Mangroves for the Future
INVESTING IN COASTAL ECOSYSTEMS
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Mangroves for the Future (MFF) is a unique partner-led initiative to promote investment in coastal ecosystem conservation for sustainabl e development. Co-chaired by IUCN and UNDP, MFF provides a platform for collaboration among the many different agencies, sectors and countries which are addressing challenges to coastal ecosystem and livelihood issues. The goal is to promote an integrated ocean-wide approach to coastal management and to building the resilience of ecosystem-dependent coastal communities.

MFF builds on a history of coastal management interventions before and after the 2004 Indian Ocean tsunami. It initially focused on the countries that were worst affected by the tsunami - India, Indonesia, Maldives, Seychelles, Sri Lanka and Thailand. More recently it has expanded to include Bangladesh, Cambodia, Pakistan and Viet Nam.

Mangroves are the flagship of the initiative, but MFF is inclusive of all types of coastal ecosystem, such as coral reefs, estuaries, lagoons, sandy beaches, sea grasses and wetlands.

The MFF grants facility offers small, medium and la rge grants to support initiatives that provide practical, hands-on demonstrations of effective coastal management in action. Each country manages its own MFF programme through a National Coordinating Body which includes representation from government, NGOs and the private sector.

MFF addresses priorities for long-term sust ainable coastal ecosystem management which include, among others: climate change adaptation and mitigation, disaster risk reduction, promotion of ecosystem health, development of sustainable livelihoods, and active engagement of the private sector in developing sustainable business practices. The emphasis is on generating knowledge, empowering local communities and advocating for policy solutions that will support best practice in integrated coastal management.

Moving forward, MFF will increasingly focus on building resilience of ecosystem-dependent coastal communities by promoting nature based solutions and by showcasing the climate change adaptation and mitigation benefits that can be achieved with healthy mangrove forests and other types of coastal vegetation.

MFF is funded by Danida, Norad and Sida

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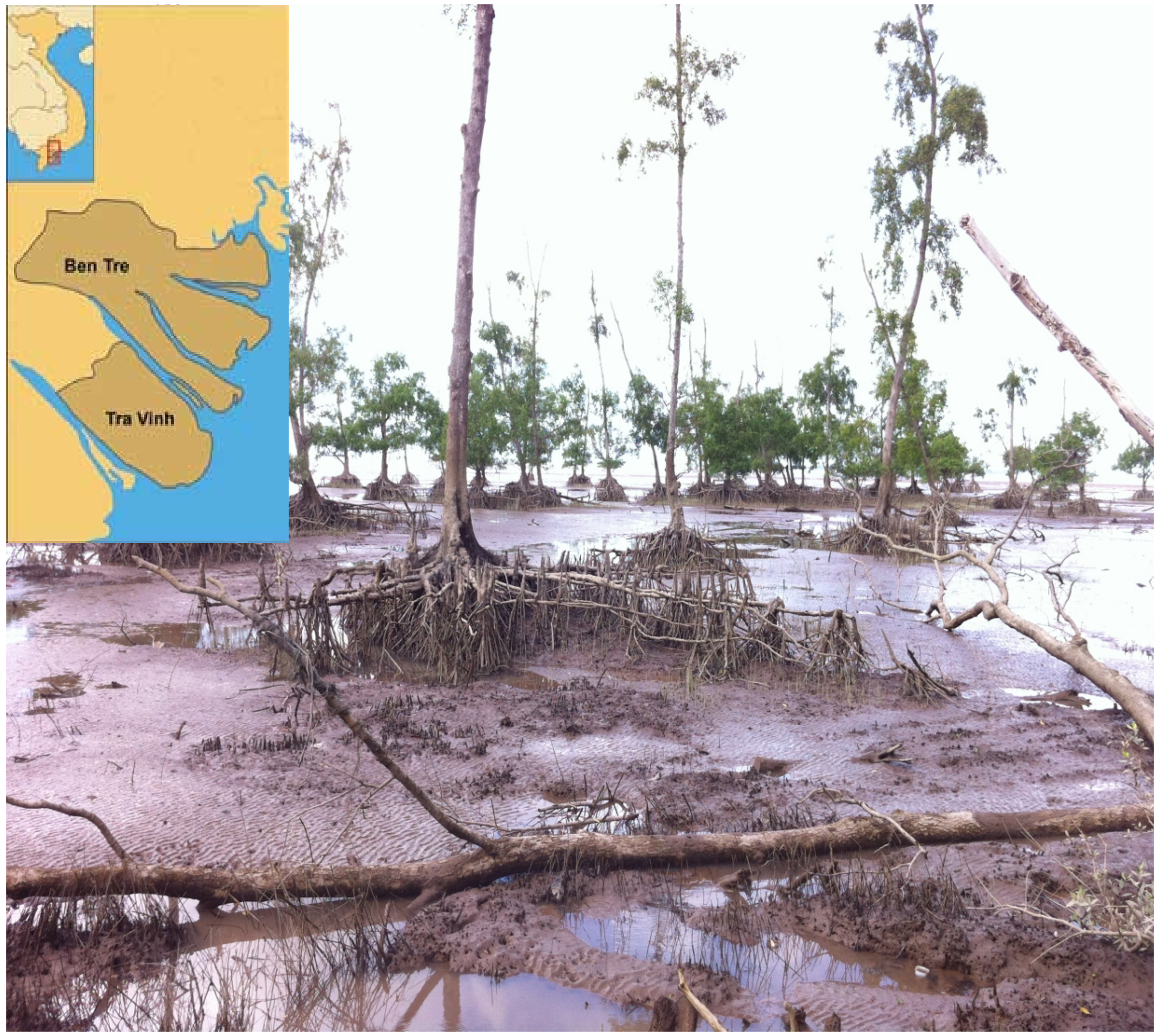
Site Evaluation

OF COASTAL EROSION AND POTENTIAL SOLUTIONS IN BEN TRE AND TRA VINH PROVINCES, VIET NAM



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Cover photo: Seaward end of the mangroves forest belt at site 7 in Duyen Hai District, Tra Vinh Province (Ing. Thorsten Albers)

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TABLE OF CONTENTS PAGE

LIST OF FIGURES PAGE

LIST OF FIGURES

PAGE

1. PREFACE

Coastal communities in many parts of Asia are particularly vulnerable to the impacts of climate change, with increased severity of extreme weather events directly affecting the lives of millions of people and damaging the ecosystems and resources they rely on for everyday survival.

This report has been produced as part of the Mangroves for the Future (MFF) initiative. MFF is a unique partner-led initiative to promote investment in coastal conservation for sustainable development. Co-chaired by IUCN and UNDP, MFF works to restore the health of coastal ecosystems as a contribution to building resilience in coastal communities in Asia. The emphasis is on generating knowledge, empowering local communities and governments, and working to promote policy solutions that will support best practice inintegrated coastal management.

Moving forward, MFF will increasingly focus on building resilience of coastal communities by promoting ecosystem-based approaches and by showcasing the climate change adaptation and mitigation benefits that can be achieved with healthy mangrove forests and other types of coastal vegetation.

Healthy coastal ecosystems play a major role in helping coastal communities to adapt to climate change impacts. Mangroves and other coastal vegetation support biodiversity conservation and enable improvements in livelihoods and human well-being, while also providing cost-effective risk reduction against such threats as coastal erosion, storm surges and tsunamis. Mangroves also offer potential for mitigating climate change impacts through their high carbon storage capacity, thereby contributing to the Reducing Emissions from Deforestation and Degradation (REDD+) process.

At the same time, MFF is working to improve the effectiveness of governance and management of coastal resources by promoting models of co-management, payment for ecosystem services and similar resource-sharing mechanisms that will benefit traditional coastal communities. This is particularly important given that conservation may often appear to have high opportunity costs when other uses of natural areas (notably aquaculture) are more profitable in the short term, and that the local communities most affected by natural resource decision making may not have a voice.

This report is one of many which highlight ecosystem-based approaches being developed and tested around Asia. It is being produced and shared by MFF in order to serve as a resource and learning tool for coastal management practitioners, but also to help in raising awareness of the many issues and challenges which surround the protection of Asia's coastlines and the communities they support.

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2. INTRODUCTION

The Mekong Delta, although relatively small in size compared with the entire country, plays an important role as “rice bowl” for the whole of Vietnam. But the lack of an integrated approach to sustainable management, utilisation and protection of the coastal zone, unclear responsibilities of local authorities and rapid expansion and economic interests in shrimp farming have led to rising concerns over environmental and social impacts and resulted in the unsustainable use of natural resources in the coastal zone of Ben Tre and Tra Vinh Provinces . This is threatening the protection function of the mangrove forest belt and reducing income for local communities.

The coastal zone is not only at risk from the negative ecological consequences of shrimp farming and the unsustainable use of natural resources, it will also be affected by the impacts of climate change which will cause increased intensity and frequency of storms and floods and rising sea levels. Decisions made now about climate change adaptation measures which focus on a single strategy rather than a diverse suite of adaptation strategies, may lead to path dependencies and ultimately to a reduction in adaptive capacity. When addressing climate change and adaptation we are dealing with uncertainty. It is therefore important not to put all efforts in a single adaptation strategy, but to focus on ecosystem-based approaches which address diversity and adaptive capacity.

Using the expertise of Dr. Thorsten Albers, in three construction phases in 2012 and 2013, approximately 5,000 m bamboo fences were built at the coasts of Soc Trang and Bac Lieu as erosion protection measure. Before that Dr. Albers did the field survey, the physical and numerical modelling as well as the design of the bamboo breakwaters and bamboo fences. Subsequently, he supported the tendering of the construction measures in both provinces. All steps of the installation and construction were documented. A monitoring programme to assess the stability and the effects of the structures was established and started.

The construction of the bamboo breakwater and bamboo fences in Soc Trang and Bac Lieu served as a pilot project for erosion protection and mangrove rehabilitation in erosion sites, which will also be used to gain knowledge for future application and optimisation through a detailed documentation and monitoring. The strategy of area coastal protection using T-shaped bamboo fences is described in detail in the “Shoreline Management Guidelines for the Lower Mekong Delta” which were prepared by the lead author Dr. Albers on behalf of GIZ Soc Trang (Albers et al., 2013). Area coastal protection will have a key role in climate change adaptation.

Based on these experiences in the coastal zone of the lower Mekong Delta Dr. Albers did a field survey in Ben Tre and Tra Vinh and evaluated different sites concerning coastal erosion planning. Various sites, which were preselected by IUCN and its national partners, were evaluated. The primary goal of the survey was to identify potential locations for the application of bamboo groins and coastal floodplain management. Available data with relevance for the visited sites were researched and analysed. In the frame of the site evaluation a visual control, photo documentation and a GPS survey of the shoreline were done. Supplementary, sediment samples (grain size distribution) were taken and analysed. Based on the survey and on available data, the degree of exposure, the hydrodynamic loads and the morphodynamic status quo were evaluated. Recommendations for further erosion control planning are given in this report.

3. BASIC PROCESSES

Large parts of this chapter have been modified from the "Shoreline Management Guidelines Coastal Protection in the Lower Mekong Delta" (Albers et al., 2013).

3.1 Hydrodynamics and morphodynamics of deltas and estuaries

Hydrodynamics and morphodynamics are similar in both estuaries and deltas. The discharge from rivers with deltas is large enough to transport the sediment load to the river mouth or beyond. If the rate of sediment supply exceeds the rate of sediment dispersal by waves and tidal currents, a coastal accumulation of sediments forms a delta, typically extending seawards from the river mouth. In estuaries without deltas, the discharge is not sufficient to transport sediments to the river mouth. Sediments therefore accumulate in the estuary and no delta is formed. In some cases, the sediment load in the estuary may not be sufficient to form a delta.

Deltas are usually fed by rivers with extensive catchment areas and many tributaries supplying both water and sediment. Water supply and sediment discharge are determined by precipitation and erosion within the catchment areas and themselves depend on the climate, local geology, relief and land use.

There is a wide variety of delta types, depending on the relative influences of river flow, wave action and tidal currents. Deltas are highly dynamic systems. Patterns of erosion and accumulation can vary in time and space.

Delta complexes can be hundreds of kilometres across. They commonly consist of an extensive lowland area just above sea-level (the delta plain), crossed by a network of active and abandoned channels (Figure 1). The raised banks of the channels are called levees, and are separated by either vegetated or shallow-water (wetland) areas. The numerous channels or distributaries range in width from tens or hundreds of metres to several kilometres.

Where the tidal range is small (less than approximately 0.5 m), the delta is dominated by the river discharge. Mixing processes and sedimentation mostly take place seaward of the mouths.

Tide-dominated deltas occur where the tidal range is large (>4 m). Although net sediment transport is seawards, there is also some landward movement of sediment on the ebb tide. In tide-dominated deltas, sediments transported by river flow and deposited near the mouths are rapidly reworked by tidal currents into a series of linear subaqueous ridges.

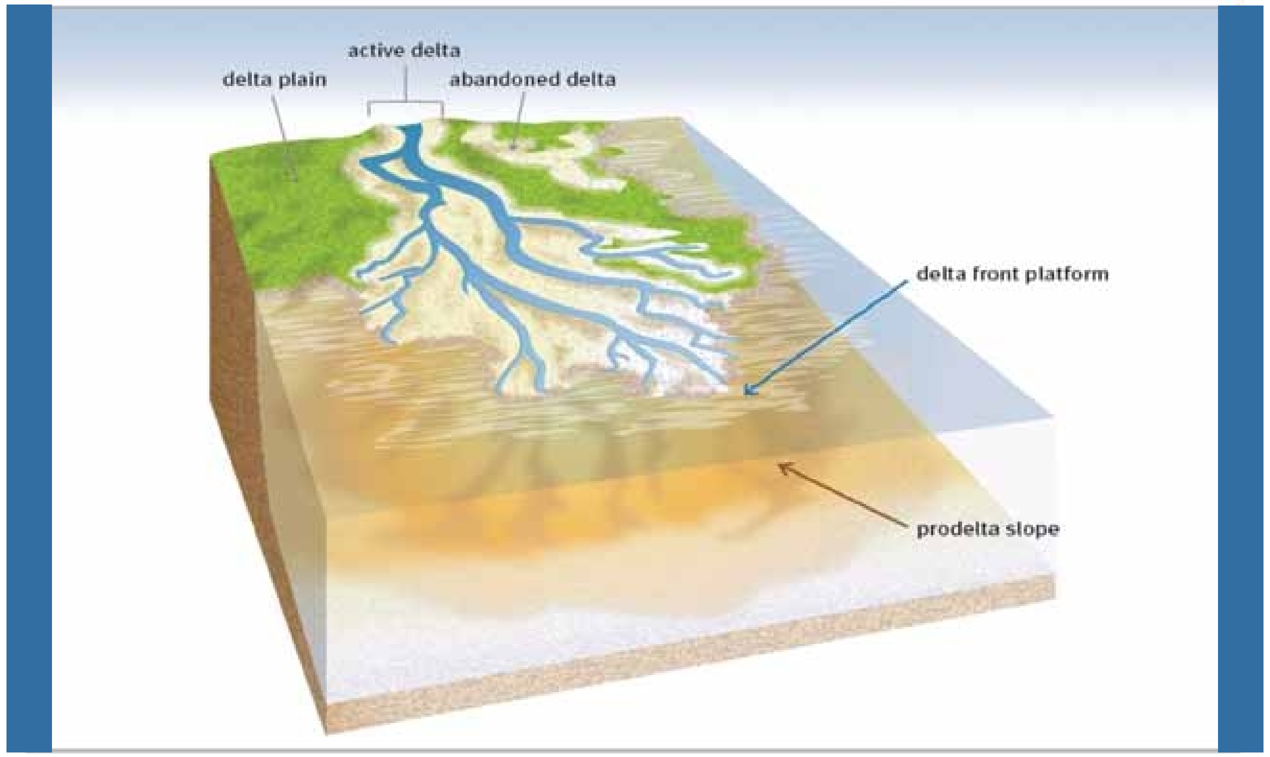

Figure 1: Perspective view of a delta showing the principal components (Albers et. al, 2013)

If wave energy at the coast is sufficiently high, a wave dominated delta can occur. In such situations, the river flow and, temporarily, the ebb current are moving seawards against the direction of wave propagation so that wave speed and wavelength decrease and wave height increases. As a result of these changes, waves approaching the river mouth are liable to break earlier in deeper water than they would normally. The strong mixing of seawater with river water in this zone leads to rapid deposition of sediments. The shorelines of wave-dominated deltas are characterised by straight, sandy beaches.

The coasts of the lower Mekong Delta are a mixed-energy environment (tide-dominated; tidal range of 3.0 to 3.5 m in the mouths of the Mekong arms) affected by the discharge regime of the Mekong River and its sediment load, the tidal regime of the Vietnamese East Sea as well as coastal long-shore currents driven by prevailing monsoon winds and the corresponding wave conditions. In this complex environment patterns of erosion and accumulation change in time and space. When the cross-section of the river widens at the mouth, the flow velocities decrease (due to the continuity equation) and the transported sediments start to settle. In general, sediments with a larger grain size are deposited closer to the mouth than finer sediments. Due to complex patterns of the bathymetry in the foreshore area sandy shorelines and silty or clayey shorelines may change independently from the general pattern. Especially in sheltered areas, e.g. in the lee side of islands or peninsulas, muddy sections may occur. While the coasts of Soc Trang and Bac Lieu Provinces are further away from the mouths of the Mekong and mostly dominated by mud, the characteristics of the coasts of Ben Tre and Tra Vinh are more diverse due to their location. For this reason an evaluation of the preselected sites is essential before planning any further erosion protection measures.

3.2 Principle of coastal protection using bamboo fences

Active measures of area coastal protection can be divided into floodplain management and nourishment. Floodplain management is a sustainable and effective method of coastal erosion and flood protection. Systematic land reclamation to create floodplains has been carried out at the German North Sea coast for more than 150 years. This principle of land reclamation and floodplain management has been transferred to the east coast of the Mekong Delta and has been adapted to local boundary conditions, by using local materials such as bamboo. Bamboo fences yielded the best results and have additional advantages due to the strength, availability and low cost of bamboo (Halide et al., 2004, Albers & Von Lieberman, 2011).

On coasts with low-lying floodplains, consisting either of marsh or a mangrove belt, the floodplain is an important stabilising element of the coastal protection system. It protects against coastal erosion and flooding. The higher the floodplain, the greater the wave dissipation on the floodplain, and as a result, the wave load on the dyke is decreased significantly. In the presence of mangroves, the wave reduction effect is even larger (Figure 2). Mangroves also reduce storm surge water levels by slowing the flow of water and reducing surface waves. Therefore, mangroves play a role in coastal defence, either by themselves or alongside other measures such as engineered coastal defence structures (McIvor et al., 2012).

In many cases, the mangrove belt at the coast has been severely damaged by cutting the mangroves, by pollution or by modification of the hydrology, e.g. through preventing the natural flow of water, sediments and nutrients by dyke construction or by measures in front of the dyke.

Due to the soil stabilising characteristics of mangroves and their impacts as sediment traps, the loss of mangroves is equivalent to the loss of the floodplain. This heavily increases the wave load on the dyke and therefore the risk of erosion and flooding of the hinterland. Thus, restoration of the mangrove platform is a very important step towards sustainable coastal protection. Even the higher loads due to the rising frequency and intensity of storms can be dealt with by using integrated floodplain management.

Mangroves grow along sheltered tropical and sub-tropical coastlines. They do not grow naturally on sites with strong erosion. At sites where severe erosion has destroyed the mangrove belt, coastal protection and climate change adaptation through mangrove rehabilitation is only possible after the wave energy has been reduced by physical barriers (Balke et al., 2011). This combination of hard (physical barriers) and soft (mangroves) coastal engineering measures can be achieved by technical solutions, which reduce erosion, stimulate sedimentation and, based on their placement and design, avoid downdrift erosion as much as possible.

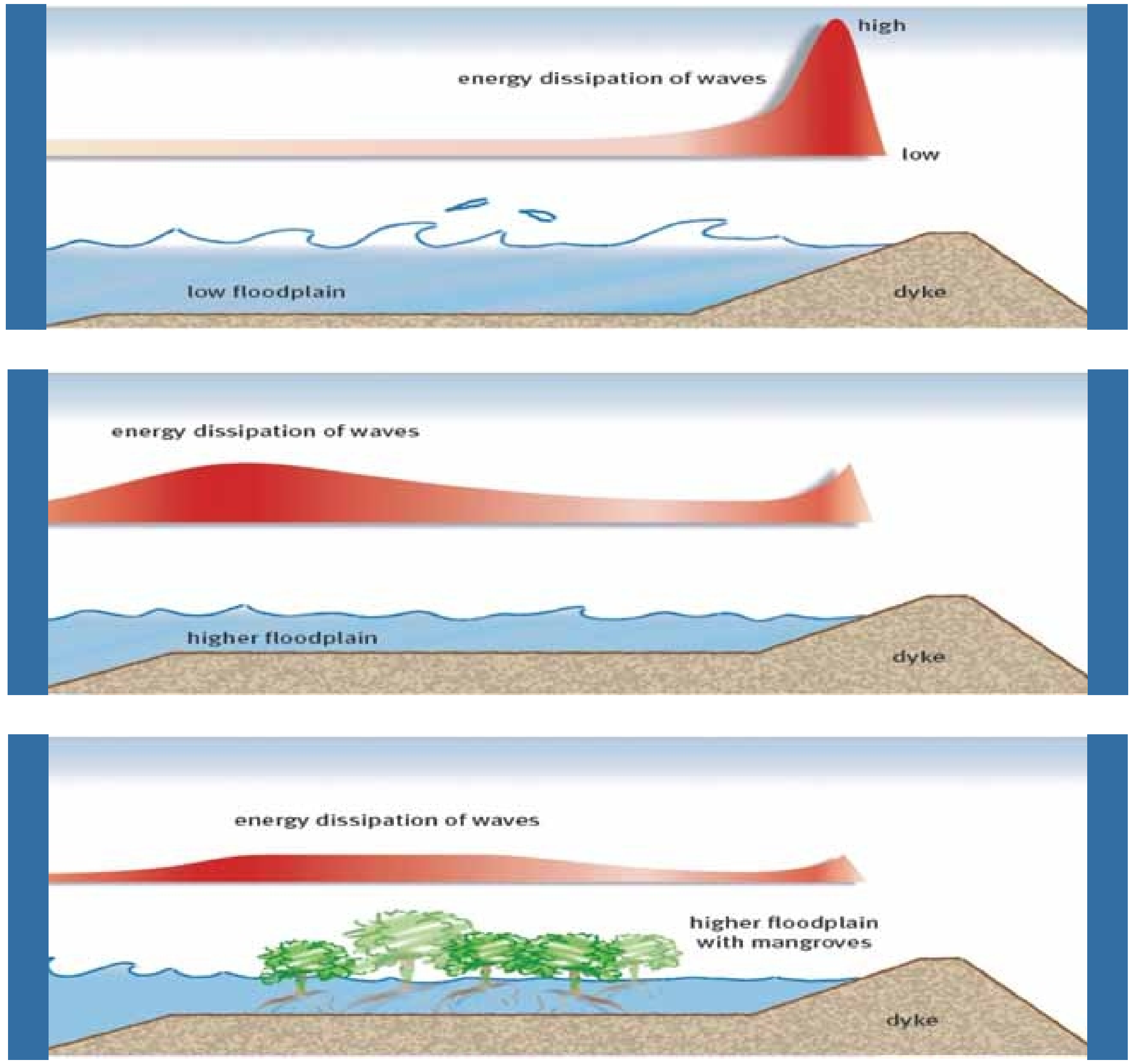

Figure 2: Impact of the floodplain on wave energy dissipation (Albers et. al, 2013)

In many cases, the construction of dykes reduces the width of the floodplain and increases the erosion of marshy areas. This reduction of the floodplain influences natural morphological processes. Restoration of marshy floodplains is therefore important in order to increase the safety level against flooding and to stop the erosion of the floodplain.

However, before the restoration of the mangrove forest in erosion sites takes place, a stable floodplain has to be established. The growth of floodplains can be enhanced by constructing sediment traps on the shallow tidal flats. This can be achieved using elements which decrease currents and waves, such as groins.

Suspended sediments and bedload are transported by tidal currents and waves. Due to decreasing turbulence, the transport capacity of the current decreases and sediment particles start to settle. This process takes place, for example, in basins and at the lee side of islands. The same principle can be applied to increase the deposition of sediments in an artificial way on the coast by means of systematic floodplain management measures. A mesh of chequered fields of calm water areas can be created through the construction of fence-like permeable structures which form a barrier against the turbulent currents and waves and support the deposition of sediments.

Cross-shore and longshore constructions form fields approximately 50 m x 50 m in size, where currents and waves are damped and deposition of sediments is supported (Figure 3). The cross-shore constructions decrease the longshore currents and the longshore constructions damp the incoming wave energy. The fences parallel to the shoreline have openings 20 m in width to secure the drainage of the fields. A system of drainage ditches, which will be created naturally by the water flow, enhances the drainage of the fields, and also helps to accelerate the consolidation process. The development of the drainage ditches can be accelerated by dredging works.

Figure 4 shows the flow and sediment transport patterns in the fields during flood tide (left) and ebb tide (right) . During flood tides, and especially while water levels are below the crest of the fences, the flow resistance is reduced within the openings, resulting in larger flow velocities in this area compared tot he flow velocity along on the landward side of the fences ($v_{f,1} < v_{f,2}$). A larger volume of water and more sediments are transported through the openings into the fields compared to sediment transport through the fences. On the landward side of the openings, the flow cross-section widens, flow velocities decrease ($v_{f,3} < v_{f,1}$ and $v_{f,4} < v_{f,2}$) and the transported sediments are distributed in a fan-shaped manner into the fields (brown arrows), and start to settle as a consequence of the decreased flow velocities. This improves the sediment input into the fields compared to structures without openings, which especially hinder sedimentation in areas further landward of the fences. In addition, such gaps between fences also do not interrupt the habitat linkage for aquatic species.

During ebb tide, the flow resistance is reduced within the openings compared to flow through the fences ($v_{e,2} < v_{e,3}$). The flow pattern in the field is directed towards the openings, and as a consequence, drainage is improved and accelerated through the openings, causing the water content of the soil in the fields during low tide to decrease and therefore accelerating the consolidation process in the fields. Consolidation is important for increasing stability against erosion. The current velocity in the fields during ebb tide ($v_{e,1}$) is smaller than the critical current velocity that induces erosion. The sediments therefore remain within the fields. The critical current velocity is only exceeded in the drainage ditches (either man-made or created by the water flow; in Figure 4 indicated with dashed brown lines), which keep up the drainage of the fields.

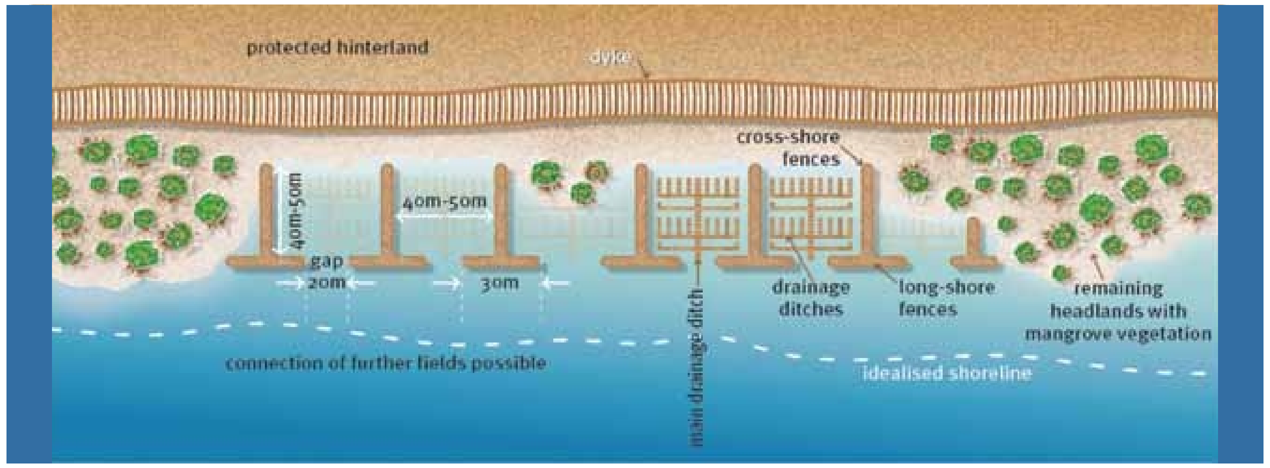

Figure 3: Land reclamation using cross-shore and longshore fences (Albers et. al, 2013)

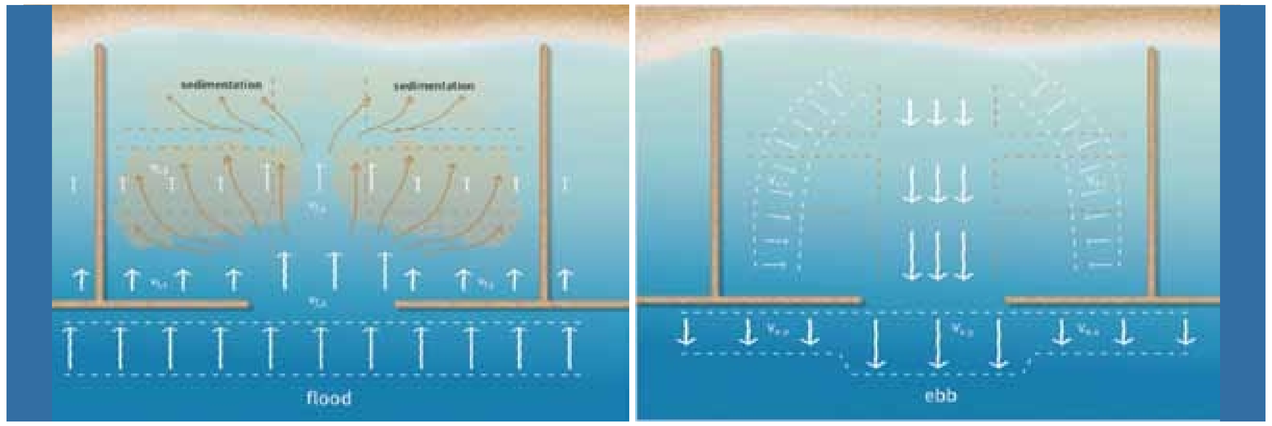

Figure 4: Flow patterns and sediment transport in the fields protected by the fences (Albers et. al, 2013)

The principle of coastal floodplain management using bamboo groins as described before only works if certain boundary conditions are fulfilled:

- Low-lying floodplains with a very shallow gradient
- Tidal conditions that result in longer durations of flooding on the tidal flats
- Muddy environment
- High concentrations of fine sediments in the water
- Sediment transport mainly in suspension
- Limited degree of exposure to waves
- No open and straight coastline; possibility to create a smooth coastline by closing gaps between remaining headlands of floodplains

Some of the bullet points interact with or cause each other , e.g. larger waves will re-suspend fine sediments and create a steeper beach mainly consisting of sand on which the duration of flooding then is not long enough to accumulate significant amounts of sediments. Thus, it is very important to evaluate the sites in Ben Tre and Tra Vinh. If the environment is not sufficient for the application of groins, the installation will not be successful.

4. SITES

Between November, 13th and 16th in Ben Tre Province and Tra Vinh Province in total eight preselected sites endangered by coastal erosion were visited and evaluated. The pre-selection had been done by the local partners of IUCN in the provinces. The site evaluation was done by Dr. Thorsten Albers who was accompanied by Mr. Duong Thanh Thoai (IUCN) and several delegates of the local partners. The aim was an evaluation of the various sites in terms of coastal erosion protection with a focus on the applicability of T-shaped bamboo fences. Figure 5 shows an overview of the visited sites (sites 1 to 6 in Ben Tre, sites 7 and 8 in Tra Vinh).

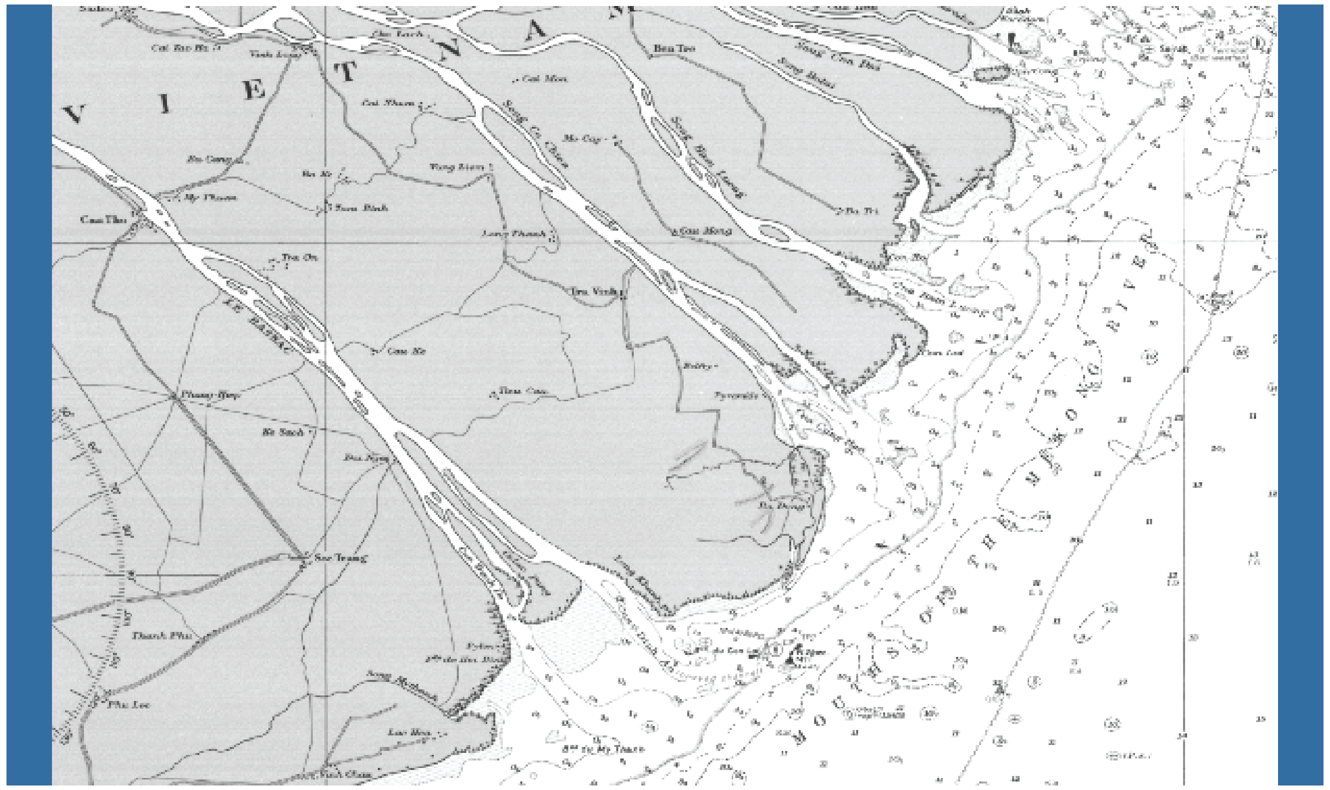

Figure 5: Overview map of Ben Tre and Tra Vinh and the visited sites

4.1 Ben Tre Province, Ba Tri District, An Thuy Commune

Figure 6 shows an overview map of site 1 (approximate position: 679532.65 m E, 1102689.91 m N; WGS 84, zone 48 P, UTM projection). At site 1 mainly a sandy beach with only minor fractions of silt and clay exists. Samples 1 and 2 represent the general soil characteristics at site 1 (sample 1: 99.68% sand, 0.32% silt and clay; sample 2: 94.18% sand, 5.82% silt and clay; see Table 1 in Annex for the results of sample analysis). The location of sample 3 was explicitly chosen to assess the characteristics of the harder silty/clayey soil that occurs only locally and is mostly covered by sand. This soil does not represent the characteristics of site 1 (sample 3:

23.41% sand, 76.58% silt and clay). The beach gradient is relatively steep, which results in short durations of flooding in the upper part of the beach. Water levels reach the top of the beach only during spring tides. In front of the eastern part of site 1 tidal flats of 150 m to 400 m width are submerged during low water. Wind directions from northeast lead to waves that approach parallel to the beach. Winds from southern directions lead to perpendicular to oblique wave angles on the beach. Due to the offshore tidal flats the wave exposure is moderate. All along site 1 an erosion edge is visible on the dry beach. Floating refuse indicates the highest water levels that are reached during spring tide twice a month. In the eastern part of site 1 remains of the former boundary of fields are visible, indicating significant erosion. Especially in the eastern part, watermelon fields are endangered by erosion and regular flooding. Farmers applied individual erosion protection measures consisting of Nypa leaves and wooden piles which have only been temporarily successful Along site 1, but especially in the eastern part smaller areas of a hard clay layer are visible. This layer is mostly covered by sand which shows the intense morphodynamics at site 1.

Figure 6: Overview map of site 1 including locations of soil samples 1, 2 and 3

Figure 7: Sandy beach at site 1, centre part, viewing direction west

Figure 8: Sandy beach at site 1, western part, viewing direction east

Figure 9: Erosion edge in site 1, western part, viewing direction north

Figure 10: Remains of former boundaries of fields at site 1, eastern part, viewing direction southeast

Figure 11: The beach at site 1, eastern part, viewing direction east, hard clayey materials

Figure 12: Improvised erosion protection at site 1, eastern part, viewing direction east

Figure 13: Watermelon fields endangered by erosion in site 1, eastern part

4.2 Ben Tre Province, Ba Tri District, Bao Tuan Commune

Figure 14 shows an overview map of site 2 (approximate position: 685051.56 m E, 1107519.82 m N; WGS 84, zone 48 P, UTM projection). At site 2 a sandy beach with only minor fractions of silt and clay exists. Smaller areas with harder sitly/clayey material are visible but mostly covered with sand. Sample 5 represents the general soil characteristics at site 2 (sample 5: 99.61% sand, 0.39% silt and clay). The location of sample 4 was explicitly chosen to assess the characteristics of the harder silty/clayey soil that occurs only locally and is mostly covered by sand. This soil does not represent the characteristics of site 2 (sample 4: 24.32% sand, 75.88% silt and clay). The beach gradient is relatively steep, which results in short durations of flooding in the upper part of the beach. Water levels reach the top of the beach only during spring tides. In many places adapted solutions of revetments were applied by the farmers. Wind directions from the northeast lead to waves that approach perpendicular to the beach. Winds from southern directions lead to oblique wave angles on the beach. Due to missing offshore tidal flats the wave exposure is larger than at site 1. All along site 2 an erosion edge is visible on the dry beach. Farmers applied individual erosion protection measures consisting of Nypa leaves and old rice bags filled with sand.

Figure 14: Overview map of site 2 including location of soil samples 4 & 5

Figure 15: Sandy beach at site 2, northern part, viewing direction north

Figure 16: Sandy beach site 2, centre part, viewing direction north

Figure 17: Sandy beach at site 2, north center, soil sample 5

Figure 18: Erosion protection at site 2, center part

Figure 19: Details of erosion protection at site 2, center part

4.3 Ben Tre Province, Binh Dai District, Thua Duc Commune

At site 3 a sandy beach with a steep beach gradient exists. Sample 6 represents the general soil charecteristics at site 3 (sample 6: 99.72% sand, 0.28% silt and clay).

Durations of flooding especially in the upper part of the beach are short. In some places local erosion protection measures (concrete tubes) already failed. Wind directions from northeast lead to waves that approach the beach with oblique angles. Waves that are induced by winds from southern directions do not reach the beach directly. All along site 3 a small erosion edge is visible on the dry beach. Floating refuse indicates the highest water levels that are reached during spring tide twice a month. Wave exposure during those events is large enough to scour the concrete tubes.

Figure 20: Sandy beach at site 3, western part, viewing direction southeast

Figure 21: Sandy beach at site 3, centre part, viewing direction west

Figure 22: Local erosion protection measures at site 3, eastern part

Figure 23: Damaged local erosion protection measures at site 3, eastern part

4.4 Ben Tre Province, Binh Dai District, Thua Duc Commune

Figure 24 shows an overview map of site 4 (approximate position: 695397.21 m E, 1120601.00 m N; WGS 84, zone 48 P, UTM projection). At site 4 a mixed environment with sandy material and larger fractions of fine sediments exists. The results of sample 7 indicate those general soil characteristics at site 4 (sample 7: 34.39% sand, 29.96% silt and 35.65% clay). The shoreline is formed by a very narrow beach with a very steep erosion edge (approximately 90°, 1 -1.5 m high). The bathymetry of the foreshore is very complex, due the location at a major creek. Wind directions from northeast lead to waves that approach parallel to the beach. Winds from southern directions lead to perpendicular to oblique wave angles on the beach. Attempts to defend smaller shrimp ponds with a narrow earth dyke failed.

Figure 24: Overview map of site 4 including the location of soil sample 7

Figure 25: Remains of small dam at site 4, eastern part, viewing direction northeast

Figure 26: Shorelines at site 4, eastern part, viewing direction northeast

Figure 27: Shorelines at site 4 including erosion edge, eastern part, viewing direction northeast

Figure 28: Beach at site 4, eastern part, viewing direction northeast

4.5 Ben Tre Province, Thanh Phu District, Thanh Hai Commune

Figure 29 shows an overview map of site 5 (approximate position: 684002.99 m E, 1094444.94 m N; WGS 84, zone 48 P, UTM projection). At site 5 a sandy beach exists. Silty and clayey material is covered with a thick sand layer. Sample 8 and 9 represent the general soil characteristics at site 5 (sample 8: 95.40% sand, 4.60% silt and clay; sample 9: 99.35% sand, 0.65% silt and clay). In the last years the characteristics of this coastal section changed due to changed morphodynamics with strong sand accumulation. Severe mangrove forest decline due to sand accumulation is visible at the southeast part of the site. Wind directions from northeast lead to waves that approach the beach perpendicular angle. Waves that are induced by winds from southern directions do not reach the beach directly. Along site 3 no significant erosion is visible.

Figure 29: Overview map of site 5 including the locations of soil samples 8 & 9

Figure 30: Sand accumulation and mangrove forest decline in the south-eastern part of site 5

Figure 31: Sand accumulation in the northern part of site 5

Figure 32: Small earth wall made by local farmers to prevent sand accumulation in the mangroves

4.6 Ben Tre Province, Thanh Phu District, Thanh Hai Commune

Figure 33 shows an overview map of site 6 (approximate position: 682757.42 m E, 1088667.35 m N; WGS 84, zone 48 P, UTM projection). At site 6 a sandy beach with only minor fractions of silt and clay exists. Sample 10 represents the general soil characteristics at site 6 (sample 10: 99.61% sand, 0.39% silt and clay). The beach gradient is relatively steep, which leads to short durations of flooding in the upper part of the beach. In many places adapted solutions of revetments have been applied by farmers and restaurant owners (e.g. old rice bags filled with sand). In the northern part of site 6 a collapsed building is visible on the beach. Wind directions from northeast and southwest lead to oblique to perpendicular wave angles on the beach. All along site 6 an erosion edge is visible on the dry beach. Floating refuse indicates the highest water levels that are reached during spring tide twice a month. Wave exposure at site is larger than at the other sites.

Figure 33: Overview map of site 6 including the location of soil sample 10

Figure 34: Sandy beach at site 6, northern part, viewing direction southwest

Figure 35: Attemps at erosion protection at site 6, northern part

Figure 36: Sandy beach at site 6 including collapsed building, northern part, viewing direction north

Figure 37: Sandy beach at site 6, northern part, location of soil sample 10

Figure 38: Sandy beach at site 6 including adapted erosion protection measures, southern part, viewing direction south west

4.7 Tra Vinh Province, Duyen Hai District, Long Vinh Commune

Figure 39 shows an overview map of site 7 (approximate position: 672038.43 m E, 1075973.59 m N; WGS 84, zone 48 P, UTM projection). At site 7 a 500 m to 650 m wide mangrove belt exists, tapering to the northwest and widening to the southeast. At the seaward end of the mangroves forest erosion rates of 100 m to 150 m in seven years can be assessed based on Google Earth images. At site 7 major fractions of silt and clay form the soil. Sample 11 represents the general soil characteristics at site 7 (sample 11: 20.63% sand, 61.11% silt and 17.26% clay. The grain size distribution is comparable to that of sample 3 at site 1, but the mud at site 7 is significantly less consolidated than the silty/clayey layers at other sites that have been covered (and compressed) by a thick sand layer. The shore has a very low gradient, which lead to long durations of flooding in all parts of the shore. Wind directions from the south lead to oblique wave angles at site 7. Waves that are induced by winds from northern directions do not reach site 7 directly. Wave exposure at site 7 is less than at the other sites.

Figure 39: Overview map of site 7 including the location of soil sample 11

Figure 40: Seaward end of mangrove forest belt at site 7

Figure 41: Mangrove forest belt at site 7

Figure 42: Location of soil sample 11 at site 6

4.8 Tra Vinh Province, Duyen Hai District, Hiep Than Commune

Figure 43 shows an overview map of site 8 (approximate position: 649792.55 m E, 1055998.78 m N; WGS 84, zone 48 P, UTM projection). At site 8 in general a sandy beach with only minor fractions of silt and clay exists. Smaller areas with harder silty/clayey material are visible (especially in the southern part) but mostly covered with sand. Sample 12 and 14 represent the general soil characteristics at site 8 (sample 12: 99.43% sand, 0.57% silt and clay; sample 14: 92.89% sand, 7.11% silt and clay). The location of sample 13 was explicitly chosen to assess the characteristics of the harder silty/clayey soil that occurs only locally and is mostly covered by sand. This soil does not represent the characteristics of site 8 (sample 13: 22.88% sand, 42.44% silt and 34.67% clay). The relatively narrow beach has steep beach, which leads to short durations of flooding of the beach. Wind directions from northeast and southwest lead to oblique wave angles on the beach. At the northern end of site 8 the concrete dyke ends. An earth dyke reinforced with a plastic foil is relocated backwards along the northern part of site 8. At the southern part of site 8 a hard clayey layer is mostly covered with sand.

Figure 43: Overview map of site 8 including locations of soil samples 12,13 and 14

Figure 44: Sandy beach at site 8, northern part, viewing direction south

Figure 45: Sandy beach at site 8, northern part, viewing direction north

Figure 46: Reinforced dyke and sandy beach at site 8

Figure 47: Sandy beach at site 8, southern part, viewing direction south

Figure 48: Hard clay layer at site 8

5. EVALUATION

5.1 Ben Tre Province, Ba Tri District, An Thuy Commune

Especially in the eastern part of site 1, significant erosion is visible, and is evidenced by the remains of old fields and the attempts of local farmers to protect their current fields.

The GPS track and the position of soil sample 3 also indicate erosion. In the western part erosion seems to beless and only occurs during stormtides.

The main boundary conditions for theapplication of bamboo fences are not fulfilled. T-shaped bamboo fences are not applicable due to the lack of fine sediments and the steep beach gradient. The durations of flooding and the sedimentation rates would be far too low to accumulate enough sediments for successful floodplain management. Thus, the principle of T-shaped bamboo fences does not work at site 1.

If hard erosion protection measures, such as groins or breakwaters, are applied at site 1, one must be aware that the erosion problem is shifted along this coastal section. Downdrift erosion will occur. Thus, follow-up costs but also maintenance costs will be very high. The constructions, if done properly, would be expensive.

It is recommended to try to hold the line in the western part of site 1 by maintaining the plants and trees there as far as possible. The extension of farmland must be avoided there.The farmers in the eastern part of site 1 apply individual emergency erosion protection measures just when the sea reaches the edge of their fields. They build improvised revetments as a narrow linear protection. It is recommended to introduce a more anticipatory approach which uses the seaward boundary of the fields as a first defence line. It can be reinforced with simple measures. Therefore an index and a subsequent evaluation of existing individual protection measures should be carried out. The field itself or at least a part of it is given up and transformed to an area that forms the second line of coastal protection. It can be vegetated but not extensively used. Available soil form the abandoned part of the field should be used to form a smooth slope towards the sea. This approach must be accompanied by management actions to convince the farmers of the sustainability of the measures. Cost-benefit analyses should support the approach.

5.2 Ben Tre Province, Ba Tri District, Bao Tuan Commune

Along site 2 erosion is visible at the higher part of the beach. The erosion edge develops during storm tides. In general erosion seems to be less than at site 1.

The main boundary conditions for the application of bamboo fences are not fulfilled. T-shaped bamboo fences are not applicable at site 2 due to the lack of fine sediments and the steep beach gradient. The durations of flooding and the sedimentation rates would be far too low to accumulate enough sediments for successful floodplain management. Thus, the principle of T-shaped bamboo fences does not work at site 2.

If hard erosion protection measures, such as groins or breakwaters, are applied at site 2, one must be aware that the erosion problem is shifted along this coastal section. Downdrift erosion will occur. Thus, follow-up costs but also maintenance costs will be very high. The construction, if done properly, would be expensive.

The same recommendations that have been given for the eastern part of site 1 are valid for site 2. The seaward boundary of the fields is established as a first defence line. It can be reinforced with simple measures. Therefore an index and a subsequent evaluation of existing individual protection measures should be done. The field itself or at least a part of it is given up and transformed to an area that forms the second line of coastal protection. It can be vegetated but not extensively used. Available soil from the abandoned part of the field should be used to form a smooth slope towards the sea. This approach must be accompanied by management actions to convince the farmers of the sustainability of the measures. Cost-benefit analyses should support the approach.

5.3 Ben Tre Province, Binh Dai District, Thua Duc Commune

Along site 3 erosion is visible at the higher part of the beach. The erosion edge develops during storm tides. In general erosion seems to be less than at site 1.

T-shaped bamboo fences are not applicable at site 3 due to the lack of fine sediments and the steep beach gradient. The durations of flooding and the sedimentation rates would be far too low to accumulate enough sediments for successful floodplain management. Thus, the principle of T-shaped bamboo fences does not work at site 3.

If hard erosion protection measures, such as groins or breakwaters, are applied at site 3, one must be aware that the erosion problem is shifted along this coastal section. Downdrift erosion will occur. Thus, follow-up costs but also maintenance costs will be very high. The construction, if done properly, would be expensive.

The same recommendations that have been given for the eastern part of site 1 and site 2 are valid for site 3. In many places the erosion edge has not yet reaches the seaward end of the fields. So it is possible to manage the area between the beach and the fields in a sustainable way. Hard measures such as concrete tubes must be avoided. The goal must be to create a smooth slope on the dry beach. One possibility that can be checked would be the application of sand bags

covered with sand dunes again. The beach at site 3 is in a dynamic equilibrium. No protection measure would be final and ultimate. Maintenance must be part of the protection strategy.

5.4 Ben Tre Province, Binh Dai District, Thua Duc Commune

Along site 4 a massive erosion edge exists that is visible only during low tide. The erosion edge develops during regular tides. Erosion is also visible at the narrow earth dyke built by locals. The comparison of aerial views and the GPS track indicates significant erosion at site 4.

T-shaped bamboo fences are not applicable at site 4 due to the lack of shallow tidal flats. On the landward side of the erosion edge the durations of flooding and the sedimentation rates would be far too low to accumulate enough sediments for successful floodplain management. The degree of exposure seaward of the erosion edge is too high for the application of the bamboo fences. The open and straight coastline and the lack of gaps between remaining headlands contradict the principle of T-shaped bamboo fences at site 3. Furthermore, the installation would be difficult due to character of the soil (hard clayey material).

Due to the complex boundary conditions simple measures to stop the erosion will not be successful. The influence of various major creeks would make any attempt to hold the current shoreline very costly. The recommendation is to create a buffer zone in which the shoreline is allowed to develop and use is forbidden. Similar to sites 1 to 3, existing structures in the hinterland could be used to create an area coastal protection system.

5.5 Ben Tre Province, Thanh Phu District, Thanh Hai Commune

At site 5 there is no problem of erosion. The severe mangrove forest decline that is clearly visible is due to increasing sand accumulation.

However, T-shaped bamboo fences are not applicable at site 5 due to the lack of fine sediments and the steep beach gradient. The durations of flooding and the sedimentation rates would be far too low to accumulate enough sediments for successful floodplain management. Furthermore, the open and straight coastline and the lack of gaps between remaining headlands contradict the principle of T-shaped bamboo fences at site 5.

At site 5 no erosion protection is needed. Locals asked for techniques to catch sand before it accumulates in the mangrove forest belt. It is not recommended to apply any major measures before further investigations even though construction such as fences could prevent sand from entering the mangroves.

Figure 49: GPS track along site 6 and the collapsed building on the beach

5.6 Ben Tre Province, Thanh Phu District, Thanh Hai Commune

All along site 6 significant erosion is visible. Remains of a collapsed building on the beach and attempts of the locals to defend their restaurants are proof of this. The GPS track and the position of soil sample 10 also indicate erosion. Figure 50 shows the GPS track along the dry beach and the building on the beach that collapsed in November 2013. On the Google Earth image from February 2010 the seaward end of the field is beyond the line that marks the dry beach in November 2013. Due to that erosion of approximately 100 m, the seaward fields had to be given up. It is remarkable that all buildings and restaurants that are on the photos in chapter 3.6 have been built after 2010.

T-shaped bamboo fences are not applicable at site 6 due to the lack of fine sediments and the steep beach gradient. The durations of flooding and the sedimentation rates would be far too low to accumulate enough sediments for successful floodplain management. Thus, the principle of T-shaped bamboo fences does not work at site 6.

If hard erosion protection measures, such as groins or breakwaters, are applied at site 6, one must be aware that the erosion problem is shifted along this coastal section. Downdrift erosion will occur. Thus, follow-up costs but also maintenance costs will be very high. The construction, if done properly, would be expensive.

In general the same recommendations that have been given for the eastern part of site 1 and for sites 2 and 3 are valid for site 6. In some places the erosion edge has not yet reached the seaward end of the fields. So it is still possible to manage the area between the beach and the fields, and the fact that local people have had to abandon some of their fields may make them more receptive to this kind of approach. Hard measures such as concrete tubes must be avoided. The goal must be to create a smooth slope on the dry beach. One possibility that can be checked would be the application of sand bags covered with sand again as an improvement of the existing individual solutions.

The coastal dunes along the southern part of site 6 seem to be high enough. In general the beach at site 6 is in a dynamic state. No protection measure would be final and ultimate. Maintenance must be part of the protection strategy. People must be aware that houses and restaurants directly on the beach are always endangered and the complete loss is just a question of time. Here, only the reduction of the damage potential can be recommended.

5.7 Tra Vinh Province, Duyen Hai District, Long Vinh Commune

Mangrove forest decline is visible at site 7 and can be assessed from aerial views.

T-shaped bamboo fences are applicable at site 7. The boundary conditions are similar to those in Soc Trang and Bac Lieu. Sedimentation rates after the installation of bamboo fences will be significant at site 7. The principle of T-shaped bamboo fences does work here, but the location is very remote. Logistics for construction are very difficult and the installation will be very costly. Since the threat is not very urgent, the recommendation is not to apply any construction here.

5.8 Tra Vinh Province, Duyen Hai District, Hiep Than Commune

Along site 8 erosion is visible. In general the erosion rates seem to be less than in other evaluated sites.

T-shaped bamboo fences are not applicable at site 8 due to the lack of fine sediments and the steep beach gradient. The durations of flooding and the sedimentation rates would be far too low to accumulate enough sediments for successful floodplain management. Thus, the principle of T-shaped bamboo fences does not work at site 8. If hard erosion protection measures, such as groins or breakwaters, are applied at site 8, one must be aware that the erosion problem is shifted along this coastal section. Downdrift erosion will occur. Thus, follow-up costs but also maintenance costs will be very high. The construction, if done properly, would be expensive. It must be taken into consideration that plans exist to lengthen the concrete dyke to the centre of site 8.

The same recommendations that have been given for the eastern part of site 1 as well as for sites 2 and 3 are valid for site 8. Existing structures (boundaries of fields) can be used to introduce a sustainable and anticipatory area coastal protection.

6. FURTHER RECOMMENDATIONS

Changing hydrodynamic loads and morphodynamics as well as changing frequencies and intensities of extreme events require site-specific designs for coastal protection. Existing coastal protection may not be sufficient anymore. Linear solutions or isolated hard structures such as barriers are very expensive technical solutions and should only be applied in special locations. Holistic approaches should be applied to cope with the challenges of coastal changes.

Four general strategies for coastal protection can be distinguished in the literature (Figure 50). The first strategy is 'retreat' where rising sea levels and storm surges force people back from their settlements because the natural elevation of the land does not offer sufficient protection anymore. The second is 'adaptation' where, for example, dwelling mounds or houses on stilts can be build. The third strategy is 'defence' where, for example, a closed dyke is established along the coastline. The final strategy is one of 'expansion' where the former coastline is reconstructed after very heavy storm surges which causes a massive loss of land and lost territories are reclaimed by means of the of the establishment of floodplains a successive embankment of the reclaime d areas (CEM, 2002).

Linham & Nicholls (2010) states that a successful coastal protection strategy consists of more than just one of the basic intervention strategies. Rather, a coastal protection strategy is a policy and implementation process involving a comprehensive decision making process and use of appropriate technology. These combination of strategies can still be applied in Ben Tre and Tra Vinh in order to establish an appropriate coastal protection system. The overall decision for the protection strategy affects the design of the actual protection measures.

As discussed previously, the application of bamboo groins is not possible at seven of the preselected sites. At the eighth site the application of bamboo groins is not recommended. As stated above, the defence of the sandy beaches alone will be costly and inefficient. If one measure is temporarily successful (with large effort and expensive maintenance), there is a large risk that erosion is significantly increased downstream. Thus, a combination of strategies including defence, adaptation and retreat should be considered.

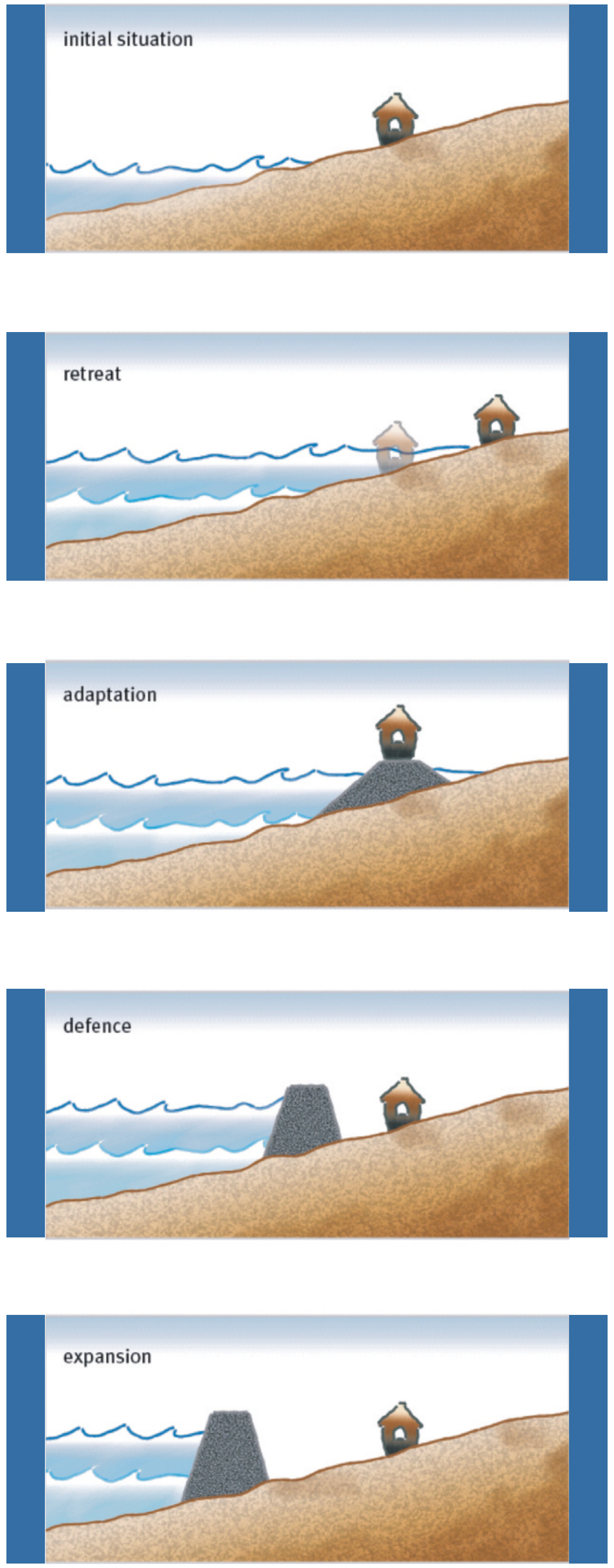

Figure 50: Coastal protection strategies
(Albers et al. 2013)

Cost-benefit-analyses will become very important in the near future due to limited financial funds and increasing requirements of coastal protection. They can support the decision for or against a certain protection measure or assess appropriate costs for coastal protection, and thus support the selection of a measure. Even risk analyses should be integrated to create priority lists. Risk analyses do not only take into consideration the values in the hinterland and the costs of the coastal protection but also the damage in case of flooding and the failure probability (damage = damage potential × degree of damage; risk = damage × failure probability). For all construction a sustainable life-cycle-management (maintenance) must be applied.

7. SUMMARY

In Ben Tre and Tra Vinh Provinces different sites on the coast suffering from erosion have been visited and evaluated. The sites were preselected by IUCN and their national partners. The primary goal of the survey was to identify potential locations for the application of bamboo groins and coastal floodplain management. In the frame of the site evaluation a visual control, photo documentation and a GPS survey of the shoreline was done. Supplementary, sediment samples (grain size distribution) were taken and analysed. Based on the survey and on available data, the degree of exposure, the hydrodynamic loads and the morphodynamic status quo were evaluated.

The principle of coastal floodplain management using bamboo groins only works if certain boundary conditions are fulfilled. Due to its location directly at the mouths of the Mekong River branches the characteristics of the coasts of Ben Tre and Tra Vinh Provinces differ significantly from those of the coasts of Soc Trang and Bac Lieu Provinces where bamboo groins have been applied successfully. While the coasts of Soc Trang and Bac Lieu Provinces are mostly dominated by mud and have a very shallow gradient, the characteristics of the coasts of Ben Tre and Tra Vinh are more diverse. For this reason, an evaluation of the preselected sites was essential before planning any further erosion protection measures.

The application of bamboo groins is not possible at seven of the preselected sites due to the boundary conditions at those sites. At the eighth site the application of bamboo groins is not recommended due to difficult logistics, high construction costs and a lower urgency. The pure defence of the sandy beaches using conventional measures of coastal erosion protection such as revetments or breakwaters will be costly and inefficient. If one measure would be temporary this sentence very unclear (under large efforts and expensive maintenance), there is a large danger that erosion is significantly increased downstream. Thus, a combination of the strategies defence, adaptation and retreat should be applied.

Further studies are recommended that investigate holistic and early measures of coastal protection on the current coastline. Today individual and local emergency measures are applied by farmers just when the sea attacks the fields. A survey should evaluate how existing structures in combination with adapted erosion protection measures can be used to defend the coastline. If necessary this must be accompanied by the surrender and transformation of the seaward fields and parallel management approaches and cost-benefit-analyses.

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9. ANNEX

Table 1: Sample analysis results

SOIL SAMPLES			
Sample	% Sand 0.05 - 2.0 mm	% Silt 0.002 - 0.05 mm	% Clay < 0.002mm
1	99.68	0.32	
2	94.18	3.29	2.53
3	23.41	61.81	14.77
4	24.32	52.33	23.35
5	99.61	0.39	
6	99.72	0.28	
7	34.39	29.96	35.65
8	95.40	2.94	1.66
9	99.35	0.65	
10	99.61	0.39	
11	20.63	62.11	17.26
12	99.43	0.57	
13	22.88	42.44	34.67
14	92.89	4.11	3.00
SOIL SAMPLES			
Sample	**Sand *(g/l)* 0.05 - 2.0 mm**	**Silt *(g/l)* 0.002 - 0.05 mm**	**Clay *(g/l)* < 0.002mm**
1	0.26	7.500	14.750
2	0.006	0.614	
3	6.245	3.280	

Water sample 1 has been taken in the surf zone at site 4. The waves lead to a high concentration of suspended sediments of 22.51 g/l. The mixed environment of site 4 with larger fractions of fine sediments is visible in the data since the suspended material mainly consists of silt and clay.

Water sample 2 has been taken in the upper layer of the water column in the main creek at site 7. Thus, the concentration of suspended sediments there is very low in comparison with the samples taken in the surf zone.

Water sample 3 has been taken in the surf zone at site 8. The waves lead to a high concentration of suspended sediments of 9.53 g/l. The sandy character of site 8 is visible in the data since the mass of sand is twice as much as the mass of silt and clay.

The results of the water samples have not been integrated in the main part of the report, since the tidal situation and wave conditions during the sampling influences the results. But the results confirm the conclusions drawn from the soil samples.