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Federal Ministry for the
Environment, Nature Conservation,
Building and Nuclear Safety

of the Federal Republic of Germany



Mangrove Rehabilitation and Restoration

An overview in Bac Lieu Province
2011-2014

Implemented by



GIZ in Viet Nam

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The project “Adaptation to Climate Change through the Promotion of Biodiversity in Bac Lieu Province” is funded by the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) and implemented by GIZ in close collaboration with the Department for Agriculture and Rural Development Bac Lieu. It's objective is to enhance the protective effect of coastal forests through the sustainable use of resources and the promotion of biodiversity.

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Introduction

This report is a summary and documentation of the rehabilitation and restoration achievements through the project “Adaptation to Climate Change through the Promotion of Biodiversity in Bac Lieu Province”. The overall objective of the project was to improve the resiliency of coastal ecosystems and coastal communities. Mangrove rehabilitation and restoration for protection against coastal erosion, strong winds and storm surges is a key element in improving resiliency to climate change along an exposed and dynamic coastline that historically has experienced considerable erosion.

The coastline of the Mekong Delta is influenced by the flow regime of the Mekong River, the tidal regime of the East and Western Sea as well as the currents driven by prevailing monsoon winds (Thin et al., 2010). The combination of these influencing factors creates a dynamic process of accretion and erosion along the coast, where often only a narrow belt of Mangrove remains, as seen in Figure 1.



Figure 1: Mangrove forest in Bac Lieu Province, Viet Nam. (Photo: courtesy of Cong Ly/GEWind)

Mangrove forest, which usually grows along coastlines and estuaries, is suffering under anthropogenic influences in the Mekong Delta. During the American war, large areas of forest were destroyed and this destruction increased in the years after, when land was converted for cultivation and shrimp production. Currently, a very narrow band of mangroves remains along the coast of Bac Lieu Province. Since the late

1990s the Vietnamese government has launched large planting projects in order to rehabilitate the forest.

Mangrove rehabilitation is defined as the re-establishment of the ecosystem’s structural and functional characteristics (Field, 1998). As part of an Integrated Coastal Management approach it aims at restoring the ecological functionality and thereby increasing the protection function of the mangrove forest belt along the coast and its resilience to climate change. A mangrove forest naturally exhibits a succession from the coast to the inland with different species adapted to the changing conditions (see Figure 2). As such, pioneer species like *Avicennia marina* or *Sonneratia alba*, with their cable roots, which spread out horizontally below the soil surface and that help the tree survive in anoxic conditions and sustain in the soft substrate (Eong & Gong, 2013), are suitable for the foreshore. In contrast *Rhizophora*, the most prominent species in the Mekong Delta, is adapted to the centre of the mangrove belt. And only if this species distribution is intact, can the forest exhibit it’s full ecological functionality.



Figure 2: Natural Mangrove distribution from the shore to the hinterland.

Due to the coast’s heterogeneity, there is not one single approach which is applicable to the Mekong Delta but site specific, appropriate solutions are needed. In the past years rehabilitation schemes in the Mekong Delta were not always successful nor did they always support the ecological functions (Thin et al., 2009), due to a focus on dense, single species planting and disregard of site specific factors, forest structure and human interaction.

In 2011 the project, in collaboration with the Forest Protection Sub Department (FPSD), developed the *Coastal Mangrove Rehabilitation Plan* (Clough, 2011). This plan is based on a ground-processed aerial image and prioritizes sites for mangrove rehabilitation and suggests

suitable species to be planted at the respective sites with the goal to re-establish the forest's ecological functionality and increase its resilience to climate change. This plan formed the basis of all rehabilitation activities in the context of the project.

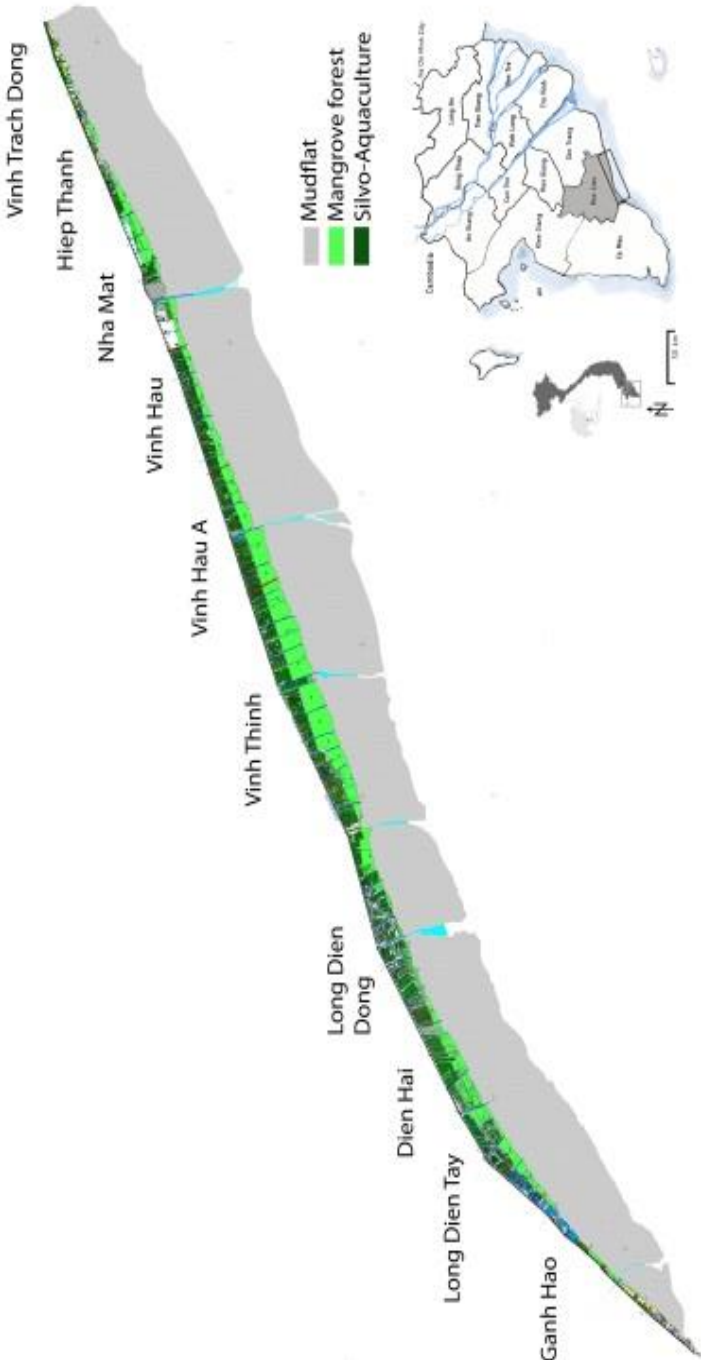


Figure 3: Land use in front (seaside) of the dyke in Bac Lieu Province

Rehabilitation achievements

Three different types of mangrove rehabilitation and restoration measures were undertaken in the years 2010 to 2014: (1) afforestation or restoration, where barren land within the mangrove belt was re-planted, (2) enhancement plantings, where seedlings were planted in order to increase diversity and structure of existing forest to increase resilience as well as (3) scattered plantings, where *Casuarina* was planted along embankments.

The following section shortly describes the current status of the area between the dike and the sea from the northern to the southern end of the province, focusing on rehabilitation measures implemented by or in relation to the project. The description of each commune (often also referred to as village) is kept short while the emphasis is put on planting activities and their success. A more detailed description of the baseline situation of the coastal vegetation can be read in the *Coastal Mangrove Rehabilitation Plan* (Clough, 2011). A map of the province including the mentioned communes is shown on the opposite page (Figure 3) and all activities are mapped and can be referred to in Annex I as well as a tabular summary of these activities and their success can be found in Annex II.

Vinh Trach Dong

The distance between sea and dike at the northern end of Bac Lieu, bordering Soc Trang province, is short and among the areas most affected by erosion (Clough, 2011). Even though the area is mostly covered by Mangroves, the forest is not closed, leaving large patches of barren land and lacking foreshore mangrove species. Most of this barren land has either been converted to shrimp ponds or the soil is very compact and saline, bearing a challenge for afforestation and making restoration necessary. Due to the high rate of erosion this area has been identified as a high priority rehabilitation area (Clough, 2011) and efforts of such are underway. However, many of the conventional plantations on barren land failed, as the soil is degraded, compacted and highly saline. Due to the strong erosion, rehabilitation of the foreshore mangrove species is not possible in some areas without restoration of the mudflat.

Within the up to 300 m wide Mangrove belt, two degraded, barren sites were identified as trial planting sites in 2011. The sites were restored through dredged canals reestablishing the water exchange and reducing salinity. Different species were planted on the embankments and canals a few months after site preparation and one year later in the canals. A detailed monitoring system which was put in place when the planting was conducted proofed the success of the restoration (see Figure 4).



Figure 4: Trial planting site (degraded, barren land) before site preparation and 14 months after.

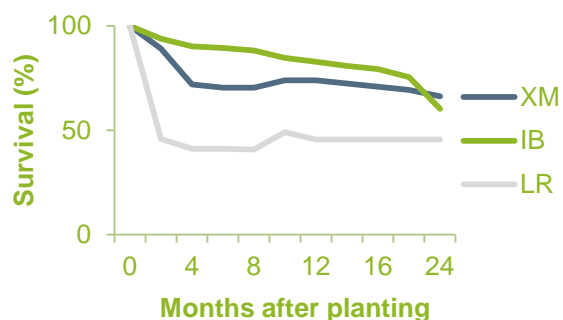


Figure 5: Average Survival of individual species on embankments over the first 24 months after planting at Sites 1, 2, 3 and 4. (CT = *Ceriops tagal*; IB = *Intsia bijuga*; LR = *Lumnitzera racemosa*)

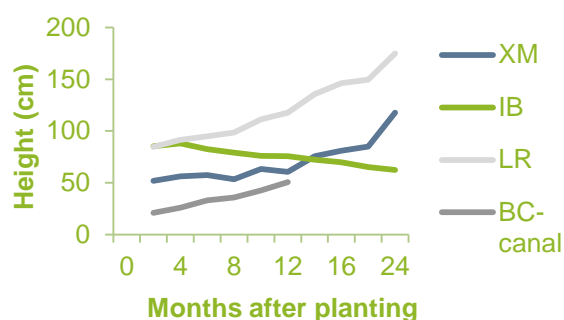


Figure 6: Average Height of individual species on embankments (XM, IB, LR) and Canals (BX) over the first 24 months after planting at Sites 1, 2, 3 and 4. (CT = *Ceriops tagal*; IB = *Intsia bijuga*; LR = *Lumnitzera racemosa*, BC = *Bruguiera Cylindrica*)

Lumnitzera racemosa, *Intsia bijuga* and *Xylocarpus moluccensis* were planted on the embankments and at the same time *Lumnitzera racemosa*, *Rhizophora apiculata* and *Ceriops tagal* were planted in the canals. Monitoring revealed that *Lumnitzera racemosa* was the most suited species for the embankments while *Intsia* was not. Even though the survival rate of *Intsia* was high, the plants did not develop well, neither in height nor in structure (see Figure 5 and Figure 6). The seedlings planted in the canal right after site preparation developed poorly due to high sedimentation rates (Clough, 2014). One year after site preparation *Bruguiera cylindrica* was planted in the canals and it exhibited a very high survival rate and good development. Therefore, the lessons learnt from the first trial sites were to exclude *Intsia* and to wait one year before planting in the canals.

The restoration technique has been applied at three further sites between 2012 and 2013 and was adopted by the FPSD in 2014. Although the

restoration technique is very successful, the necessary investment is above the governmental cost norms and therefore the FPSD relies on additional funds to restore the barren land sites in Vinh Trach Dong.

At two sites in Vinh Trach Dong, T-shaped bamboo breakwaters were installed at erosion areas in 2012. These structures are based on hydrodynamic measurements and numeric modelling and reduce erosion while triggering sedimentation and thereby recreate conditions for mangrove rehabilitation (Albers, 2012, 2012a, Albers et al. 2013). Once natural regeneration of *Avicennia marina*, the mangrove species naturally growing at and most suitable for the seafront, occurred, additional seedlings were planted to accelerate the canopy closure. The survival rate of the additionally planted seedlings was at 70 % and rapidly increasing natural regeneration was observed, expanding along the shore and onto the mudflat, as seen in Figure 7.



Figure 7: Erosion site in Vinh Trach Dong at which T-shaped bamboo breakwaters were installed and *Avicennia* seedlings planted. Top: before intervention. Center: 6 months after T-shaped bamboo breakwaters were installed. Bottom: 26 months after.

At an accretion site in Vinh Trach Dong *Avicennia marina* and *Sonneratia alba* were planted on the mudflat. *Sonneratia alba* is, like *Avicennia marina*, a species that is well adapted to the front of the Mangrove belt and can withstand long inundation and high levels of salinity. Although it was once widely spread in Bac Lieu Province, very few trees remain for which reason it was mixed with *Avicennia* to restore the natural succession of the mangrove belt and increase biodiversity. The survival rate

was slightly lower than of *Avicennia*, but the seedlings developed well and fruited two years after planting.

All of the sites rehabilitated in Vin Trach Dong had been identified as priority planting sites. However, Clough 2011 recommends only the following four species to be planted in this area (with the area adjacent to the dike being an exception): *Avicennia marina*, *Ceriops tagal*, *Xylocarpus moluccensis* and *Lumnitzera racemosa* along with *Rhizophora apiculata* if necessary. *Intsia bijuga* and *Rhizophora mucronata* were planted even though not recommended. Monitoring showed that *Intsia bijuga* was not successful but *Rhizophora mucronata*. Based on these lessons learnt, the latter can be recommended to be used for rehabilitation measures as it is also not a very common species in the province.

Hiep Thanh

The distance between the dike and the sea along the coast of the Hiep Thanh village is wider than further up north. When comparing the current course of the shore to earlier years, land gain can be observed between 1965 and 1995 followed by steady land loss in later years. However, the rate of erosion is much lower than further up north, which can probably be attributed to the existing *Avicennia* stands along the shore. Most of the land between dike and sea is also covered in Mangroves enclosing large shrimp ponds with little to no vegetation.

No priority planting sites have been identified in Hiep Thanh, however reforestation activities have been conducted by the FPSD. Three large extensive shrimp ponds (total area of 30 ha) have been planted with evenly spaced *Rhizophora mucronata* as seen in Figure 8. Additional shrimp ponds were reforested in 2013 by the FPSD. Furthermore scattered *Casuarina* was planted along the canals and

adjacent to the dike to improve stability and increase shading.

At the northern end of the village, close to the border of Vinh Trach Dong, 5 ha of land have been devoted to an Arboretum. This area bears a high diversity of Mangrove species and is meant to function as a gene bank and as a site for environmental education in future. Between 2012 and 2014 additional species have been planted in the Arboretum. It now contains 26 species, all of which were formerly endemic in Bac Lieu province. A walkway, bridge and signboards have been installed at the Arboretum for it to be accessed easily for educational purposes.



Figure 8: Reforested Shrimp pond in Hiep Thanh

Nha Mat

Coastal Nha Mat is prevailed by a tourist site and a pagoda next to which the forest is relatively intact and dense. The few patches of bare land are, according to the *Coastal Mangrove Rehabilitation Plan* (Clough, 2011), unsuitable for reforestation and therefore not classified as priority sites. However, efforts of biodiversity enhancement with *Ceriops tagal* have been made on a 2.5 ha *Rizophora* stand north of the

tourist area by the Forest Protection Sub Department. This site has not been investigated but it was mentioned that the success rate is relatively low.

Vinh Hau A

The distance between the dike and the sea at the Vinh Hau A village is around 800 meters and mostly covered in forest. As the Mangrove belt is wider than 400 meters, the area adjacent to the dyke is categorized as buffer zone, rather than full protection zone (see Figure 9). The so-called 60:40 law is applicable for this area and the land is leased out to single farmers by the FPSD. The tenants are allowed to use 40 % of the land for income generation and 60 % has to remain forested. The area is therefore mostly used for silvo-aquaculture¹.

There are only 6.6 ha of priority rehabilitation sites in this area, all of which are located directly at the shore, and no planting has taken place there.



Figure 9: Aerial image of the Mangrove belt in Vinh Hau A. From the bottom to the top: The buffer zone is adjacent to the dike and the full protection zone in front of it by the sea.

Vinh Hau

Vinh Hau's coast exhibits a very similar structure to Vinh Hau A, apart from being about 400m wider in the south. The southern area is

¹ Silvo-aquaculture is an extensive, small scale farming method that incorporates mangrove forest in aquaculture ponds.

covered in dense, high grown, forest near the coast and silvo-aquaculture ponds with natural *Avicennia* regeneration near the dike.



Figure 10: Forest cover behind (landward) the dike

The population density is visibly lower than further north and, as seen in Figure 10, the forest cover behind the dike (landwards) is much higher than in any other villages. This area shows the most intact Mangrove belt in the entire province with the natural succession being almost intact. There are no priority planting sites and hence no afforestation activities have taken place there.

Vinh Thinh

The distance between the dike and the sea in Vinh Thinh is the greatest of all in Bac Lieu province. However the up to 1.5 km wide Mangrove belt is mainly single aged *Rhizophora* monoculture and *Avicennia* by the shore. In some areas the Mangrove belt also extends a couple of hundred meters inland, like it does in Vinh Hau, but much of this forest is being cleared or thinned, as seen in Figure 11. The area just landward of the dyke is the so-called corridor and no concrete structures are allowed to be built there. However, as the area is not under the jurisdiction of the FPSD there are no official restrictions to logging or thinning.

A number of priority planting sites have been identified as well as extensive biodiversity enhancement needs.



Figure 11: Mangroves being cut landward of the dike, as witnessed on the 17th of November 2011.

On an area of 85 ha scattered *Rhizophora mucronata* has been planted by the FPSD. The planted species does however not exactly correspond to the site conditions, especially not in at the site by the sea, as the roots of *Rhizophora* are not capable of stabilizing the soil and therefore the species is not adapted to grow at the seashore. The success of this planting activity has not been monitored. Further 20 ha *Rhizophora mucronata* were planted in extensively farmed aquaculture ponds landward of the coast.

Long Dien Dong

The coast line of Long Dien Dong is or has been majorly used for aquaculture and hence the forest stands are limited to low density stands in ponds with the shoreline and the southern end being an exception. The area is densely populated unlike the two villages further up north. A number of priority reforestation sites have been identified as well as biodiversity enhancement needs.

Scattered planting of *Rhizophora mucronata* was done within different older *Rhizophora* stands at the northern end of the village. The success of the activity cannot be verified due to the large area (over 40 ha) on which the seedlings had been distributed.

At the southern end of the village, *Lumnitzera racemosa* was used to fully reforest 2.8 ha of bare land. This was done as part of an environmental education activity where schools raised seedlings and then planted them in May 2011. The success of this plantation has not formally been monitored but was, after inspection, assessed to be over 70%, as seen in Figure 12.



Figure 12: Bare land reforested as part of an environmental education activity (picture taken 1 year after planting took place)



Figure 13: Existing sea wall at Ganh Hao which is currently (2014) being extended.

Dien Hai, Long Dien Tay and Ganh Hao

The coast of Dien Hai is covered in dense forest and aquaculture ponds with two priority planting sites having been identified. However, these sites are majorly affected by erosion and successful planting is bound to be difficult.

Bordering Long Dien Tay suffers from increased erosion and the distance between dike and sea does not exceed 300 m. *Lumnitzera* species have been planted in the past (prior to the existence of this project) and the remaining priority sites are lacking regular drainage due to an elevated seaward embankment covered in salt resistant grass species, posing a challenge for reforestation due to high salinity. However, it was not advised to break this embankment even though it would increase water exchange due to an expected increase of erosion.

Ganh Hao is the most southern village along the coast of Bac Lieu and suffers from severe erosion. The mangrove belt does not exceed a width of 300 m and is majorly impacted antropogenically due to the proximity of Ganh Hao township. Furthermore this area also suffers from lacking water exchange, posing the same challenges for reforestation as Long Dien Tay. No planting activities have taken place within these three villages. A seawall is currently (2014) being constructed.

Conclusion and recommendations

The coastline of Bac Lieu province is seamed with a Mangrove belt which protects the earth dyke and the hinterland from erosion, strong winds and storm surges. However, the forest condition is not ideal in terms of health, structure and composition, inhibiting the ecosystem's full functionality. Mangrove rehabilitation and restoration was therefore one major component of the project "Adaptation to Climate Change through the promotion of Biodiversity".

Between 2010 and 2014 new restoration techniques were successfully tested and extensive rehabilitation measures supported with the aim of re-establishing the forest's natural structure and increasing its resilience. The project's focal area was the northern part of the province's coast as it is amongst the most degraded areas with scope for improvement.

The successfully piloted approaches of restoration of degraded, barren land and eroding floodplains were closely monitored and the experiences and lessons learnt compiled in comprehensive reports². Since 2012 the techniques have been replicated at other sites within the province and beyond.

The success of any forest plantation is amongst others dependent upon the seedlings' health and condition. During the project implementation it has however been observed that the planted seedlings were often under

water stress resulting in reduced survival rates for which reason it is recommended to emphasize adequate seedling care and handling.

During the project implementation the importance of correct site assessment and site specific solutions has been confirmed and highlighted. A site assessment manual (Clough, 2014a) as well as a planting guideline (GIZ, 2013) were compiled and disseminated through corresponding trainings. It is recommended that the importance of these issues is emphasized furthermore.

Probably the most important recommendation in regard to site specific Mangrove rehabilitation is to be made in regard to financing mechanisms. Between 2011 and 2014 the available government budget could not be spent for adequate restoration because it could not cover the sum of nursery raised seedlings, planting labor, transportation and sometimes necessary land preparation. Through existing cost norms and large planting area targets, no incentive is given for site specific measures but for cheap, short-term solutions. This often results in inappropriate species being planted outside of priority areas to ensure survival and target achievement. Therefore it is recommended to reduce the planned total area to be re- or afforested and to set goals to rehabilitate degraded forest adequately. Additionally the set budget per hectare should be increased for priority sites in order to allow for the application of site specific techniques.

² Albers, T, San, D.C., Schmitt, K. 2013. *Shoreline Management Guidelines: Coastal Protection in the Lower Mekong Delta*.

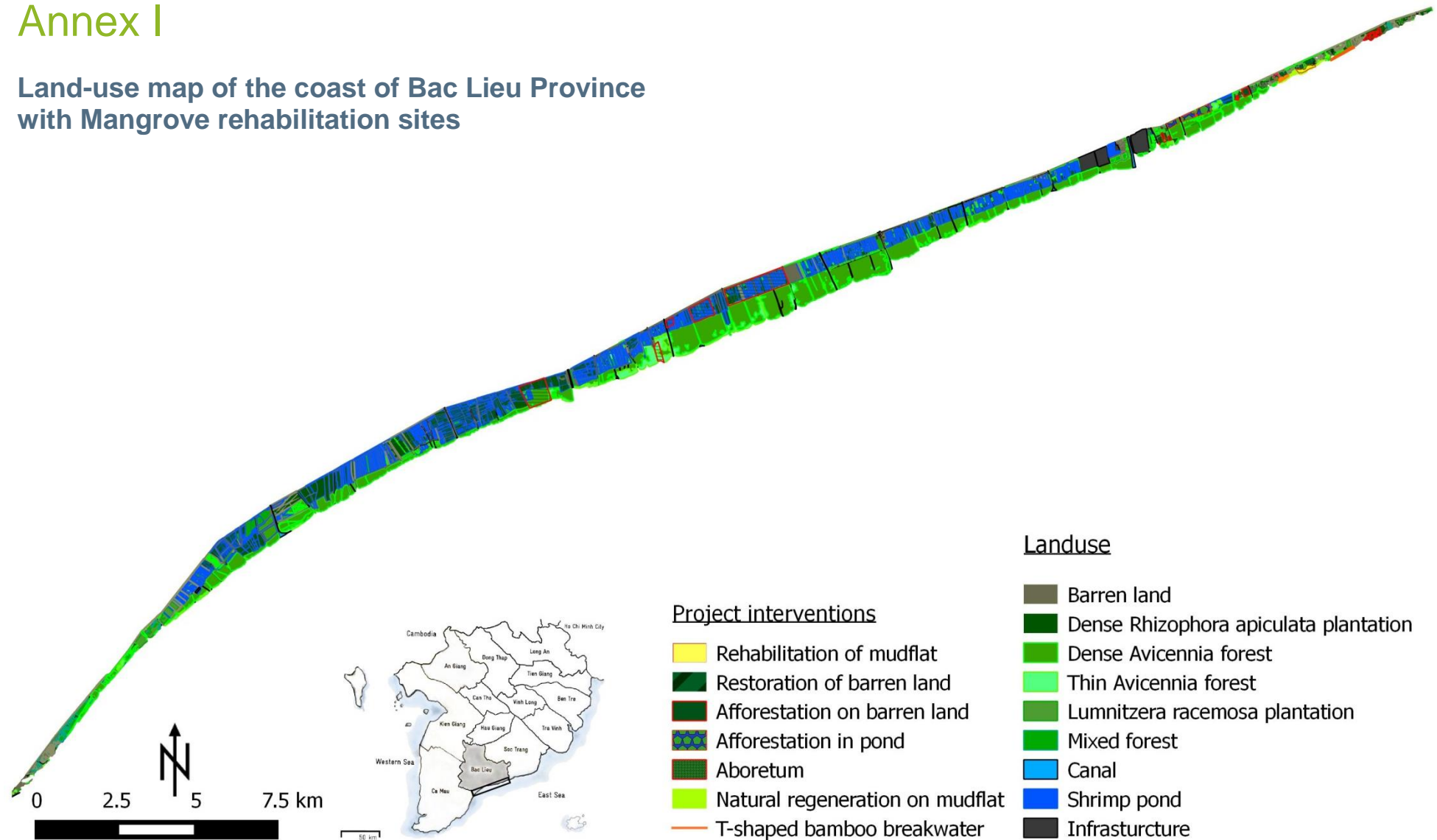
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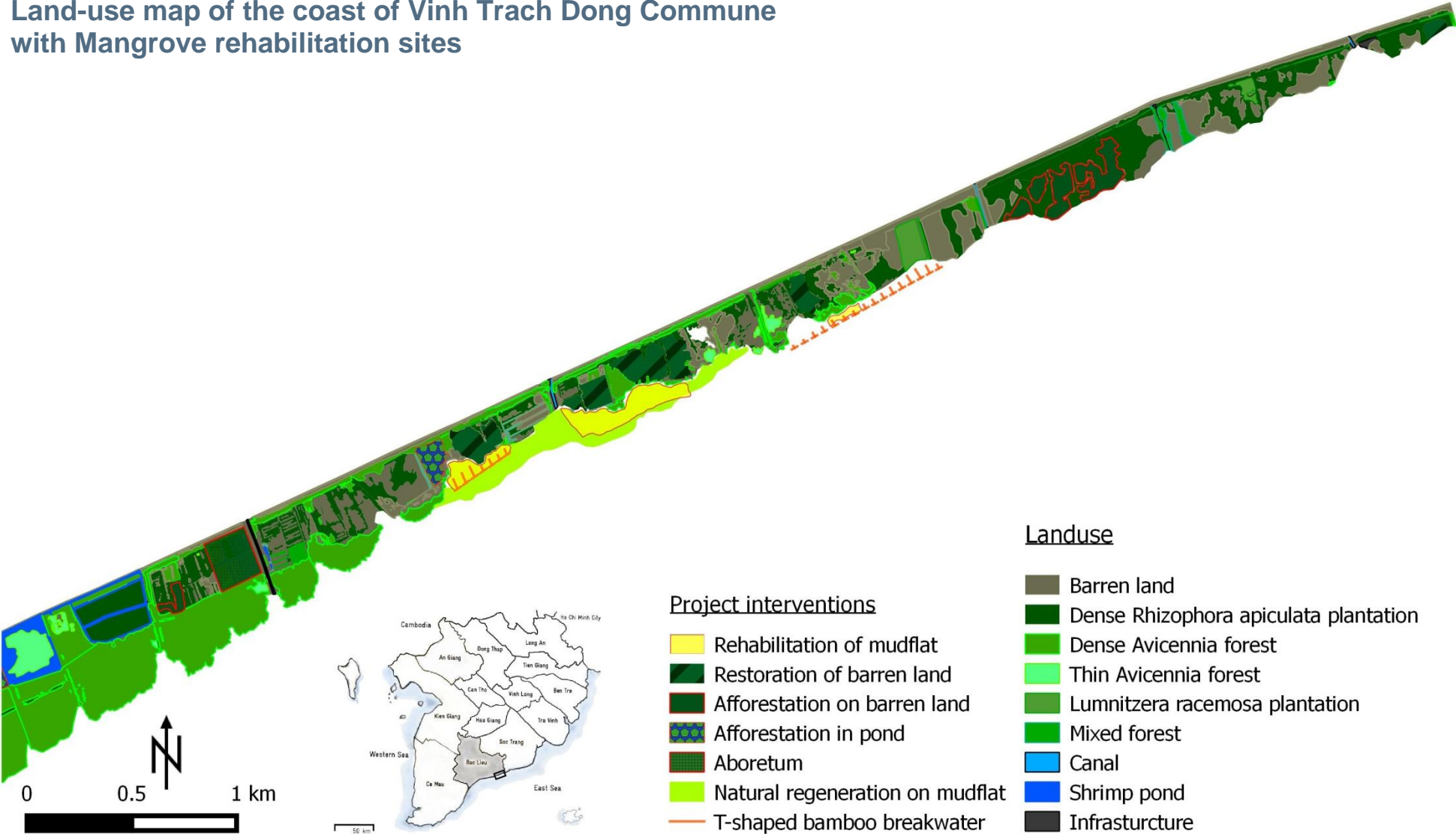
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Annex I

Land-use map of the coast of Bac Lieu Province with Mangrove rehabilitation sites



Land-use map of the coast of Vinh Trach Dong Commune with Mangrove rehabilitation sites



Annex II

Tabular summary of Mangrove rehabilitation activities in Bac Lieu province 2011-2014

Year of planting	Species ³	Area in hectars	Type Enhancement/ Afforestation	Previous land use according to map	Location	Priority According to Clough 2011	Notes
2010	RM	2,9	E	Thin Avicennia	Long Dien Dong	3	Environmental Education
2010	RM	40,0	E	Rizophora & Avicennia	Long Dien Dong	3	
2010	RM	11,6	E	Rizophora & Avicennia	Vin Thin (Hoa Binh)	3	
2010	RM	41,0	E	Rizophora	Vin Thin (Hoa Binh)	3	
2010	RM	23,0	A	Rizophora	Vin Thin (Hoa Binh)	3	
2010	CT	2,7	E	Rizophora	Nha Mat (Bac Lieu)	3	
2010	RM	5,6	A	Pond	Hiep Than (Bac Lieu)	3	
2010	RM	7,1	A	Pond	Hiep Than (Bac Lieu)	3	
2010	RM	17,5	A	Pond	Hiep Than (Bac Lieu)	3	
2010	CT	2,0	A	Barren land with rizophora	Hiep Than (Bac Lieu)	3	Apparently not successful
2010		1,0	n/a	Mixed forest	Hiep Than (Bac Lieu)	n/a	Arboretum
2010	CT	3,9	A	Barren land with rizophora	Vinh Trach Dong (Bac Lieu)	1	
2010	CT	2,9	A	Barren land with rizophora	Vinh Trach Dong (Bac Lieu)	1	
2010	CT	0,8	A	Barren land with rizophora	Vinh Trach Dong (Bac Lieu)	1	
2010	CT	0,9	A	Barren land with rizophora	Vinh Trach Dong (Bac Lieu)	1	
2010	CT	0,1	A	Barren land with rizophora	Vinh Trach Dong (Bac Lieu)	1	
2010	CT	0,2	A	Barren land with rizophora	Vinh Trach Dong (Bac Lieu)	1	
2010	RM	2,0	A	Barren land with rizophora	Vinh Trach Dong (Bac Lieu)	1	

³ AM: Avicennia marina, CE: Casuarina CT: Ceriops tagal, IB: Intsia bijuga, LR: Lumnitzera racemosa, RA: Rhizophora apiculata, RM: Rhizophora mucronata, SA: Sonneratia alba, XM: Xylocarpus mollucensis

Year of planting	Species ⁴	Area in hectars	Type Enhancement/ Afforestation	Previous land use according to map	Location	Priority According to Clough 2011	Notes
2011	RM	20,0	A	n/a	Vin Thin (Hoa Binh)	n/a	Behind dyke
2011	RM	10,0	E	Thin Avicennia	Vin Thin (Hoa Binh)	3	
2011	CE		S	Barren land with bushes	Hiep Than (Bac Lieu)	n/a	Along Canals
2011	CE		S	Barren land with bushes	Vinh Trach Dong (Bac Lieu)	n/a	Along Canals
2011	CT, LR, XM, IB, RA	2,2	A	Barren land with rizophora	Vinh Trach Dong (Bac Lieu)	1	Site 3
2011	CT, LR, XM, IB, RA	0,9	A	Barren land with rizophora	Vinh Trach Dong (Bac Lieu)	1	Site 1
2012	CE		S	Barren land with bushes	Hiep Than (Bac Lieu)	n/a	Along dyke
2012	LR, IB, XM	1,6	A	Barren land with rizophora	Vinh Trach Dong (Bac Lieu)	1	Site 2
2012	AM	2,0	A	Accretion area	Vinh Trach Dong (Bac Lieu)	n/a	Erosion Site 4
2012	LR, IB, XM	2,1	A	Barren land with rizophora	Vinh Trach Dong (Bac Lieu)	1	Site 4
2012	IB, LR	0,5	A	Monitoring Site 3	Vinh Trach Dong (Bac Lieu)	n/a	
2012	CT	1,8	A	Barren land with rizophora	Ganh Hao		
2013	AM, SA	5,0	A	Accretion area	Vinh Trach Dong (Bac Lieu)	n/a	Site 6
2013	LR, EA, XM	4,0	A	Barren land	Vinh Trach Dong (Bac Lieu)	1	Site 5
2013	CE	2,5	A	Along sea dike	Vinh Trach Dong (Bac Lieu)	n/a	
2013	IB	1,0	S	Forest	Hiep Than (Bac Lieu)	n/a	
2013		0,5	A	Arboretum	Vinh Trach Dong (Bac Lieu)	n/a	
2013	RM	88,0	A	Ponds	Hiep Thanh (Bac Lieu)	n/a	Behind dyke
2014	AM	2,0	A	Accretion area	Vinh Trach Dong (Bac Lieu)	n/a	Erosion site 3
2014		1,0	A	Arboretum	Vinh Trach Dong (Bac Lieu)		
2014	LR	4,0	A	Barren land	Vinh Trach Dong (Bac Lieu)	1	Site 7

⁴ AM: Avicennia marina, CE: Casuarina CT: Ceriops tagal, IB: Intsia bijuga, LR: Lumnitzera racemosa, RA: Rhizophora apiculata, RM: Rhizophora mucronata, SA: Sonneratia alba, XM: Xylocarpus mollucensis

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