



mangrove restoration guide



BEST PRACTICES AND LESSONS LEARNED
from a Community-based Conservation Project



The best time to plant a tree was 20 years ago.
The next best time is today.

Chinese Proverb

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Foreword



Udo Gattenlöhner

A few weeks after the Tsunami in December 2004, I travelled from Colombo, the capital of Sri Lanka, to the southern end of the island. The pictures of the massive destruction caused by the tidal wave stuck in my memories. Railway tracks bent like matchsticks and completely wrecked buildings demonstrated the destructive power of the billow. What impressed me on this trip was the outstanding protection a healthy mangrove forest offers to coastal areas. The massive wave lost nearly all of its deadly strength behind just a small stretch of mangrove forest – decelerated and tamed by the compact roots and branches of the mangrove trees.

In a dramatic way the Tsunami demonstrated the importance of mangroves for the protection of people's lives. However, beside the protection against tidal waves, intact mangrove forests provide many other valuable functions for climate change mitigation, fisheries and species protection – a long list. This unique habitat, consisting of many meters deep brackish ground, can sequester more CO₂ and methane than any other forest. Therefore they play a significant role in fighting climate change. Nevertheless, these essential ecosystems still get destroyed at an alarming rate. Transformation into commercial shrimp farms and other aquaculture

enterprises are some of the main reasons for the massive destruction of mangrove forests. Yet the rapid decline of mangroves gets hardly any recognition.

Our strong hope is that the various Mangrove Projects all over the world will change the attitude towards the global protection of this fascinating and important habitat. Our project partner organisations in India, Sri Lanka, Thailand and Cambodia have all been implementing various measures in the framework of our mangrove project with incredible engagement, based on years of experience. What convinced me most on my visit, was the strong involvement and commitment of the local people – this surely gives hope for the protection of these unique and precious forests.



Udo Gattenlöhner
Executive Director

introduction

INTRODUCTION



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angroves are exceptional ecosystems. Up to 50 meters tall, they stand along tropical and subtropical sheltered coastlines and form forests that are not only home to unique biodiversity, but also provide a number of ecosystem services that are priceless for humans.

Among others, they provide the basis for many coastal fisheries, work as natural shields against storms and Tsunamis and form major carbon sinks. Together with coral reefs and tropical forests, mangroves are among the most productive and at the same time most threatened ecosystems on earth. With them, countless animal and plant species that breed and live in these niche-rich ecosystems are disappearing.

In spite of all the benefits derived from mangroves' existence, human activities are threatening these unique ecosystems. Coastal urbanization, agriculture, aquaculture, logging and other destructive causes made mangrove forests shrink by at least 25% from their original worldwide cover (UNEP, 2014), with some experts giving even higher numbers, estimating the actual loss with up to 50%.

The long-standing partnership of Global Nature Fund (GNF) with organizations such as the Nagenahiru Foundation and the EMACE Foundation in Sri Lanka, the Center for Research on New International Economic Order (CRenIEO) in India, the Fisheries Action Coalition Team (FACT) in Cambodia and the Mangrove Action Project (MAP) in Thailand, aims to put an end to the destruction of valuable mangrove forests in the four countries mentioned. In the framework of a project called "Mangrove reforestation in Asia – local action and cross-border transfer of knowledge for the conservation of climate, forests and biodiversity" the project team restored over 100 hectares of damaged or destroyed mangrove forests – an irreplaceable ecosystem for unique biodiversity, important carbon sink, and essential livelihood support for the local communities. An important pillar of the initiative and a pre-condition for the long-term success of the activities has been the involvement of the local communities through environmental education, alternative income generation and the introduction of sustainable resource practices.

These goals have been achieved only through the indispensable financial support from the German Federal Ministry for Economic Cooperation and Development (BMZ).

Mangrove Forests

Standing on a tangle of slender roots, mangroves form characteristic forests that are found along the coastlines of the tropics and subtropics (approximately between 30° N

and 30° S latitude) in the Americas, Africa, Asia and Oceania. They grow along seashores and riverbanks, in shallow-water lagoons and in estuaries and deltas. If environmental conditions are suitable, mangroves can be extensive forests that grow up to 50 metres in height, extend from 30 to 85 km inland and stretch over 150 km along the coastline. In this context, the term "mangrove" describes both the ecosystem (that is to say the forest) and the plants – trees, shrubs and palms – that compose the forests.

It is estimated that mangroves cover an area of about 152,000 km² worldwide. Hence, they only account for less than 0.4% of the world's forests and less than 1% of the area of tropical rainforests (FAO, 2007). Despite being a relatively minor forest cover, mangroves are incredibly important ecosystems for biodiversity and people. Half of the global mangrove area is located in just six countries – Indonesia (approximately 30,000 km² – so alone, 20% of the total world area!), Australia, Brazil, Mexico, Nigeria and Malaysia. At the continent level, Asia is by far the winner, housing around 40% of the world's mangrove area, the highest mangrove species diversity as well as some of the world's largest mangrove forests. The Sundarbans between Bangladesh and India, for example, is the largest continuous mangrove forest in the world and covers approximately 10,000 km². It is a UNESCO World Heritage site and home to the majestic but highly endangered Bengal Tiger (*Panthera tigris tigris*).

Mangroves grow in sheltered, shallow waters where land and sea meet, in an area affected by tides (the tidal zone). Tidal zones are special habitats that are inhospitable for most plants and animals, due to their unique combination of environmental characteristics that are highly stressful for plants. For instance, although plants typically breathe through their leaves, their roots also require oxygen for respiration. In muddy or waterlogged soils, the roots suffocate due to a lack of oxygen. Extreme tides and waves also create physical pressures on the trees and shrubs, uprooting them if they are not solidly anchored in the soil.

In addition, water in tidal habitats is salty because of the presence of seawater, even in estuaries where it mixes with freshwater, known as brackish water. Thus, salt poses a major challenge for the survival of plants since it creates a pressure on plant tissues that causes them to dehydrate (osmotic pressure). Considering that the salinity of mangrove water fluctuates depending on the tide and can be twice that of the sea when water evaporates at low tide, the plants constantly use energy to deal with salt.

Mangroves and Biodiversity

With only 50 to 70 known mangrove species worldwide, belonging to different plant families (including *Rhizophoraceae* and *Avicenniaceae*), mangrove forests have a comparatively low tree species diversity compared to other tropical ecosystems. Despite this, mangroves are exceptional habitats at the interface between land and water and have unique characteristics and functions

Mangroves are the only woody plants that can grow in the brackish water of their tidal habitats, because they have developed remarkable and highly specialized adaptations that allow them to survive these hostile conditions:

COPING WITH SALINITY Mangroves have several unique adaptations that allow them to cope with excess salt, such as shedding leaves and bark. Thanks to these adaptations, they can live in hypersaline water and tolerate up to 100 times more salt than most other plants. While some species remove excess salt through the roots or the leaves via excretion or transpiration, others accumulate the salt in their leaves and then shed them when they are full.

ROOT ADAPTATIONS Aerial roots are a characteristic feature of mangroves. This trait serves two purposes at the same time: Firstly, they work as aerating devices, allowing the plants to escape the anaerobic conditions of waterlogged soil: at low tide their lenticels (the bark pores that enable plant respiration) can breathe directly in the atmosphere while they close when they are covered by water during high tide. Second, the various shapes of roots found among different species of mangroves can absorb the impacts of waves or the pressures of extreme tides by providing solid anchorage in soft, muddy soil for even tall, massive mangrove trees.

SEED GERMINATION Mangroves' offspring is dispersed by water in all species. In most mangrove species, it is neither a seed nor a fruit that leaves the parent tree but an already germinated young plant – a seedling. After pollination, the embryo grows on the parent tree into a more or less fully developed seedling for a period that often stretches over several months. This rare phenomenon in terrestrial plants is known as vivipary. Once seedlings fall off the parent trees, they float for some time – several days, weeks or even months – and then root in the mud or on the ground after sinking. Vivipary is thought to be an adaptation that primarily enables mangroves to disperse offspring that can take root and establish relatively quickly, thus avoiding being dislodged by tidal water movements.



Together with coral reefs and tropical forests, mangroves are among the most productive and at the same time most threatened ecosystems on earth.

making them highly attractive for other plant and animal species. Therefore, mangroves are home to a unique variety of species.

Mangroves support a wide range of organisms by providing habitats, breeding grounds, nurseries and food for a large variety of animals. Their roots, trunks and canopies are inhabited by numerous marine and terrestrial species of other plants, animals and microorganisms. The widely ramified mangrove roots provide perfect anchorage for sponges, algae and mussels, while prawns, crabs and fish use the open area between the roots for shelter, spawning, and food source. They also protect soils from erosion and thus stabilize a habitat that is exposed to continuous tidal

movements. Above water, reptiles, amphibians, birds and insects use the trunk and canopy's wide network of branches. Many mammal species, like monkeys and the famous Bengal Tiger, use the dense forest system as shelter and food source. With the ongoing loss of the mangrove ecosystems, many associated animal and plant species will inevitably lose their habitats and vanish. In this connection, UNEP states in a 2014 publication that "40% of the animal species dependent on these ecosystems are now considered vulnerable and/or at risk of extinction."

While many species spend their whole life in the mangroves, there are also a lot of animals that only use the sheltered environment for a stop-over or during a specific

A huge variety of species, such as the majestic Bengal Tiger, lives in and from mangrove forests.



period of their life cycle. Many fish species, for example, grow up under the cover of the mangrove trees but migrate to the open sea as adults. Therefore, mangroves play an important role as nursery habitats for many commercially important species, such as shrimp and multiple fish species. The many species that live associated with mangroves form complex forest ecosystems that play multiple ecological functions which are not only important locally but also for neighbouring ecosystems. Mangroves are highly productive forests that enrich the water with nutrients coming from the organic material they produce, such as leaves, barks and flowers, as well as from the sediment that accumulates around their densely ramified roots. Thanks to the constant tide movements within the ecosystem, this nutrient-rich water and material is also being transported to the open sea and further inland (UNEP, 2006)

Mangroves and People

Around 90% of the worldwide mangrove forests grow in developing countries. More than 100 million people live within 10 km of large mangroves forests and directly benefit from the ecosystems (UNEP, 2014). Thus, mangroves are not only home to a wide variety of animals and plants, they also provide numerous benefits essential to local communities. These benefits are called ecosystem services and they include protection from floods, cyclones and typhoons; reduction of salt water intrusion to agricultural lands and freshwater ground supplies; slowing soil erosion; recycling nutrients; filtering pollutants; regulating water flows and supplies; maintaining biodiversity; and, contributing to carbon sequestration.

Primarily, the ecosystems provide clean air and water. Mangrove forests can sequester far more carbon per hectare than tropical rainforests or marshes. The UNEP ranks them as one of the most carbon-rich ecosystems on earth, due to their ability to store huge amounts of carbon (about 1,000 tons per hectare!) over thousands of years (UNEP, 2014). What makes mangroves a unique carbon storehouse is their ability to lock carbon up in the anaerobic soils. Besides being considered major carbon sinks, mangroves also keep water systems clean and healthy by soaking up heavy metals and pollutants.

Another important aspect is the forests' possible lifesaving role as shields against storm surges, tsunamis and tropical cyclones, as well as their reduction of soil erosion in coastal areas. Some experts assume that a healthy 100 m wide mangrove forest can already buffer the power of smaller waves caused by hurricanes up to almost 70% (UNEP,

2014). The real value depends on many factors, however, such as mangrove age, density, root structure and even species. There are various reports from villagers in India and the Philippines, on how mangroves reduced disaster risk and protected them from cyclones and typhoons.

For local livelihood support, mangroves are equally important as breeding and nursery areas for fish, crabs and shrimp, which form the basis of major fisheries. The market value of seafood obtained from mangroves has been estimated to range between US\$7,500 and US\$167,500/km²/year by the Millennium Ecosystem Assessment of 2005 (cited in UNEP, 2006). The continuous destruction of mangrove forests thus very often also impacts local fish catch. According to a report by the Food and Agriculture Organization of the United Nations (FAO) of 2007, each year coastal fisheries lose about 480 kg in annual production for every hectare of forest that is being destroyed. By maintaining a rich biodiversity, healthy mangrove forests preserve fish stock in the long term and hence ensure a source of income and food security for local people.

According to the UNEP, about 40% of the animal species that are dependent on the mangrove ecosystem are considered vulnerable or at risk of extinction.

Moreover, the local population can profit from the commercial use of products that can be derived from mangrove trees as well as through eco-tourism. Products include timber for construction, dye for clothing and coating for tools from the mangroves' tannins, food for livestock, charcoal and firewood. The robust wood from mangroves, which is resistant to rotting and the burrowing of many marine invertebrates, makes this timber a valuable high-quality building material (UNEP, 2006).

In summation, mangroves support the conservation of biodiversity and, in many ways, they provide invaluable benefits that are precious for human well-being. UNEP estimates that, with the current rate of loss, people may lose the various values from mangroves' ecosystem services within the next 100 years (UNEP, 2014). Thus, it is of major importance to conserve these irreplaceable ecosystems in order to avoid the adverse consequences that their degradation causes.



Mangroves play an important role for local livelihoods, for instance as habitat for edible fish species and for disaster risk reduction.

Threats to Mangroves

Despite their priceless value, mangroves have undergone an alarming decline on all four continents where they are found. This rapid degradation and loss is expected to continue if current trends are not changed. On average, mangrove forests vanish three to five times faster than other forests (UNEP, 2014). This makes mangroves one of the fastest declining ecosystems in the world, and much of what remains is in a degraded condition. In fact, mangroves have been disappearing faster than coral reefs and terrestrial tropical forests but have gained less public or political attention (Valiela et al, 2001).

The continuous degradation of mangroves has caused their ecosystems to shrink by more than 20%, equaling 3.6 million

hectares worldwide since 1980, with Asia and North and Central America having been hardest hit (UNEP, 2014). The major destruction has occurred in spite of the mangroves' important functions, mainly as a result of human-created unsustainable practices. UNEP estimates that by 2050 South-East Asia, which is home to about 40% of the global mangrove area, will have potentially lost 35% of its forest cover since the year 2000 (UNEP, 2014). Furthermore, it states that mangrove losses release emissions equivalent to nearly 20% of the worldwide emissions from deforestation (while mangroves make up less than 0.4% of the global forests!), causing economic damages of US\$6 billion to US\$42 billion annually.

More than half of the global loss of mangroves is attributable to aquaculture, with 38% alone due to shrimp



Mangroves vanish at an alarming rate: since 1980, about 3.6 million hectares of mangrove forests have been destroyed.

farming (Valiela et al, 2001; UNEP, 2014). Especially in South East Asian countries, the rapidly expanding shrimp industry is the main cause for loss of area. Because of its high economic return and the huge worldwide demand for shrimp, unsustainable methods, such as the extensive use of pesticides, antibiotics and fungicides, are being used. This considerably reduces the lifespan of shrimp ponds, which soon need to be relocated to a new site, while the old one is left behind destroyed.

Further threats to mangroves include coastal urbanization, climate change with associated rising sea levels, agriculture, logging, and mining. In many coastal zones, high population pressure, the demand for living space and building materials, charcoal-making, and conversion into agricultural and aquaculture industry sites, has led to an alarming

degradation of mangroves. Pollutants from these industries further threaten much of the remaining mangroves. Furthermore, habitat, environmental, and hydrologic changes from dam constructions, regulation of rivers, and diversion of water for example for irrigation, all impact the composition and input of nutrients, sediments and freshwater, thus negatively affecting mangrove ecosystem equilibrium.

While governments, companies and high-level decision makers are mainly the cause of this degradation, rural, local communities are the most affected by the negative consequences of continued mangrove destruction, such as impacts on subsistence fisheries, climate change and the reduced protection from soil erosion and storm surge, just to mention a few.

restoring mangroves

A GUIDE TO COMMUNITY-BASED ECOLOGICAL MANGROVE RESTORATION (CBEMR):
RE-ESTABLISHING A MORE BIODIVERSE AND RESILIENT COASTAL ECOSYSTEM WITH
COMMUNITY PARTICIPATION



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angrove restoration is an inherently complex task that is prone to failure when the necessary conditions are not met. Traditional mangrove rehabilitation follows the same principles as the restoration of terrestrial forest. This involves collecting seeds, planting them in a prepared nursery and transplanting the seedlings to the desired location. However, these efforts can have limited results. Thus, the present project has also emphasised implementing alternative restoration techniques and furthering innovative approaches to mangrove restoration.

Based on its expertise, the Mangrove Action Project (MAP) has co-developed and promoted the concept and practice of Community-based Ecological Mangrove Restoration (CBEMR), which has also been applied in the context of this project. This holistic approach to mangrove restoration views the plant and animal communities to be restored as part of a larger ecosystem, connected with other ecological communities and their functions.

Community-based Ecological Mangrove Restoration (CBEMR) defined

The CBEMR concept is based upon the fact that mangrove forests can self-repair, or successfully undergo secondary succession, if certain pre-conditions are met. CBEMR thus focuses on re-establishing the hydrology that will facilitate this natural regeneration process. One of the advantages is the restoration of a more biodiverse, natural species composition, as compared to the rather “artificial” composition achieved through single species, hand planting.

The technique also explicitly engages local communities in the restoration process, empowering them to be stewards of their environment, and enabling them to regain the livelihoods lost when the mangroves were destroyed. Three to eight-day intensive workshops can train local people in the basic principles and applications of CBEMR, follow-up processes, long-term community management, as well as monitoring plans to ensure project sustainability.

CBEMR is a holistic approach that has been used very effectively to restore both the biodiversity and functionality of mangrove ecosystems. It aims to restore certain ecosystem traits and replicate natural functions. It has been shown that mangrove forests worldwide can successfully undergo secondary succession over periods of 15 to 30 years if:

- » The normal tidal hydrology is ensured and is not disrupted.
- » The availability of waterborne seeds or seedlings (propagules) of mangroves from adjacent stands is ensured and not disrupted or blocked.

Because mangrove forests may recover without active restoration efforts, it has been recommended that restoration planning should first look at the potential existence of stresses such as blocked tidal inundation that might prevent natural secondary succession from occurring, and removing those stressors before attempting reforestation. If stressors are responsible for the lack of regeneration, these should be determined by observing the site for six months to a year after the stress has been removed. There should be evidence of volunteer seedlings appearing on site within 12 months after the hydrological adjustments. If this is not the case, a reassessment of the hydrology and identification of other potential problems should be undertaken. If seed limitation is a factor, then buckets of collected seeds from a nearby source can be broadcasted on an incoming spring tide.

CBEMR views the plant and animal communities to be restored as part of a larger ecosystem, connected with other ecological communities and their functions.

Only if natural recovery is not occurring after these activities, the third step of assisting natural recovery, through hand planting of nursery-raised seedlings or propagules collected in the correct zonation, should be considered.

Unfortunately, many mangrove restoration projects move immediately into planting of mangroves without



CBEMR restores both, the biodiversity and the functionality of mangrove ecosystems.

determining why natural recovery has not occurred. There may have even been large capital investments in growing mangrove seedlings in a nursery before the stress factors are assessed; this often results in major failures of planting efforts.

Advantages of CBEMR over other current Methods

CBEMR involves a more methodological ecosystem approach than the usual monoculture restoration efforts, incorporating natural mangrove dispersal and ecological recovery. The key is in the re-establishment of the hydrology of the area considered for restoration, and then working with nature itself to help facilitate regeneration of the area's naturally occurring mangrove species.

The CBEMR concept is based on a set of basic ecological principles and is capable of producing a much more naturally functional and biodiverse mangrove ecosystem than other more capital and labour-intensive methods such as hand-planting. It is also based on principles of community engagement and empowerment, recognizing that sustainable restoration requires the active participation of the affected local communities.

To ensure success, long-term monitoring and evaluation need to be built into the restoration framework to assess progress and take corrective action, if required. Since short-term progress may be less visible at CBEMR sites than after classical reforestation, monitoring should involve a sufficient time span (at least three to five years)

to better understand the nuances that determine success or failure at each unique restoration site.

When to use Planting and CBEMR

Generally, most often, planting is not required if certain pre-conditions for the area are met, such as an intact hydrology. Furthermore, proper protection from people and grazing livestock needs to be ensured during the time of natural succession. One needs to be more patient, but if allowed to restore naturally, a higher species biodiversity and mangrove restoration closer to the original species composition is usually ensured.

If planting is desirable, then all the principles of CBEMR should still be followed closely, which includes full involvement of communities from the earliest planning stages to monitoring. Before planting, one must ensure that any stress factors that may have caused prior mangrove loss and destruction are resolved, as for example a changed hydrology or contaminated soils. During planting it is critical to mimic nature by using as many species as were naturally occurring on site, by emulating natural growth patterns, and by planting each species in its correct zonation.

Monitoring is an important final step in order to assess success rates, being able to implement corrective measures if needed, and to develop a set of lessons learned in order to improve the quality of future restoration activities.

The following list of pros and cons of CBEMR and traditional reforestation might help in decision-making and to determine what is best suited for a specific site.

TRADITIONAL REFORESTATION

PRO	CON
<ul style="list-style-type: none"> » Planting speeds up recovery. » Can be a way to demonstrate claim to an area if there is danger of encroachment. » If planted in the correct tidal zone, economically desirable plants (e.g. Nypa Palm) can be promoted. » Planting can create employment, as the maintenance of nurseries requires a fair amount of labour – at least over the project period. » Nurseries can be used for environmental education and raising awareness, especially if sign-posted with educational information and labelled species. » Involving local communities in controlled and informed planting is important for developing awareness and ownership of a project. 	<ul style="list-style-type: none"> » Planting may be a waste of time and resources if an area can regenerate naturally. » Reforestation often involves the wrong species in the wrong zones (e.g. tidal mudflats or eroding high energy zones) and possibly the wrong time, which results in a high failure rate. » Dense plantations are not as biologically diverse as natural mangrove stands. Also relatively few mangrove species tend to be grown in nurseries. » Monocultures are more vulnerable to diseases and insect infestation. » Nurseries may be affected by insects, drought, floods, or poor maintenance. » Often mangrove planting occurs without assessing and eliminating disturbances, which is a guarantee for failure. » Successfully growing seedlings in nurseries requires lots of technical knowledge.

CBEMR

PRO	CON
<ul style="list-style-type: none"> » Success rates are generally higher. » Community is involved from planning to implementation to monitoring, which ensures success. » CBEMR works with nature and natural cycles so mangroves grow in the correct zone, which ensures good growth rates. » Naturally regenerated mangroves are closer to the original forest and have higher biodiversity. » Restoring large areas can be less expensive using CBEMR. » Small-scale planting of desired species in the correct zone can still be utilized to promote stewardship and project ownership. 	<ul style="list-style-type: none"> » Recovery is generally slower initially as it depends on natural seeding and production cycles so projects require a longer timeframe. » If little or no mangrove seed is available nearby the restoration site, lack of propagules entering the site will pose a problem. » Donors prefer projects with high visibility, that provide good photo opportunities like planting. Naturally regenerating sites may not be as visually attractive as planted sites. » Less employment is created.

Guidance to successful Mangrove Restoration

The following summary gives a brief guide on seven basic steps that are pre-conditions for successful mangrove restoration. The seven-step system has been co-developed by the Mangrove Action Project (MAP) in order to provide coastal managers and mangrove restoration practitioners with a comprehensive and accessible, basic methodology.

As each restoration site is unique, this system, however, can only serve as a basic set of good practices, which should be translated into tailor-made work plans for the respective region.

In addition, it is important to remember that only when combined with the consequent protection of remaining mangrove ecosystems along with close cooperation and involvement of local communities, can restoration activities be sustainable and have a long-term success.

THE BASIC PRINCIPLES OF COMMUNITY-BASED ECOLOGICAL MANGROVE RESTORATION

A PROPER INVOLVEMENT OF COMMUNITY MEMBERS AND ANY OTHER RELEVANT AGENCIES SHOULD BE ENSURED DURING THE WHOLE PROCESS.

1

Understand the autecology (individual species ecology) of the mangrove species at the site; in particular, the patterns of reproduction, propagule distribution, and successful seedling establishment.

2

Understand the normal hydrologic patterns that control the distribution and successful establishment and growth of targeted mangrove species.

3

Assess disturbances and modifications of the original mangrove environment that currently prevent natural secondary succession (recovery after damage).

4

Design the restoration program to restore appropriate hydrology and, if possible, utilize natural volunteer mangrove propagule recruitment for plant establishment.

5

Implement the restoration plan using the natural nearby mangroves as a reference model.

6

Only utilize actual planting of propagules, collected seeds, or cultivated seedlings after determining (through steps 1-5) that natural recruitment will not provide the quantity of successfully established seedlings, rate of stabilization, or rate of growth of saplings defined as objectives for the restoration project.

7

Design and follow a long-term monitoring plan (usually for 3-5 years) which is critical to ensuring the success of the restoration project.



CBEMR explicitly engages local communities, empowering them to be stewards of their environment and enabling them to regain the livelihoods lost.



Before you start: Be prepared and select an appropriate site!

Before you start a mangrove restoration project it is always useful to check whether there were any similar programs in that area. If so, it is helpful to gather information regarding their success and/or failure, and to learn from former consolidated findings.

Equally important is the selection of an appropriate restoration area that has a good chance for rehabilitation and

that can be worked on with the available funds, time, and human resources. It may also involve resolving land ownership and land-use issues necessary to ensure long-term access to and conservation of the site and its associated wildlife.

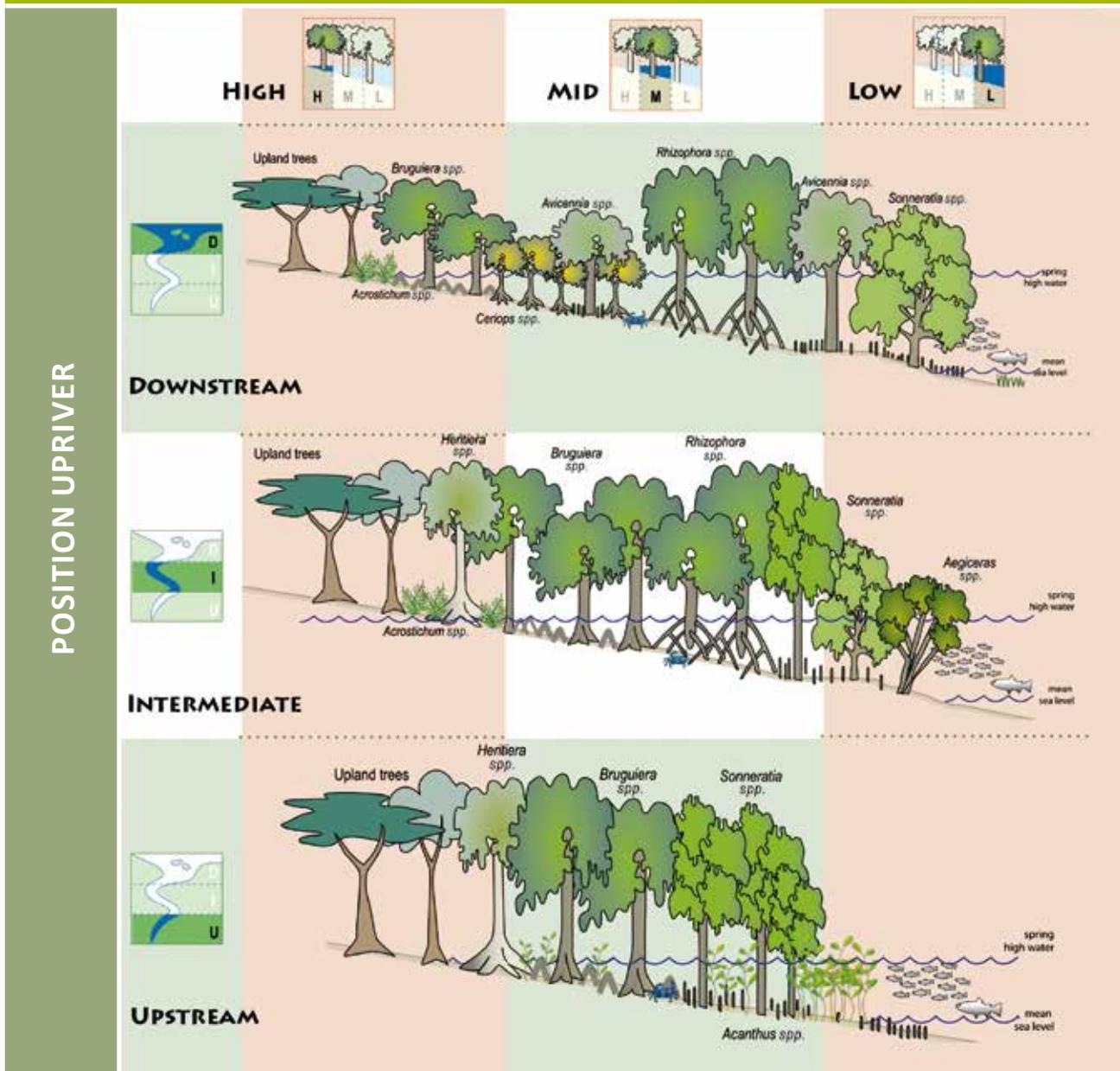
Try to gather as much information as possible about your site (historical photographs, literature, tidal conditions, etc.). Understanding your site and the normal hydrologic patterns is one of the most important attributes of targeted planning. A reference mangrove site for examining normal hydrology in the particular area might be useful.

THINGS YOU MAY NEED BEFORE STARTING MANGROVE RESTORATION ACTIVITIES

- » Information on biophysical features of the location (i.e. area topographic maps, land-use plans, historical air photos, if available, and remote sensing images like Google Earth).
- » Major climate parameters (i.e. rainfall, temperature etc.) and information on the tidal and hydrological system (tide tables) as well as earth movements (e.g. land subsidence).
- » Dominant soil type.
- » Water chemistry (salinity, pH, temperature).
- » Type of forest (primary, secondary, degraded). A forestry management map may be available.
- » Species inventories (flora and fauna).
- » Local knowledge/traditional uses and land tenure.
- » Ecosystem products, functions and attributes.
- » Pressures and threats to the area.
- » Potential areas available for rehabilitation/restoration.
- » Survey equipment (camera, compass, rope, stakes, notebook, measuring tape, GPS unit, auto-level).



TIDAL ZONE



Natural mangrove distribution depends on the preferences of a particular species for various conditions, such as tidal zone and estuarine position (according to Duke, 2006).

Get started!

1 Understand the mangrove's autecology

In order to understand the patterns of reproduction, propagule distribution and successful seedling establishment, it is necessary to have a look at the individual species ecology of the mangroves – their autecology.

Because of their various shapes and sizes, propagules can float differently. Furthermore, it is important to consider the different plant zonation which is characterised by different conditions, depending on the tidal zone and the position of the restoration site upriver, such as the scope of tidal inundation, salinity and the amount of fresh water available (Fig. 1).

Different mangrove species prefer different conditions and thus occur in different zones. Take into account which species is appropriate for which zone.

2 Understand the normal hydrology patterns

Each mangrove species thrives at a different substrate level, which in some part dictates the amount of exposure the mangrove will have to tidal waters. Understanding the normal hydrologic patterns that influence the distribution and growth of existing natural mangrove plant communities in the restoration area is thus essential. Therefore, a sufficient understanding of the determining factors such as depth, duration and frequency of tidal inundation of tidal flooding is vital. There are various tide-classifications to distinguish, like those that are inundated by all high tides, those by all medium-high tides, or those by normal tides. In addition, there are those inundations that only happen during spring tides or equinoctial tides.

Three important points concerning the tides should be evaluated:

- » Height and depth of the tides.
- » Duration of the tidal inundation.
- » Frequency of the tides.

If a nearby healthy mangrove forest exists, it is helpful to imitate the slope and topography of the substrate.

3 Assess disturbances

It must be determined whether the target area for an intended restoration was a mangrove area in the past. If so, it is important to understand why the original mangrove cover vanished, if external stressors or disturbances have been responsible for the loss, and if they currently prevent the natural succession of mangrove forest. The potential stresses on the location should be investigated and eliminated or at least reduced to a level where long-term survival of new mangrove saplings can be ensured. If you cannot correct these, you should consider picking a new site. It is also crucial to involve the local communities in this process.

Some potential stressors could be:

- » Disturbing human activities (shrimp ponds, dykes, tree felling, agricultural encroachment or run off, road construction, etc.).
- » Hypersaline or acid sulphate soils (usually after intensive shrimp farming).
- » Overgrazing by animals.

- » Blocked tidal inundation.
- » Lack of groundwater or freshwater runoff.
- » Shoreline abrasion and lowered substrate level caused by high wave energy.

4 Develop your hydrological rehabilitation strategy

The basic theory behind hydrological rehabilitation is the recreation of natural slope and substrate height, which will support normal tidal flow, and the natural re-establishment and growth of mangrove seedlings.

Another important factor is to ensure unhindered flow of tidal streams through the entire restoration area. This can happen by either unblocking possibly restricted canals or water flows, or by creating new streams, e.g. by digging canal systems. The natural exchange and flow of water – through the whole mangrove area from the terrestrial edge to the sea – is essential, as the streams create the site, including its zone-specific composition of fresh water and salinity in the area. From upland, mangroves are fed by ground water, springs, runoff and streams, and connect this fresh water inflow with the salt water of the seaside, thus facilitating tidal flooding of the mangrove area. When these tidal streams are disturbed, a mangrove may dry out and die over time.

For a successful restoration, imitate nature and ensure that hydrological conditions are truly supportive of mangrove growth.

In case you want to restore abandoned shrimp ponds or areas close to such ponds blocking the hydrology of your site, the best option is to level their dyke walls. If you cannot level the walls entirely, opening strategic breaches in the right places – usually the mouths of historic tidal creeks – may be enough to support the exchange of tidal waters and should lead to further degradation and removal of the walls over time.

For excavated areas, backfilling the site supports the recreation of the natural slope. The definition and use of a benchmark reference site further helps to rebuild the exact tidal elevations relative to this reference site, thus ensuring that the hydrology is correct.



If allowed to restore naturally, a higher species biodiversity and mangrove restoration closer to the original species composition is usually ensured.



Always keep in mind: Even if mangroves survive for several years in the rehabilitation area, they may remain stunted or even die out unless hydrological conditions are truly supportive of mangrove growth.

5 Implementation

Implement the restoration plan by using the natural nearby mangroves as a reference model. Be aware of the soil substrate level in reference to mean sea level or a datum marker and imitate natural tidal waterways so that the frequency, depth and duration of tidal inundation are also similar. Tidal creeks should be snake-like in shape, and also wider at the mouth and narrowing as they move up-slope. A good tidal channel will be self-flushing preventing siltation. It is important not to pile the dredged spoil on the channel banks as this will block tidal flushing and be washed back into the waterway. Move the spoil into islands as far away from the edge as reasonably possible. Use local human labour for excavation and hydrological adjustments where possible, as it provides local wages, builds stewardship for the restoration site, and has proven to be an excellent tool for teaching the principles of CBEMR by doing and observing. These skills will be very useful for needed future adjustments or restoration work.

6 Planting mangroves – only if necessary

If seedlings have established in the rehabilitation area but at lower densities than hoped for, you may consider further supporting the site by direct hand-planting. It is important to only plant mangrove species that previously occurred naturally on the site and in the correct zone.

The area for a mangrove nursery needs to be chosen diligently. Preferably, the nursery should be located in the inter-tidal zone so that hand-watering is not required. Building the nursery close to households will make it easy to access and to provide regular maintenance. If there have been mangroves in the area before, ask yourself why they have vanished and eliminate possible stressors before you start growing seedlings (see step 3). Then, you need to ensure that sufficient person power and knowledge on growing the seedlings is available. Additionally, it is recommended to clearly define and record criteria such as species, type of seed, months of seed collection, indicators of maturity, seed selection, seed storage, sowing, shading, watering and pest control.

When planting, it is critical to emulate nature, e.g. species composition of a site, growth patterns and distribution of species in their correct zonation. Enough space between the seedlings allows natural volunteers to grow, ensuring

SOME HINTS FOR PROPER MANGROVE PLANTING

- » Hole Size: The prepared hole for planting should be 1.5 times wider and 1.5 times deeper than the root ball of the seedling.
- » Avoid “J“-Roots: When placing the seedling in the prepared hole it is recommendable to hold the seedling so that the top of the root ball is even with the surface of the soil. It is also important that the roots are allowed to dangle freely, straight into the hole. Roots in contact with the bottom of the hole will curl upward (like the letter “J”) which may stunt growth or even kill the plant.
- » Loose Soil: Only lightly back-fill soil into the hole so that it is completely filled with loose soil. Compacting the soil too much eliminates small air pockets needed by the roots.
- » Timing: It is best to ensure that saplings are transplanted within a month to gain the best results.



Monitoring is key to the long-term restoration success and helps identifying and correcting possible problems in due time.

species diversity. Seedlings or prologues are best planted at the beginning of the rainy season, which is the ideal growing season with plenty of moisture and lower saline conditions.

Dissemination of Seedlings

For reforestation through planting, there are different strategies that can be applied:

- » Raising seedlings in a nursery from local seed sources.
- » Planting propagules (seeds) directly.
- » Relocating natural seedlings from unsuitable areas or very dense sites into the restoration area.
- » Broadcasting propagules by throwing them on the water surface during incoming tides. This enables seeds to find their own suitable location for rooting and thus supports natural distribution and growth patterns. It is recommended to do this on a series of different tides during the month of maximum availability of the seeds.

No matter which strategy you decide on, you should always make sure to use local sources for seeds and seedlings, as they are well-adapted to the local environment and ensure natural (site-specific) species composition.

Propagules and seeds suitable for collection are commonly found along high-tide lines. If an area lacks natural seed sources, seeds may be collected from a similar area that has a lot of seeds, transported to the restoration site, and distributed by one of the strategies above.

7 Monitoring

Monitoring is the final step most often overlooked or carried out only once shortly after restoration, while many potential problems that might impact the project's success could yet occur over the next few years. Monitoring has several critical functions, including informing if the restoration is meeting the goal for recovery, helping to recognize problems and make early corrections, and is an important tool for learning and improving future restoration projects. Monitoring can be simple time-lapse photos, or more scientific, using fixed or random quadrats or transects. The method or combination of methods selected should suit the skills, time and budget available over a period of three to five years. Regular monitoring allows tracking changes over time, and seeing if the modifications are working. According to international experts, monitoring is recommended to be scheduled at the following monthly intervals: Time Zero (TO), + 3, 6, 9, 12, 18, 24, 36, 48 and 60 months (where "Time Zero" is the completion of physical restoration work). Four monitoring sessions occur in the first year, to find any problems early and correct them.

The main goal of CBEMR monitoring is to measure the density of natural seedling recruitment over time. Besides observing volunteer seedlings on site, there should be an evaluation of the site hydrology to see if tidal flooding is occurring in a similar way to the natural mangrove reference forest. Observation should include other flora and fauna occurring on-site which can also be a good indicator of problems or rehabilitation success.

the project

THE PROJECT



In response to the urgent need to protect mangrove ecosystems and their biodiversity, Global Nature Fund and its five partner organizations from India, Sri Lanka, Thailand and Cambodia jointly launched the “Mangrove reforestation in Asia – local action and cross-border transfer of knowledge for the conservation of climate, forests and biodiversity” project in 2012.

In the framework of the four year initiative, the team restored over 100 hectares of degraded or destroyed mangrove forests at five different project locations throughout Asia. The close collaboration within the team, as well as with the local communities and authorities, has been key for the success of the project.

For restoration activities, the partners used traditional planting techniques as well as the CBEMR approach. Due to the longstanding experiences of the partners in their project areas and the field of mangrove reforestation, the most suitable methods have been picked in order to allow best possible results.

For the traditional reforestation, seedlings have been grown in mangrove nurseries and private home gardens and planted out by local community members, offering employment and additional income to the local communities. The home garden growers have been paid for each successfully grown seedling and have additionally been provided with vegetable and herb seedlings. This further supported their nutrition and

opened opportunities for the sale of surplus harvests on the local market.

Various environmental education programs and regular exchange meetings between the project team further ensured raising awareness and ownership among the project communities, as well as expert exchange on challenges, successes and lessons learned.

“Now, when we see the new mangroves growing in the catchment areas, we feel that we are supporting our future generations and preserving the lake and its environment. We want to see more green around our lake and safeguard it from becoming a brown one.”

Mr. Chintake – Kaduruwa, Sri Lanka

Project Partners...

Between January 2012 and December 2015, the project “Mangrove reforestation in Asia – local action and cross-border transfer of knowledge for the conservation of climate, forests and biodiversity” has been implemented. In the framework of this transnational initiative, five experienced project partners from four Asian countries realized activities for the sustainable protection of valuable mangrove ecosystems. Global Nature Fund, Germany, initiated and managed the project.



GERMANY Global Nature Fund and the Living Lakes Network

Global Nature Fund (GNF) is a non-profit, private, independent foundation for the protection of environment and nature. GNF was founded in 1998 and has offices in Radolfzell, Bonn and Berlin. One of GNF’s core initiatives is the Living Lakes Network – a global network of organizations that champion the protection of lakes and wetlands. The network currently comprises over 100 members all over the world, and has been recognized as an “Official Project of the United Nations Decade of Education for Sustainable Development 2005-2014” for the fifth time in a row.

www.globalnature.org; www.globalnature.org/livinglakes



CAMBODIA FACT

The Fisheries Action Coalition Team (FACT) is a group of NGOs that came together to address coastal issues, especially problems related to local fisheries. FACT was formed in the year 2000 and mainly works around Tonle Sap Lake. Apart from biodiversity restoration programs, FACT is involved in mangrove restoration efforts in the coastal zone and has a strong advocacy on fishing rights and coastal resource usage.

www.fact.org.kh



INDIA CRenIEO

The Center for Research on New International Economic Order (CRenIEO) was established in 1979 as an action research centre and has been involved in fisheries development activities at the Pulicat Lake since 1984. CRenIEO concentrates on skills development, formal school education and on income generating activities for local communities. CRenIEO has also been conducting environment education programs in schools around Pulicat. Since 2008 CRenIEO has been actively involved in mangrove restoration activities in the South of Pulicat Lake.

www.crenieo.org



SRI LANKA EMACE

EMACE is an experienced NGO that predominantly works in the Bolgoda Lake region in the areas of biodiversity restoration and biodiversity protection. EMACE implements renewable energy schemes, biocultivation, climate change mitigation programs and runs environmental education programs for the community. In addition, EMACE engages in community-based micro finance programs and strives to be innovative in their approach.

www.emacesrilanka.com



SRI LANKA Nagenahiru Foundation

The Nagenahiru Foundation was established in 1991 and is involved in a variety of activities including community level environmental education, nature conservation, advocacy programs as well as poverty mitigation and community empowerment programs. It also engages in providing skills to women for the fabrication of products made from natural wetland resources and coir fibre. The foundation is intensively involved in mangrove restoration and conservation programs.

www.nagenahiru.org



THAILAND MAP-Asia

Mangrove Action Project (MAP)-Asia is a regional office, which opened in 2001 in Trang, southern Thailand while MAP has been registered as non-profit in Washington State, USA since 1992. MAP-Asia focuses on coastal resources conservation, promoting sustainable community livelihoods, and capacity building. The organization has strong expertise in mangrove restoration and networks with partners throughout Asia and beyond. MAP-Asia promotes CBEMR since 2003 and also trained the other project partners on it.

www.mangroveactionproject.org



... and Project Areas



TRAPAING SANGKE COMMUNITY FACT

The project site is situated in the Trapaing Sangke commune in the Kampot Province of Cambodia, where a community fishery was established in 2009. The community fishery covers 337 hectares including 45 hectares for fish conservation, 30 hectares for mangroves reforestation and restoration, and 10 hectares of existing mangroves forest area. The community consists of three villages with more than 1,000 families. 80% of the community members are fishers and thus are heavily dependent on the natural resources of the mangrove forests and sea, such as crab, fishes and shrimp.

The mangrove forests in the Trapaing Sangke commune are rapidly degrading due to increasing coastal population, climate change, coastal development, agriculture, and

aquaculture. Previous attempts by local fishers in the community to sustainably manage and restore the mangroves failed, due to a lack of knowledge and time.

However, the vast majority of the community relies on the mangroves' natural resources for their livelihoods. Many of them live below the poverty line. Due to the poor economic conditions in these rural and structurally weak areas, there are few income alternatives besides fishing. The only other means of earning an income are often farming or irregular day labour. In this context, the overuse of the mangrove forests creates a vicious cycle because the damaged habitats cannot sustain the fisher families. An increase in poverty, poor nutrition and accelerating degradation are the results. Besides relevant sensitization measures, it is therefore of singular importance to provide the families with alternative sources of income.



PULICAT LAKE CReNIEO

Pulicat Lake is situated in southern India and has a surface area of around 460 km². The lake is characterised by its shallow depth of 1.5 m on average. It is the second largest brackishwater ecosystem in the country and is situated on the east coast of India. The lagoon is an important habitat for 160 fish species in 26 families, and more than 100 species of terrestrial and aquatic birds, small mammals and reptiles. The Southern part of the lake is considered highly productive and is densely populated.

Pulicat is a thriving fish trading centre but the per capita catch has declined drastically. Population continues to increase, as does pollution caused by locals and commercial activity, along with destructive fishing gears and climate change, all of which have led to dwindling

fish resources which puts stress on the people and the lake. Competition for catches often leads to strife. There once was a strict traditional fishing rights system called “Padu” which regulated fishing schedules and gears and limited overfishing, but nowadays very few villages still practice it.

The mangrove restoration project focuses on an area that was flanked by abandoned aqua farms and left in degraded conditions for the mangroves, which were stunted and barely surviving. In the villages of the project area most people live below the poverty line. Fishing is done mostly by hand or using small nets predominantly to catch shrimps and mud crabs. Since 2000, CReNIEO has formed women self-help groups in these villages, helping them to have access to banks and avail themselves of Government schemes. They are mostly daily wage earners and do some small-scale cultivation.



BOLGODA LAKE EMACE Foundation

Bolgoda Lake is located in south western of Sri Lanka. The lake consists of two major water bodies that cover a vast area of 374 km². It is one of the biggest sources of fresh water within the western district of Sri Lanka. Bolgoda Lake has a rich biodiversity that harbours seven varieties of mangrove plants, many associated species and 45 varieties of fauna. Its natural beauty has great potential in an area bordering the capital of Colombo, for development, tourism and fisheries, but it is gravely threatened by industrial pollution.

The main threats in the area are encroachment over the reservation zone of the Bolgoda Lake, garbage dumping by visitors, and industrial pollutants that are discharged into the lake. Due to the destruction of the mangroves caused by felling, industrial and other developments, the income generated by fishing has been drastically reduced. Land fillings of the Bolgoda wetland, and converting the lake border to residential areas has contributed to lake

water stagnation and pollution of the drinking water sources. The filling of the wetlands causes flooding in the major townships, associated with substantial economic losses for the local residents due to the congestion and inability to access vital services during flood situations. The main objective is to restore the mangroves to mitigate economic losses, to reduce vulnerability to natural disaster, and to concomitantly improve the livelihoods of the local community. In this context the project focusses on the fisher folk and farmer families of the lake, most of whom live on less than US\$2 a day. Overfishing, pollution of the lake by hotels and industries, and the unsustainable, unplanned development of the area have hindered their livelihoods for many years.

The project site is located at an area that was originally a mangrove habitat but was cleared approximately 70 years ago and converted into rice paddy fields. A soil dam along the lake and estuaries was built to control salinity and tide water flow and allow rice cultivation. However, this conversion was not successful and the fields were soon abandoned. For the last 50 years, weeds and invasive plants have been thriving in the area.



MADAMPE LAKE Nagenahiru Foundation

The Madampe Lake Wetland system is located on the south west coast of Sri Lanka, which harbours a unique biodiversity and includes a variety of vegetation types, predominantly mangroves and marshlands. Due to the diversity of habitats and a broad variety of plants, a large number of animal species including invertebrates, amphibians, reptiles, birds, and mammals can be found around the lake. The mixture of vegetation types and presence of small and large islands within the lake has made the wetlands an ideal habitat for numerous species of birds. A total of 83 bird species belonging to 36 families have been recorded.

Mangroves are one of the most prevalent ecosystems in Sri Lanka and provide a range of ecosystem services to the local communities. They play a major role in preventing coastal erosion and support nesting and reproduction for fish and birds. Nevertheless, during the past few decades mangrove resources have been drastically damaged or reduced due to increasing human activities such as illegal tree felling, aquaculture, clearing for settlements, agriculture and tourism. The local communities in the project region of south western Sri Lanka depend on the natural resources provided by the Lake and the surrounding wetland systems. However, there is neither adequate management nor an environmental awareness program in place, by which the local farmers and fishermen learn about sustainable use of the environment. As a result, the area has already suffered damage from over-fishing, emissions of pollutants into the water system and the extensive use of chemical fertilizers.



ANDAMAN COAST MAP

The Andaman Sea coast of Thailand is 865 km long and extends from the Malaysia border in the south to Myanmar in the north. The mangrove restoration project sites are located in three of the six coastal provinces, namely Trang, Krabi and Phang Nga. The area receives plenty of rainfall nearly year round, so the vegetation is tropical with forests reaching up to 80 m in height. Mangroves cover more than 600 km² of the coast. There are about 280 edible fish species belonging to 75 families, of which 232 species are found in mangroves. The sea also hosts many vulnerable fauna species, including dugong (*Dugong dugon*), several dolphin species, such as Irrawaddy Dolphin (*Orcaella brevirostris*) and four species of endangered sea turtles.

Shrimp aquaculture has been the main cause of mangrove loss in Thailand. Due to unsustainable intensive

management many of these ponds have a short life span and are abandoned due to disease and water quality problems after a few years. In addition, existing mangrove planting programs in Thailand often focus on very few species (2-4 at most, primarily *Rhizophora spp.*) that are not nearly as productive or biologically diverse as the original forest. Therefore, within these mangrove plantations natural biodiversity is being lost.

The target group is the local community of each coastal village within which the mangrove restoration sites are located, often where mangrove loss has been high due to shrimp aquaculture expansion in the 1990s. These villagers live in close interaction with the mangrove forest and the estuary.

Most community members make their living from small-scale traditional fishing using multiple gear from long-tail boats, aquaculture involving mainly fish-rearing in floating pens, but also crab, clam and oyster raising, and agriculture, in particular rubber tree tapping and oil palm plantations.

Outcomes and Achievements

Mangrove restoration

In the framework of the project, more than 100 hectares of degraded or destroyed mangrove forests have been restored. In order to achieve this effort, almost 140,000 seedlings were grown in nurseries and replanted by local community members at the restoration sites in Sri Lanka, Cambodia and India.

In Thailand, the CBEMR method has been applied in six communities, where encroached mangrove areas as well as abandoned shrimp ponds have been secured and restored through the correction of the sites' hydrology. The other partners have been trained in the CBEMR method and successfully implemented it on own pilot sites.

Together with the reviving forests, a constant increase of mangrove-associated flora and fauna, such as birds, fish and crustaceans, has been observed throughout the

restoration sites. This positive development is further supported by the implementation of comprehensive species inventories in the project areas, which help the project partners to better understand the ecosystems they are working in and develop tailor-made projects on basis of long-term conservation strategies in future.

The restoration has not only contributed to nature conservation, it has also improved the livelihoods of local communities and especially fisher families who live in the catchment areas. In addition, the implementation of the restoration activities offered people possibilities for supplementary income, for example through supporting seedling planting, land preparation or by growing seedlings in private gardens, which have been purchased from them for the project. The involvement in the growing and planting process as well as the further monitoring of the restored areas considerably increased the awareness and acceptance of the project within the local communities and built up capacities that empower people to independently manage and conserve an important part of their own livelihoods.

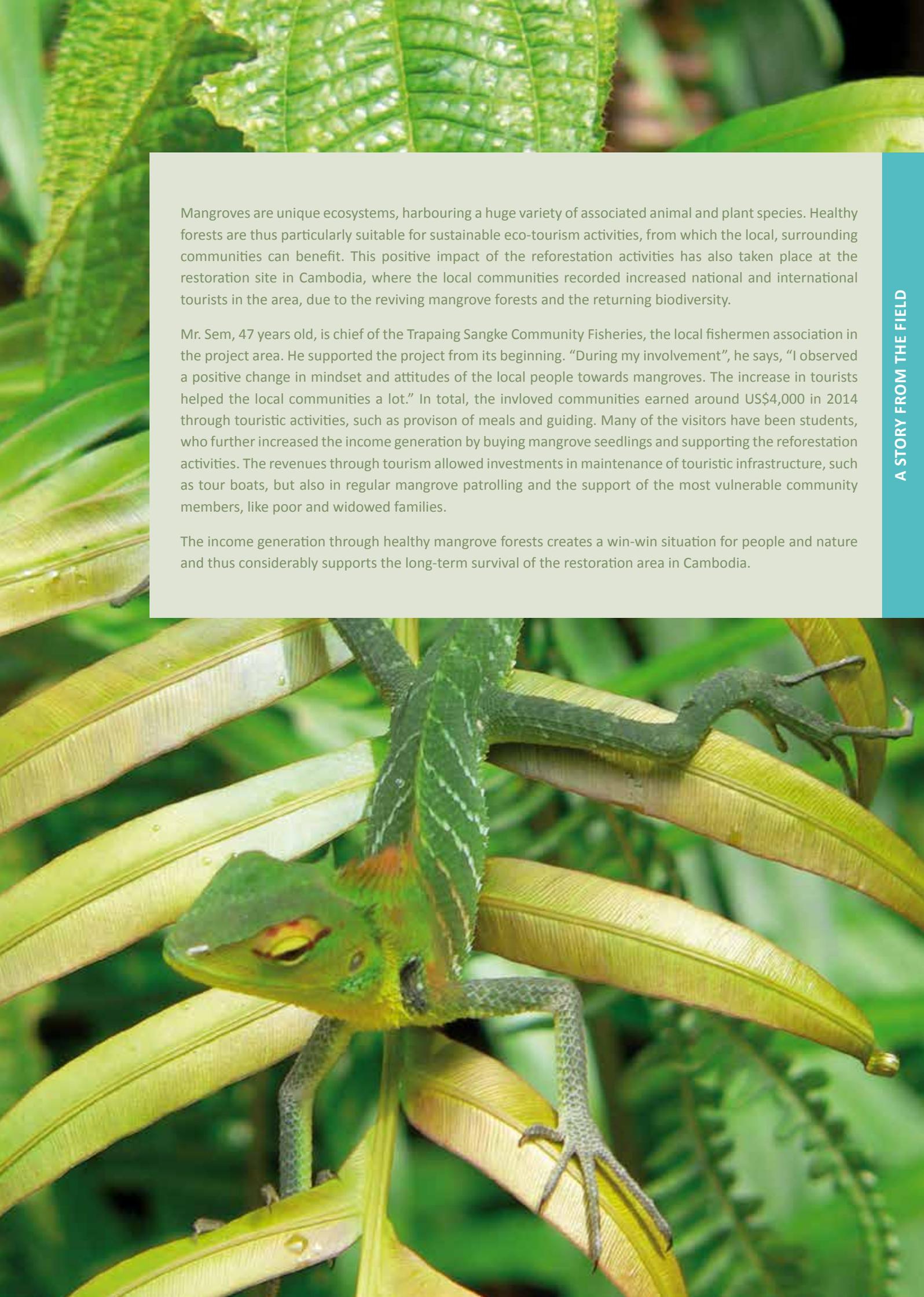


"I am fishing near the restoration site in Thangal and I see more fishes and prawns since the project started. Nowadays, I do not go far but fish between the mangroves here. The catches I get have increased by 2 to 3 times which I sell at the Pulicat market."

Ms. Devanayki – India



Irrespective of which restoration method is being used, community involvement is key to the long-term success.

A vibrant green lizard with a distinctive red and yellow stripe on its head is perched on a large, yellowish-green mangrove leaf. The lizard's body is covered in fine, scaly patterns, and its legs are firmly gripping the leaf. The background is a lush, out-of-focus green, suggesting a dense mangrove forest.

Mangroves are unique ecosystems, harbouring a huge variety of associated animal and plant species. Healthy forests are thus particularly suitable for sustainable eco-tourism activities, from which the local, surrounding communities can benefit. This positive impact of the reforestation activities has also taken place at the restoration site in Cambodia, where the local communities recorded increased national and international tourists in the area, due to the reviving mangrove forests and the returning biodiversity.

Mr. Sem, 47 years old, is chief of the Trapaing Sangke Community Fisheries, the local fishermen association in the project area. He supported the project from its beginning. “During my involvement”, he says, “I observed a positive change in mindset and attitudes of the local people towards mangroves. The increase in tourists helped the local communities a lot.” In total, the involved communities earned around US\$4,000 in 2014 through touristic activities, such as provision of meals and guiding. Many of the visitors have been students, who further increased the income generation by buying mangrove seedlings and supporting the reforestation activities. The revenues through tourism allowed investments in maintenance of touristic infrastructure, such as tour boats, but also in regular mangrove patrolling and the support of the most vulnerable community members, like poor and widowed families.

The income generation through healthy mangrove forests creates a win-win situation for people and nature and thus considerably supports the long-term survival of the restoration area in Cambodia.

Livelihood support

The creation of alternative income opportunities for the local communities surrounding the project areas constituted an important pillar of the project. The generation of alternative sources of income improves livelihoods, builds relationships within the local population, increases the awareness of and the support for project activities and is an important measure to reduce the pressure on the mangrove forests.

Within the project, two major activities for livelihood support were applied. On the one hand, a buyback system for mangrove seedlings from household nurseries has been established. Participating families received mangrove seeds and training on how to grow the seeds successfully in their private home gardens. Once old enough, the seedlings were bought back for restoration purposes.

The buyback scheme has been complemented with training on sustainable growing practices and the dis-

tribution of crops seedlings, such as vegetables and herbs that have been grown in the private gardens for own use or sale on the local market.

Furthermore, the partners realized a series of other small-scale livelihood initiatives in accordance with the special needs of the different communities. Among others, these included the support of further agricultural programs, such as raising goats and chickens, construction of wells and toilets, or provision of equipment and training for fishermen and other small businesses like beekeeping. In return, the local communities actively supported the project implementation and committed to the long-term preservation and protection of the restoration sites as well as to the use of sustainable resource practices.

“Before the project we used to cut mangroves and sell the wood for construction and other purposes. Through the project we received a cage and 60 hens to start a poultry farm. Now, we sell the eggs from our hens instead of wood.”

Mrs. Jayanthi Ranasinghe & Mr. Nelson – Sri Lanka



Alternative sources of income are important in fishing communities with mangroves suffering from excessive overuse.

Mr. Muthukrishnan, his wife and his four kids, live in one of the project villages in India. Mr. Muthukrishnan is a tribal fisherman, fishing in Pulicat Lake. The family is participating in the buyback system for mangrove seedlings. For each successfully grown sapling, the family received 25 Rupees (about 0.35 Euro). With this income and some of his own savings, Mr. Muthukrishnan was able to buy his own fiber catamaran (a small fishing boat) for himself and his son. By using this boat, he can increase his catch and therefore income, he says. Additionally, the fisherman participated in environmental education activities and community meetings. "Through the project, we were able to understand the importance of mangroves and the role they play for shrimp, fish and mud crab, which I fish."

Mrs. Nagabossham, her husband and her three kids live in the neighbouring village Edaiyankulam. The family received one female goat through the project in December 2012. Since then, the goat gave birth to two male and two female kids. Mrs. Nagabossham reared the two males for some months and sold them on the market. She invested the money she earned into the education of her children. The two female kids, she kept: "I feel blessed with the two females. Now I can expand, double my stock and double my income" she says, smiling.



Environmental education and community involvement

Environmental education plays an important role to ensure the long-term success and sustainability of (mangrove restoration) projects. Sensitizing children and community members to the importance of mangroves provides them with essential knowledge about the benefits of the ecosystems, and generates awareness of why these forests should be protected in the future. Therefore, all partners established or refurbished information centres where they have been conducting continuous environmental education programs. A huge variety of activities for pupils and adults such as exhibitions, drawing contests, field visits and visitation of the mangrove nurseries have been conducted here.

Furthermore, regular exchange meetings with the local communities, village elders, and different representatives from ministries, universities, fishing associations and women's groups have been realised. These have proven

key to the success of the project, as they built up trusting cooperation with the most important stakeholders of the project and thus support sustainability. A bi-directional information flow thereby ensured a platform for the local communities to give feedback on the project activities, express concerns and to support the implementation process with traditional knowledge of the ecosystems. At the same time it provided the project partners the chance to consistently sensitize and train the target group on mangrove protection and CBEMR, as well as other topics, such as recycling and practices on sustainable crop growing and fishing techniques.

Overall, several thousand people participated in environmental education activities or received educational information throughout the project timeframe and have thus been sensitized on the importance of mangrove ecosystems for themselves and future generations.



Environmental education programs and regular exchange with the local communities inform, sensitize and build up trust.





Mr. Bung Bao is a senior member of the Laem Makham Village in Trang, Thailand. He is descended from a long line of fishermen who have lived next to the mangroves and utilized them for generations. Locally he is known as the “mangrove expert”. When the village was identified as one of the project locations, he immediately stepped forward, excited to contribute to the restoration of an area his family and village hold sacred. Mr. Bung Bao helped take the lead on the CBEMR project and showed great initiative so that he quickly became the project’s contact person in the village. Particularly important was Mr. Bung Bao’s local knowledge, with which he supported the project implementation and restoration of an abandoned rice paddy adjacent to the village. Mr. Bung Bao explains “The private property area was excavated by the government to extract fill material for a new road construction to the village ten years ago. The soil in the area was too dry making mangrove growth impossible”. By creating new channels for water to flow through the land, soil conditions improved, so the team was able to prepare the area in order to allow natural colonization of mangroves, as they never previously grew on this site behind the natural mangroves. Several months later Bung Bao was excited to announce: “Now that the mangroves have started to grow and the hydrology of the area has improved, fish and crabs have begun to populate the water ways providing the village with extra food and income from selling them at the market.”



Establishment of a transnational network for mangrove protection

Not only the exchange and communication on a local level was important for the project's success, but also the regular, cross-border exchange of the project partners. By combining knowledge and expertise from Sri Lanka, Cambodia, Germany, India and Thailand, they formed a transnational network for mangrove protection.

The framework of the network allowed regular exchange on lessons learned and challenges during implementation, as well as discussion of strategies on different aspects, such as long-term sustainability and community involvement, and to transfer recommendations of the other partners to their own project context. Each partner has their own field of expertise, as environmental education and alternative

restoration methods, and provided the rest of the team with helpful advice to make the implementation more efficient and successful.

At the beginning of the project, all partners participated in training on CBEMR in order to enable them to implement this technique on pilot areas in their own project countries. Afterwards, the partners met on a yearly basis in one of the project countries to learn about different strategies and approaches by visiting the project site and meeting local stakeholders. By the end of the project, each partner had the opportunity to visit each project site and thus gained a great deal of valuable new input for their own project work.





Project community in Thailand.

The exchange of international experts helps disseminating lessons learned and best practices which improve future projects.



Lessons

LESSONS LEARNED



LESSONS LEARNED

SITE SELECTION

Choosing sites with the right conditions is crucial for the success of mangrove restoration projects. Hydrology is one of the most essential factors for the successful restoration of mangrove forests. Similar to many possible sites for mangrove restoration, hydrology was also challenging at some of the project sites. Under these conditions traditional reforestation measures are prone to failure. Thus, re-establishing hydrology should be the first step, before considering rehabilitation.

MIND SEASONAL PATTERNS

If restoration is conducted, ensure increased survival rates through planting only during the rainy season. If fires are an issue for the project site, water should be sprayed during the dry season. Protective, sufficiently wide canals across the land can prevent wildfire from spreading to the project areas.

DISTRIBUTION OF RESTORATION SITES

Although having multiple restoration sites can be complex and time-consuming, a wide variety of sites in different zones can also be beneficial for future trainings and field study trips. The number of villages involved in Thailand, for example, has helped to disseminate the CBEMR approach more widely and expanded the partners' connections and networking.

LAND TENURE

Unclear land tenure can be a fundamental obstacle to mangrove restoration. It is therefore very important to clarify land ownership from the very beginning so there are no misunderstandings on the long-term conservation of the site and project investment. This also includes making written long-term agreements with the landowners, to make sure that they are actually committed to the project. The provision of livelihood support to the communities in exchange for long-term user rights of the site can further facilitate long-term support and acceptance.







BENEFIT FROM LOCAL KNOWLEDGE

Local fishermen often have good traditional knowledge about tidal patterns during different seasons. Including their knowledge can be very helpful and, for example, allowed the creation of hydrology correcting canals without further technical consultancy in India.

COMMUNITY INVOLVEMENT

In many areas, mangroves disappear due to coastal development or remain degraded because the local communities over-utilize them in an unsustainable way. These processes often occur because local communities have limited knowledge about mangroves and are unaware of the benefits they provide. Therefore, the involvement of the local communities is indispensable for the success of mangrove conservation and restoration. However, it has to be kept in mind that developing a relationship with a new community can take quite some time, effort and budget. This particularly applies when it is intended to actively work with a community that has little knowledge and experience in conservation work. If possible, try to select restoration sites in communities that already have strong capacity in conservation work or calculate sufficient time and resources when starting to work in unexperienced ones.

ALTERNATIVE INCOMES

The unsustainable use of mangroves often occurs due to a lack of alternative income opportunities. It is therefore important to develop alternative income strategies together with local communities. The provision of alternative income sources through the cultivation of cash crops and the buyback scheme of mangrove seedlings grown in household nurseries, have been very successful in the context of the project. Livelihoods can be a good mechanism to promote long-term conservation, especially when the livelihoods are directly linked with conservation work e.g. beekeeping, fishing and eco-tourism.

PROJECT ORGANISATION

Building a good organisational structure for the project is crucial. Especially regarding the involvement of the local communities, a proper structure and internal regulations that assign clear but realistic responsibilities are key. A regular follow up and exchange is vital.







SUFFICIENT TIME FOR FOLLOW-UP PROCESSES

In order to ensure a successful and sustainable project implementation, a follow-up phase of at least five years is required for restoration sites. Thus, sufficient time for monitoring and evaluation activities after actual restoration should be allocated. Unless external funding is sourced to finance the activities, this can become challenging.

LAW ENFORCEMENT

Although mangrove forests are often legally protected, low awareness among local communities and local law enforcement officers commonly results in poor law enforcement with regard to encroachments. Sensitization of local communities and law enforcement agencies is thus important to encourage collective action of the civil society for mangrove protection.

LET NATURE COME BACK ON ITS OWN

Allowing a site to restore naturally usually ensures an ecosystem closer to the original species composition and a higher species biodiversity. If the site needs further support by direct hand-planting, make sure that nature is emulated, e.g. by considering species composition of a site, growth patterns and distribution of species in their correct zonation. Sufficient space between the planted seedlings allows room for saplings returning naturally and thus increases biodiversity. Whatever restoration practice is selected, never forget to involve local communities in the planning, implementation and monitoring process.



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