate. Besides, cattle, tortoises, crabs destroyed several seedlings. Even though they were protected with wraps, crabs dug under the wraps to eat the seedlings.
- Plant maintenance/motivated contractors to tend the planting until it was properly established.

Recommendations

- A well-informed and knowledgeable team on EbA should be put together for project management and implementation.
- Clearly defined and justifiable objectives should be in place from the onset of the project.
- Proper EbA procedures should be followed for successful project implementation (see Part 2).
- Efforts should be made to engage communities, government and private sectors from the beginning and throughout the project.
- EbA options should as much as possible have a livelihood element to capture the interest of communities to participate so that they understand that EbA projects benefit them directly.
- Long-term monitoring and research programme with the University of Seychelles (UniSey) need to continue through student involvement.
- Sustainability of the project (beyond project funding) can be ensured by delegating responsibilities or handing over the activities to the UniSey and an interested NGO (or other entity) with the capacity to manage and implement EbA initiatives. The UniSey-

NGO joint venture should be supported by a committee, which comprises various stakeholders from the districts, local government, tourism, agriculture, fisheries, environment, private sector and business community. The UniSey-NGO entity can seek funding to pursue some of the activities and generate funds from other ventures such as selling of plants from the nursery, guided visits of restored wetlands. The activities started by the project need to be integrated into a larger conservation-rehabilitation programme, helping to support the planning, implementation and monitoring that will ensure long-term sustainability.

- A team should be established to tend the replanted plot under the support and guidance of the Mangrove Restoration Specialist or a local NGO.
- A budgeted component of any project should go to training interested people in rehabilitation techniques. These people can then be employed by the project to implement project activities.
- Future projects should aim to build more knowledge and experience on mangrove rehabilitation from propagation, planting, other EbA options and to that end should promote dialogues between practitioners and scientists.
- Future projects also need to strengthen the understanding of core concepts, provide an analysis of current and prevailing knowledge gaps and research needs for EbA, with an insight into where potential research should be focused for future knowledge generation.

Lessons learned

- Regular monitoring is a key aspect in determining the success of EbA interventions. This aspect is, however, sometimes neglected in projects. Monitoring allows the project team to identify problems with the interventions and to swiftly rectify the issue.
- Adaptive management is a vital feature of any EbA interventions. Unforeseen events may occur anytime, requiring adjustments. Inflexibility in the administrative systems sometimes hinders prompt adaptive management.
- Mangroves can be propagated outside of wetlands. Our experience of propagating mangroves in a nursery on firm ground and irrigating with freshwater was successful. On Praslin, mangroves were propagated in the nursery uphill in the forest.
- Different species of mangroves require different timescales during propagation with some needing to stay longer period in nursery.
- Simple data collection protocols should be in place at the nursery level to collect important information on seedling growth and survival, pest and disease, management etc. A dedicated person needs to be trained to undertake data collection and management.
- Good quality propagules and seedlings are required to ensure the desirable results.
- The timing of seed availability should be considered when planning project activities.
- For the best results, planting distance should be respected. Mangroves should be planted at a spacing of one metre but species like white mangrove, black mangrove and yellow mangrove can be planted at 50 cm apart.
- Planting mangroves at high densities, e.g. 50 cm apart or less, helps to protect them from crab predation. Crabs will eat the ones on the outskirt leaving the central ones protected.
- The time allocated by the project for replanting was inadequate for monitoring of results.
- On Curieuse, protective measures against giant tortoises need to be put in place prior

to planting activities. This can be in the form of large structural barrages strong enough to withstand the strength of the tortoises and which can hold several hundred plants, or smaller barriers around each plant (more time and materials required), or long trenches of 70 cm deep and 1 m wide around the planting site which will direct tortoises away from the site. For the last option, tortoises trying to access the planting site will fall into the trenches. In attempting to get out, they will walk along the trench which should direct them out of the planting site. This was a method used in the old days on Curieuse.

- Efforts to raise awareness among communities and improve stakeholder participation are needed throughout the project cycle. Constant awareness raising efforts are needed to instil local appreciation of the importance of mangroves.
- Project designers also need to plan from the outset to convince the community that they are the owners of the project and the benefit will be theirs.
- Projects of this nature, i.e. ecosystem rehabilitation, should last for minimum 4 years in order to bring about appreciable results. Project duration should consider time needed to propagate plants, planting and monitoring of rehabilitation interventions thereafter, unforeseen events such as vandalism, predation, drought, which can have an impact on tree growth and undermine replanting efforts. It is important to leave flexibility into the project schedule from the outset.

Overall project accomplishment

The EbA South project was a good initiative to introduce people to ecosystem-based approaches to climate change adaptation. Ones of the first activities were community awareness raising and training workshops, which were well attended and received positive feedback particularly in bringing to light the issues of climate change and nature-based solutions to address the situation.

The project selected appropriate species and sites for replanting after assessing the existing natural vegetation in the area. It established two mangrove nurseries on Anse Royale and Curieuse and provided seeds and other necessary materials and equipment for plant propagation. The mangrove planting was carried out with 6 species of true mangrove *Avicennia marina, Bruguiera gymnorhiza, Ceriops tagal, Lumnitzera racemose, Rhizophora mucronata* and *Xylocarpus granatum* and one mangrove associate *Xylocarpus moluccensis*. Several non-mangrove native species were also propagated. Over 50,000 seedlings were propagated and planted on 20 ha of wetlands. Near the end of the on-the-ground interventions (December 2018), overall survival rate was around 65% (higher that the project target of 40%).

Community members took part in the replanting campaign and helped to put protective wraps around the seedlings to protect from grazing animals. Members especially from Praslin who took part in project activities acquired a high level of competence in mangrove nursery plant propagation and planting.

The project conducted awareness and training programmes for schoolchildren and members of various communities on the importance of mangroves, mangrove flora and fauna, ways to grow mangroves and non-mangrove plants, and planting techniques. Over 500 individuals participated in these activities and their engagement in the project motivated beneficiaries to protect the replanted areas. Moreover, their newly acquired knowledge and skills will be certainly useful for future sustainability.

The establishment of a long-term monitoring and research site at Anse Royale and the presence of the University of Seychelles in the vicinity of the project site provide the practicability for long-term monitoring and research on mangroves and the rehabilitated sites.

Opportunities and the way forward

Community-based ecotourism can be financially viable, providing valuable extra income for local community members. Such alternative livelihood options should be further explored. Several project sites, e.g. Anse Royale and Kot D'Hauban, can be turned into an attraction for both residents and tourists, as well as an outdoor classroom to support educational activities. Tourists have been observed visiting the Anse Royale site particularly for its wildlife and hence there are opportunities to develop this aspect further, e.g. building bird hides for birdwatching, constructing an observation platform and boardwalks through the mangroves. The Anse Royale site can serve as a good case study for a ridge to reef or an integrated coastal zone management initiative considering the different ecosystems that are being rehabilitated and the engagement of multiple stakeholders.

Capacities of various individuals and organisations have been built through the EbA South project. The continued engagement of these participants and organisations in future EbA activities should be sustained, e.g. on the maintenance and management of the rehabilitated sites.

The implementation of most EbA-related initiatives in the Seychelles has involved the participation of NGOs and community-based groups. This is indeed a good participatory approach as EbA should form an integral part of life at the community level which helps support peoples' livelihoods and their adaptation to the impacts of climate change. Continuous and coordinated awareness and capacity building are required and should be well integrated into project design.

It is important that lessons learned are appropriately captured, documented and disseminated locally and internationally. It is through these learning opportunities that EbA projects can be continually strengthened and their overall environmental, social and economic benefits better understood, and valorised.

Finally, the essence of EbA interventions as a tool to climate change adaptation should be about empowering the community with the necessary skills and knowledge to effectively function and adapt to any eventuality be it environmental or development challenges.

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