



Assessment Report of the Biophysical, Ecological and Socio-Economic Conditions of Mangroves Ecosystem of Timor Leste



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Background

Mangroves of Timor-Leste are important ecosystem that providing various ecosystem function and services that support the both livelihoods and environment. Mangrove can be found in both North Coast and South Coast of the country, occupying small patches along narrow coastal flats in the north coast; and in the river mouths, lagoons, and behind sandbars in the South Coast. Mangrove areas covering around 1,300 ha, mostly located in the North Coast (Alongi, 2014, Richards and Friess, 2015).

In general mangroves in Timor-Leste has been exploited at least since 1940s for agriculture, timber, and opened for settlements (Alongi, 2014). The exploitation had causing the loss of nearly 90% of Timor-Leste's original mangroves that estimated to be around 9,000 ha in 1940. The degradation of mangroves occurred in all mangroves areas, but particularly severe in the north coast. Along the Metinaro, the remnant of large mangroves that had been cut, could be easily seen inside the forests and spotted from satellite image. In the South Coast, the damage particularly occurred in Viqueque and Covalima Districts, where some of the mangroves had been converted into rain-fed rice fields, or logged for timber and fire wood.

Mangroves in Timor-Leste provide various critical ecosystem functions and services, especially for livelihoods. It's a common sighting along the coast, community living around the mangroves are searching for crabs, fish, and cockles to support their daily income. Community also use mangroves timber as favorit materials for housing due their extreme durability like Lumnitzera and Ceriops, and their availability close to settlements.

Some mangroves, like *Sonneratia* and *Acrostichum* are consumed as fruits and vegetables by coastal community in the South Coast. Most of the mangroves sites are also home to waterbirds and stop-over place for migratory birds (Trainor, 2005). Community along the coasts also experiencing how the mangroves had sheltering them from the strong wind, coastal erosion, and high waves. Therefore, mangroves are not only provide foods, materials, and extra income for community, but also protecting them from the risk of disasters.

The loss and degradation of mangroves have negative consequence for both human and environment. Some community members have reported the lower number of crabs and shrimps captured in the recent years, while others are fearing that the degraded mangroves would no longer provide sufficient protection from natural disasters. The facts are evident of the need to restore mangroves of Timor-Leste and to provide sufficient formal and informal mechanism to protect them. By doing so, mangroves could regain their function and services for the benefit of communities, at local and national level.

About this report

This report is describing the area, distribution, and biophysical condition of mangroves in Timor-Leste. The report also provides information about some socio-economic aspect of the ecosystem, particularly the livelihoods and perception of communities on mangroves also included in the report.

The aim of this report is to help the efforts for mangrove restoration in Timor-Leste, particularly by providing the current biophysical state of mangroves in the country that could be used to design the area, target species, and methods of restoration.

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Methodology

The report is based on an assessment in 11 largest mangroves concentration in seven districts across the coast of Timor-Leste. The assessment was carried out between 15 March 2017 to 28 March 2017, covering an approximately 1,500 ha of coastal wetlands in both North Coast and South Coast.

In each location, we observed the status of mangroves by estimating the areas, identifying the species, estimate their population, observing physical characteristic particularly soil, tidal, inundation areas; and identifying past and future threat to the mangroves.

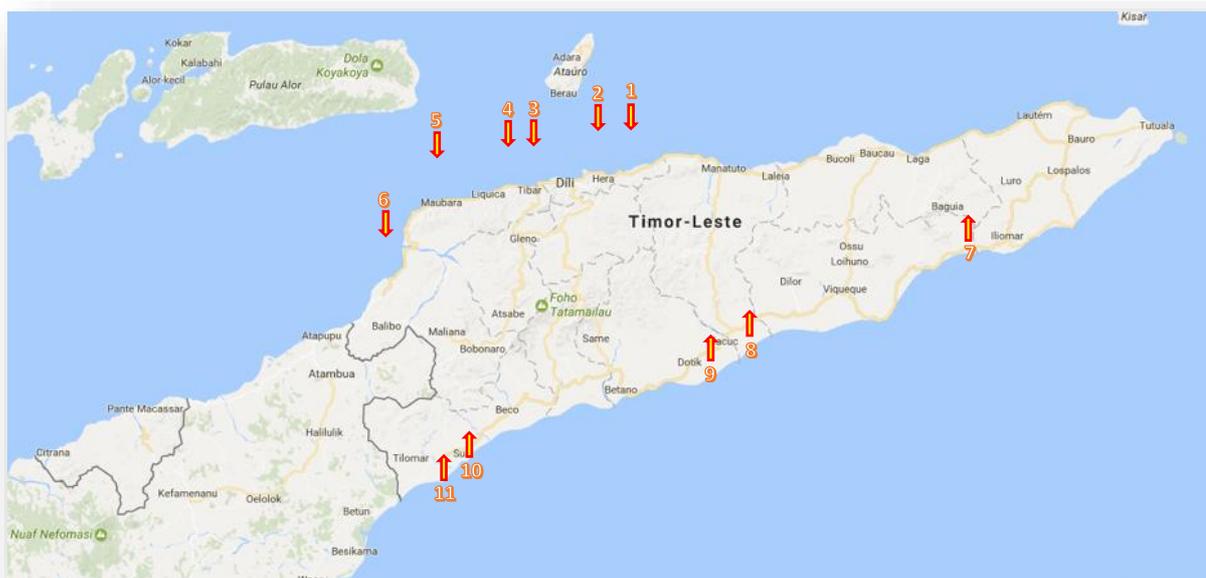


Figure 1. Location of Timor-Leste mangrove assessment. Image: Google Map

Mangroves in Timor-Leste can be divided into two major groups based on location namely, the north coast mangroves and south coast mangroves. The region in the north coast is characterised by lesser rainfall (< 1000 mm/year) that creating the arid landscapes and the wetlands along the coast have relatively higher salinity. The south received much rain throughout the year (> 1,500 - 2,000 mm/year) and forming low salinity lagoons where mangroves grow. The situation also made species in the north dominated by stunted mangroves like *Ceriops*, species with good adaptation to sandy beaches and high salinity like *Sonneratia* and *Rhizophora stylosa*. In the south coast, species with good adaptation with lower salinity like *Nypa* is growing well.

Mangrove Transect

Main purpose of the transect survey is to estimate the number of species, size of trees, species dominance, abundance, and distribution. There were two types of transects, firstly the square transects: 1x1 m or 2x2 m for small trees with height less than 2m; and 10x10 or 20x20 for larger trees.



Figure 2. Mangroves inventory activities

Secondly is the line transect, conducted by walking along the straight line and observe the species along the line. This method was less unreliable compared to the area transect, but were chosen as the methods on some areas were wild animal, particularly crocodile, were present.

Species Identification

The identification of the species was carried out by observing the structure and floristic nature of the mangroves and compare their features with identification books written by Giesen (2006), Noor et al. (2006). Each of species was photographed particularly flowers, hypocotyl, leaf, bark, root, and habitus.

During the first field work, 15 – 28 March 2017, we were focusing on identifying *true* mangroves. We expect, in the next regular field visits, we will expand our species identification to associate mangroves.

The result of the species identification is explained in this report and compiled as pocket book, *The Field Guide for Identification of Mangroves in Timor-Leste*.

The Cause of the Loss and Degradation

To understand the major driver of the loss and degradation of mangroves, we conducted direct observation on each location, identifying the possible cause of the loss, like the remnant of roots as the cause of timber logging, the dying mangrove due to sea level rise, and stunted mangroves due to high siltation.

In addition to the observation, we also interview local community about their livelihoods and how they related with the mangroves' resources, and other cause of the loss and degradation of mangroves.

Impediment to Natural Restoration

One of important thing we tried to identify during the field works was whether the natural regeneration of the mangroves success or failed in the study locations. In the case the regeneration is failed, we will try to find the factors contributing to the unsuccessfulness of natural recolonization of the mangroves. Specific factors that we evaluate in each site were:

- (1) Availability of mother trees that provide seedlings to the areas.
- (2) Hydrology condition of the areas, whether there is obstruction of tidal waters to regularly inundated the areas, the height, duration, and frequency of the inundation.
- (3) Whether there are other factors that may hamper the movement of seedlings, waters, or other biophysical condition that prohibit the seedling establish and grow naturally.

Mangroves in the North Coast

Summary

Mangroves in the north coast can be found in nearly all districts, characterised by the small clusters of fringing mangroves in the silt clay coast. The area of each cluster is varying from as small as 0.07 ha in some spots in Tibar to over 370 ha in Metinaro. Total area of mangrove in the study locations along the north coast is approximately 645 ha, around 20% or 129 ha are severely degraded and endure irreversible changes.

Past studies found around 19 species in the Timor-Leste , of which 2 paired of species (*Ceriops tagal* and *C. australis*; and *Sonneratia caseolaris* and *S. ovalis*) were considered as the same species in Giesen (2006) guideline. At least 14 species from the past record are also found during the survey in the North Coast, of which three species, including *Dolichandrone spathacea*, are only found in this study and added into the list as new entries.

Drivers of the Degradation and Future Threats

Mangroves facing two large scale direct threats, from land and from sea. The first is large scale threat is land soil erosion that bringing fine sediments, sands, and gravels during the rain and strong wind, to the mangroves area. The materials are piling in the landward side of mangroves covering mangrove muddy habitat with sands, literally in all mangrove locations in the north coast. The situation not only effectively kill most mangroves but also creating irreversible change of ecosystem, from mangrove ecosystem into sandy-coast ecosystems. In the areas where the pile of land sediment is relatively thin, some mangroves managed to survive but showing a stressful condition (stunted, stop to regenerate).

The other serious threat is sea level rise. Observation along the coast of Hera and Metinaro showed a strong indication that the higher of sea level was the main cause of the mortality of many *Sonneratia*. Highly likely all old *Sonneratia* that currently dominating mangroves in the north coast of Timor-Leste will perish. The low fertility soil in the region make the species has

low survivability in the long-inundated water. Other species with better adaptation to the higher water level like *Rhizophora*, were surviving. However, the natural succession from *Sonneratia* dominated population into *Rhizophora* dominated population is less likely to occurred without intervention. This is due to the high level of sea water that will prevent *Rhizophora*'s natural recolonization.

There is strong indication that many of the current mangroves, particularly in the landward side, are the last mangrove stands in the area with very small chance to regenerate. Therefore, in the short term, all mangroves clusters in the Hera and Metinaro require immediate protection from harmful human activities, particularly cutting and construction building. To allow natural regeneration in the middle and seaward zone, protection of mangroves from animal grazing (water buffalos, cows, goats, and pigs) is extremely needed, either through physical protection through fencing or other means such as active community regulation (*tara bandu*). Following is the detail of mangrove condition in the North Coast

Hera and Metinaro

Hera and Metinaro mangroves are two neighbouring mangrove areas that share similar geophysical conditions divided only by administrative boundary. The mangrove stretched across 21 km coastline, starting about 15 km from Dili to the East. The mangroves in Hera are scattered across the first 8 km to the east covering a total 115 ha. While the Metinaro mangroves stretched nearly uninterrupted over 13 km along the coast of Metinaro with total area around 374 km. The Metinaro mangroves were considered as the largest mangroves area in Timor-Leste (Alongi, 2014).

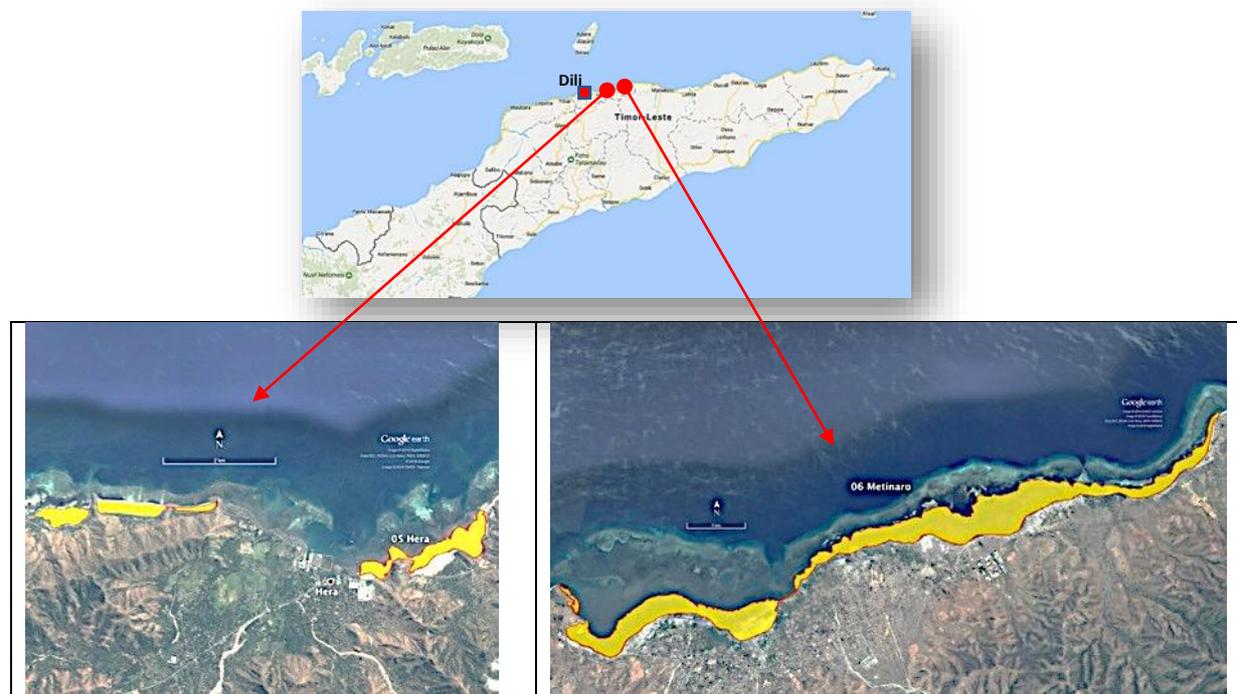


Figure 3. Mangroves in Hera (photo left) and in Metinaro (photo right)

The mangroves in these locations developed a unique formation where the landward zone dominated by either stunted dense *Ceriops tagal* (15,000 - 35,000 trees/ha), *Avicennia*, or mix

Ceriops and Avicennia. The width of the zone is varying between 10 – 200 m. In the next zone (middle zone) toward the sea, vegetation is comprising a mixed of Rhizophora, Lumnitzera, and Bruguiera, with around 3,000-4,000 trees/ha and the width of the zone between 50m to 250 m. At the sea edge, the mangrove community is dominated by pure Sonneratia, particularly in the sandy substrate; and mixed with Rhizophora in the muddy substrate with around 1,000-2,000 trees/ha. The width of the Sonneratia-Rhizophora zone is between 10 – 50 m.

The zonation of mangroves in the north coast is a common pattern zones in mangroves, except for the unique formation of the stunted mangroves that dominating the landward side.

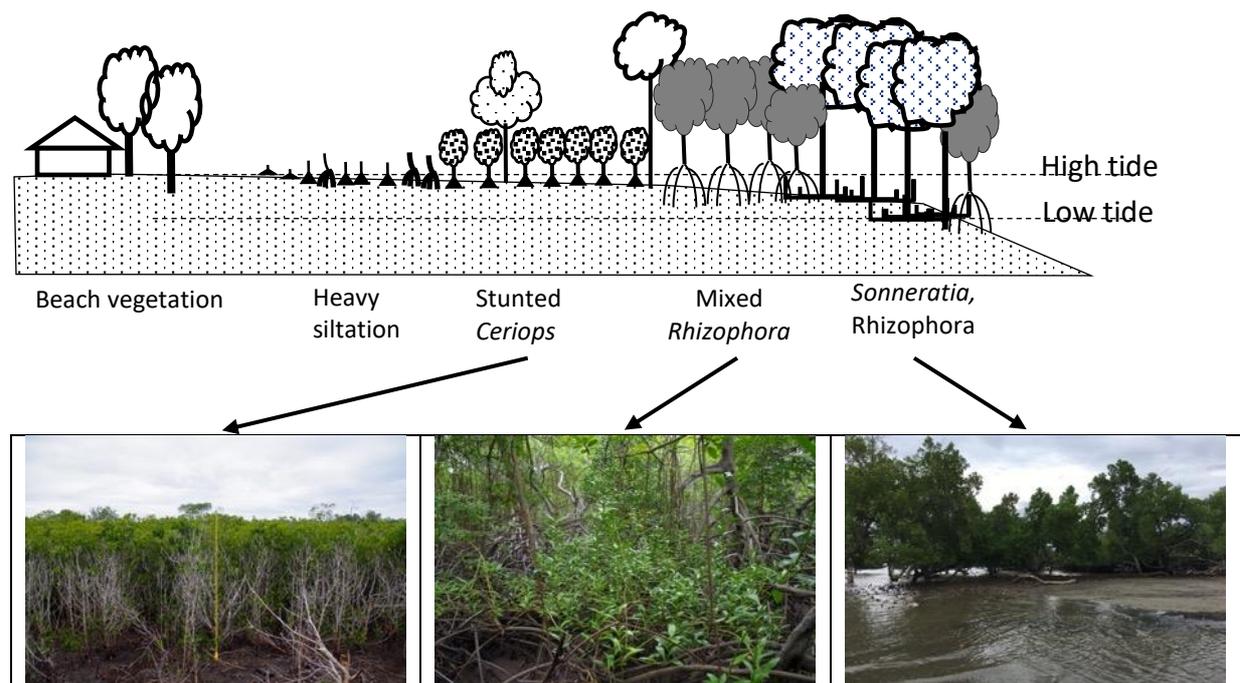


Figure 4. Typical mangrove zonation in Hera and Metinaro. The landward is dominated by stunted Ceriops (photo left), the middle zone is occupied by mixed species like Rhizophora, Avicennia, Lumnitzera, Bruguiera, and Acanthus (photo middle); and at the sea edge dominated either by pure Sonneratia or mixed sonneratia and Rhizophora.

Mangrove communities of Hera and Metinaro share the similar species, comprised of at least 14 species of true mangroves as listed in the Table 1. All the species are consistent with the finding in previous studies (Boggs et al., 2009, Alongi, 2014), except for the *Dolichandrone spathacea*, *Acrostichum speciosum* and *Aegiceras floridium* which are the new finding to the list.

The dominant species are *Sonneratia alba*, *Rhizophora apiculata*, *Ceriops tagal*, and *Avicennia*. Perhaps, the local name for mangroves, *Ai Parapa*, was derived from a similarly pronounced *Perepat*, the Indonesia – Malay name for *Sonneratia*, which was dominated to the North Coast. The other species like *Bruguiera*, *Lumnitzera*, and *Exoecaria* could be found in small numbers along the coasts of Hera and Metinaro. As for the *Rhizophora mucronata*, there was only one tree found in the area during the study and a cluster of seven trees of *Dolichandrone spathacea* in Metinaro.

Table 1. List of species in Hera and Metinaro

Species	Local Name	Remarks
1. <i>Acanthus ilicifolius</i>		Field identification
2. <i>Acrostichum speciosum</i>	Caecoli; Lira	Field identification
3. <i>Aegiceras floridium</i>		Field identification
4. <i>Avicennia marina</i>	Parapa	Field identification
5. <i>Bruguiera parviflora</i>		Field identification
6. <i>Bruguiera sexangula</i>		Field identification
7. <i>Ceriops tagal</i>	Parapa	Field identification
8. <i>Dolichandrone spathacea</i>	Sappatiru	Field identification, new listed
9. <i>Exoecaria agallocha</i>	Tanu	Field identification
10. <i>Lumnitzera racemosa</i>	Lurka	Field identification
11. <i>Rhizophora apiculata</i>	Rara	Field identification
12. <i>Rhizophora mucronata</i>		Field identification, only one tree found
13. <i>Sonneratia alba</i>	Klara	Field identification
14. <i>Pemphis acidula</i>		Field identification

Mangroves have been known to provide numerous function and service that support the life. The *Lumnitzera racemosa* and *Ceriops tagal*, are well-known for its extreme strength and durability. Perhaps, this is the cause of their high exploitation of in the past. In the case of Metinaro, the most visible ecosystem functions of mangroves along the coastal stretches are the protection of community settlement and infrastructure from strong winds and tidal waves. Other services that identified during the assessment are the provision of fish and fire woods like *Ceriops tagal* for communities. However, due to the smaller size of the mangroves, utilization of mangroves services was only carried out by small number of community members.

In general, the mangroves are heavily disturbed by both direct and indirect human activities. The situation make the mangroves area are now far smaller compared to their original state. For the case of Metinaro, original area is estimated to be around 500 ha, and by the year 2017 the mangroves have lost around 25% of their area.

The environmental pressures along the coast of Hera and Metinaro caused by soil erosion and sea level rise make mangroves failed to regenerate or expand naturally. Therefore, any small disturbance to the existing mangroves could cause irreversible damage.

Driver Of The Loss and Degradation

Road and Building Construction

Road and building along Hera and Metinaro changed the wetlands ecosystem permanently. However, the actual scale of the impact to the mangrove is not clear as the roads have been built for a long time. The roads, perhaps, could have helped reducing the sands' spill over to the mangroves area. The newly-built building complex along the road have obvious direct consequences to the mangroves as they are reducing the wetlands area.



Figure 5. Road and building construction inside the mangroves along the Hera and Metinaro

The road was built across the mangroves in Metinaro, creating a semi-isolated wetland behind the road (photo left); a building complex was built in a coastal wetland in Hera.

Fish and shrimp ponds

Currently there is some continuing efforts to build shrimp/fishpond along the Hera and Metinaro. The ponds, although built on the degraded mangroves have direct negative consequence to the environment as they drastically change the type of ecosystems and reducing potential area for wetland restoration. There is also possibility that the pond dikes reflect the incoming waves and create unfavourable condition for mangroves to grow and regenerate.



Figure 6 Construction of water channel and embankments for fishpond

Some of the ponds were likely developed with the help from government related projects. While the project had good intention, it is very important to avoid any physical development in the coastal wetlands area along the coast of Hera and Metinaro.

Uncontrolled Animal Grazing

This is the major current problems faced by mangrove along the Hera and Metinaro. Animals like water buffalos, pigs, cows, goat are freely wandering the mangroves, grazing on young leaves and shoots, and trampling on the newly grow seedlings. The situation creates a condition were young seedlings almost impossible to thrive in the environment because of feedings and trampling.



Figure 7. Water buffalo roaming the supposed to be natural recolonization sites in Metinaro.

Mangrove Cutting

Mangrove cutting is one of the most devastating activities to the existing mangroves. Despite the obvious shrinking area of mangroves along the Hera and Metinaro, the cutting is continuing until now. The coverage of cutting areas are relatively low, we found three spots with area 100 – 200 m². However, there is strong evidence that the cutting is not followed by natural regeneration. Even the area of massive mangroves logging occurred between 2007 – 2009 in the Metinaro, has not recovered until now.



Figure 8 Freshly cut mangroves, 2017 (left) and old cut mangroves, 2008 (right).

Heavy Sedimentation

Along the north coast of Timor-Leste, including Hera and Metinaro, the coastal areas are suffering from sands piling from the hills that covering large area along the coast. The situation is particularly worst on mangroves as the sands bury mangroves pneumatophore roots. The hot and dry sand eventually kill the mangroves and change the wetland ecosystem into sand flats.



Figure 9. Heavy siltation on mangroves areas

Sea Level Rise

In the last two decades, the sea level has raised over 22 mm in Timor-Leste (Barnett et al., 2007), but there is no record about the actual increase of the sea level in Hera and Metinaro. Observation of the dead mangrove trees in the area strongly indicated that most of them were *Sonneratia* with aerial roots submerged for a long time during high tide. Other species like *Rhizophora*, or even *Sonneratia* with higher aerial roots (exposed to the air during high tide), were still surviving.



Figure 10. Mangroves (*Sonneratia*) that dying due to the increase of sea level, beyond the height of their pneumatophores.

In other places, mangrove may adapt by gradually shift to higher grounds or accumulating organic materials that uplift the soil-surface elevation (Lovelock et al., 2015). There is no easy way to deal with the situation, especially for the fringing mangrove in the north coast of Timor-Leste. The space to move inland is blocked by sands and built-up area, especially road. At the same time, accumulation of organic materials from mangroves in North Coast is very small to help elevate the soil surface to match the sea level rise.

Tibar, Ulmera, and Biacou

Mangroves along the Tibar, Ulmera, and Biacou occupied small clusters of mudflat along the coasts, west of Dili. The area of clusters is varying from 0.07 ha of dying *Sonneratia* and *Rhizophora* in Tibar, a seven ha of healthy *Sonneratia* in Beacou; and the largest, 24 ha of mangroves that partly degraded in Ulmera. Unlike in Hera and Metinaro, the area of mangroves in the west of Dili are smaller and the stunted *Ceriops* is uncommon.

Total mangrove area of the tree locations is 78 ha comprised of 22 ha of mangroves in Tibar; 45 ha in Ulmera; and 11 ha in Beacou. Original area of mangroves is estimated to be around 112 ha.

Mangroves in these areas are dominated by *Sonneratia* and with some clusters of *Rhizophora apiculata*, *Ceriops tagal*, and *Lumnitzera*. The density of the trees in the Ulmera and Tibar is relatively low, around 100 – 400 trees per ha; while in Biacou the tree also dominated by *Sonneratia* and *Rhizophora*, with the dense of around 300 – 800 trees per ha.



The width of mangrove green belt in Tibar, Ulmera, and Biacou is relatively thin, make the mangrove zonation is not clear. In all sites, the landward side occupied by mixed of *Sonneratia*, *Rhizophora apiculata*, *Lumnitzera*, and *Ceriops tagal*. While the sea side dominated by pure *Sonneratia* or mixed with *Rhizophora*.

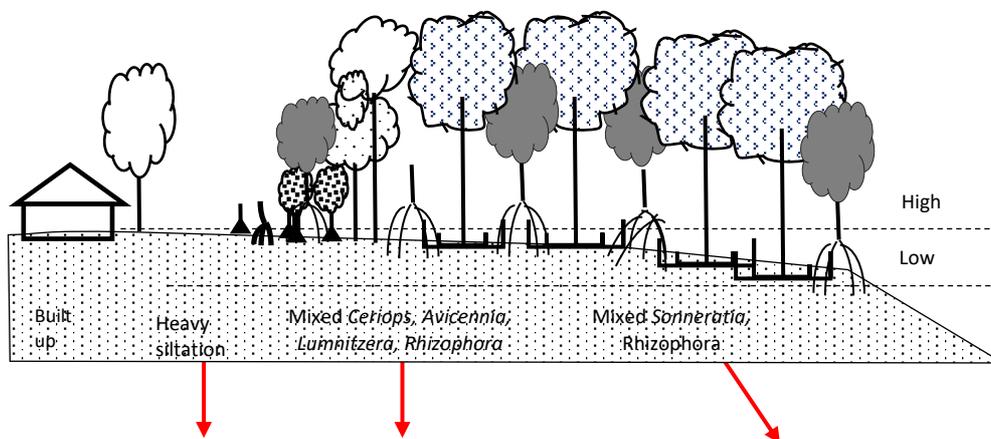




Figure 11. Mangrove zonation commonly found in Tibar, Ulmera, and Beacou

In the very narrow fringing mangroves, most of the mangrove green belt occupied by pure *Sonneratia* or pure *Rhizophora*. Some small clusters of mangroves also found consisted of *Rhizophora stylosa* that striving to grow in Tibar.

In general, we found around 10 species of mangroves during the study along the coast of Tibar, Ulmera, and Beacou. All the species are listed in the previous studies by Boggs et al. (2009) and Alongi (2014). Some of the species was abundant in the past but completely disappear in the recent years like *Acrostichum speciosum* due to the grazing by cattle.

Table 2. List of species in Tibar, Ulmera, and Biacou

Species	Local Name	Remarks
1. <i>Acanthus ilicifolius</i>		Field identification
2. <i>Avicennia marina</i>	Parapa	Field identification
3. <i>Bruguiera parviflora</i>		Field identification
4. <i>Bruguiera gymnorizha</i>		Field identification
5. <i>Ceriops tagal</i>	Parapa	Field identification
6. <i>Exoecaria agallocha</i>	Tanu	Field identification
7. <i>Lumnitzera racemosa</i>	Lurka	Field identification
8. <i>Rhizophora apiculata</i>	Rara	Field identification
9. <i>Rhizophora stylosa</i>		Field identification
10. <i>Sonneratia alba</i>	Klara	Field identification

Mangroves along the Tibar, Ulmera, and Beacou are providing various function and ecosystem services to community and environment. Similar with mangroves areas in Hera and Metinaro, community in these coasts harvesting fish, crabs, and mussels in the mangroves as source of foods and incomes. Some small-scale mangrove cuttings for fire woods also found during the studies.

Interview with community revealed that most of them perceived mangrove forest as the natural shield from strong winds and waves. Therefore, most of community members interviewed during the field work agreed that the mangroves need protection and restoration. At least one community group in Ulmera has been voluntarily collecting various seedlings and tried to grow them in the nurseries.

In general, all the mangrove clusters along the coasts, west of Dili, are heavily degraded, suffering from direct and indirect human activities. Similar with Hera and Metinaro, the direct human activities are including fish pond and salt pan development, mangrove cutting, and

cattle grazing. While the indirect human activities are sea level rise and siltation due to erosion in the hills across the mangroves.

Timber and Wood Exploitation

In the past, timber logging was rampant causing the loss of many big trees, particularly *Lumnitzera* and *Ceriops*. However, as the mangroves areas become smaller and degraded, such exploitation is now rare. A small-scale mangrove cutting can be seen in Tibar and Metinaro, community said for fire woods. The species that are common for cutting is *Rhizophora* and *Ceriops*. Fishers also utilising the *Rhizophora*'s bark to treat fishing nets.

There is no evidence that whether the level of the cutting and bark harvests are sustainable or not. However, as the natural regeneration of mangroves is very low in the area, the practices needed to be ceased immediately by providing alternative fire woods and timber from uplands.

Fish Pond and Salt Pan

The mangroves areas of Tibar and Ulmera are heavily utilise as aquaculture pond and salt pans. In the ponds, the community cultivate mud crabs, milkfish, and wild shrimp that enter the ponds freely during the high tide. Nearly 50% (15 ha) of the mangrove loss in the three locations were now built as aquaculture and salt pans.



Figure 12. Salt pan in Ulmera

Some of the community members are planning to create more ponds in the degraded areas of mangroves (mud-flat), whenever they get technical and financial supports. The situation is not found in Beacou as the area has less suitable land for fishpond.

All aquaculture pond or salt pan expansion in the mangroves area should be stop and move somewhere else that have less environmental risks.

Cattle Intrusion to the Mangroves

One of the most challenging thing to the allow a natural regeneration of mangroves in these areas is disturbance from cattle (buffalo, goats, pigs, and cows), that regularly enter the mangroves. The buffalo, goat, and cow trampling and foraging young shoots, and pig rooting the mangroves. The activities were so massive that make young seedling nearly impossible to establish naturally.



Figure 13. A pig running away from mangroves during the study in Tibar

Community should be encouraged to better managed their livestock and at the same time mangroves in these areas should be protected with fencing. Utilising social capital approach such as *tara bandu* may also effective to increase the chance of mangrove seedling to survive from cattle.

Siltation and Sea Level Rise

The low fertility of sediment in wetlands in the north coast of Timor-Leste may have caused the very slow pace of adaptation of *Sonneratia* with sea level rise. Therefore, although the increase of sea level is relatively slow, estimated to be only 4 mm per year, the situation creates deadly condition for old *Sonneratia* in sea ward along the coast of Tibar, Ulmera, and Beacou. It seems, the old trees' pneumatophores can no longer grow higher and leaves them suffocated during the high tides. Species like *Rhizophoracea* are likely to survive as they have higher pneumatophore roots to cope with the higher tidal level. Therefore, the coastal wetlands along the north coast that once dominated by *Sonneratia*, are likely to evolve into *Rhizophora* dominated wetlands.



Figure 14. Mangroves, *Sonneratia* are dying due to continuing higher sea level, while *Rhizophoracea* in the background is striving to survive.

The other problems are coming from the land where during the rain, tons of sands and gravels poured into the wetlands. The sediment piles change the ecosystems from wetlands into sandy beach that kills the mangroves. There is also a strong indication that old *Sonneratia* growth directly in front of the creek were suffering a stress, perhaps due to the fine sediment covering their pneumatophore.

Maubara Lake

Maubara Lake is a unique wetland in the north coast. The lake, although without visible connection to the sea, is a saline wetland surrounded by mangroves. In total, there are four saline lakes along the North Coast, west of Dili. The other three are the Tasitolu lakes that consisted of three neighbouring saline wetlands, just outside Dili to the west.

Total area of the Maubara Lake inundated during the heavy rain could reach 47 ha, while during the normal year the water surface is only around 18 ha.



Figure 15. Maubara lake, location on the map of Timor-Leste, aerial photo, and panoramic photo

Mangrove biodiversity of the lake is very low, only three species of true mangroves found during the survey. This perhaps it was caused by the lack of water exchanges (tidal) to the lake that impede the movement of seedlings from other places. Despite the low mangrove biodiversity, the lake is a place for around 18 water bird species, of which some of them are migratory birds. The fact that make them as an important wetlands sites at the national level.

The three mangroves species that grow in Lake Maubara are *Avicennia marina* which dominated the area, 355 species/ha, occupied shallow part of the lakes up to the dry land that only inundated by the water one or twice a year (buffer zone). Another species that common in the buffer zone is, particularly in the northern side, is young trees of *Exoecaria Agallocha* (< 2m high), 1950 trees/ha. While the densely populated adult tree of the *Exoecaria Agallocha* (177 trees/ha) can be found in the South side of the lake. The third mangrove species is *Lumnitzera Racemosa*. Their population is very small, scattered in the east side of the Lake.

Currently there is no specific community activities to utilise the mangrove resources in the lakes. There were tourism facilities, boardwalk, abandoned in poor conditions. It seems, some community members were also catch fish in the lakes but the scale was very small.



Figure 16. Young seedlings strive to survive.

The mangroves in the Lake are heavily degraded due to logging, particularly in the east side of the lake. However, there are many signs showing that natural seedlings could survive if the areas are protected from animal trampling and grazing. In addition, creating canals to the degraded areas would enable the distribution of seedlings and restore back the wetlands forest surrounding the lakes.

Important Mangrove Areas of Timor-Leste

1. Metinaro



Location	Dili Municipality
Proposed status	<p>National Importance</p> <p>The site is the largest continues mangroves areas in Timor-Leste</p> <p>The site is source of livelihoods for local communities</p> <p>The site provide protection for community from strong winds, waves, and coastal erosion.</p> <p>International importance.</p> <p>Ramsar Criterion 2: The site supports vulnerable, endangered, or critically endangered species or threatened ecological communities. Migratory, frequent water bird - <i>Numenius madagascariensis</i>, EN</p> <p>Ramsar Criterion 8: it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.</p>
Mangrove biodiversity	There are 19 species of true mangroves found in the location, which one species <u>could possibly</u> <i>Bruguiera hainesii</i> a species listed in IUCN Red List as Critically Endangered species. A further species identification is needed.
Mangrove Areas	Original area: 497 ha
Current areas	375 ha
Potential restoration area	60 ha
Beach revegetation area	100 ha
Major threats	Mangrove cutting, aquaculture development, animal grazing, sediment spill.
Immediate intervention required	<p>Protection</p> <ul style="list-style-type: none"> - Establishment of <i>tara bandu</i> to protect the mangroves from livestock and cutting - Fencing to block livestock entering the natural regeneration sites. <p>Restoration</p> <ul style="list-style-type: none"> - Creation of canals and bunds to traps natural seedlings - Limited re-planting activities, particularly species <i>Ceriops</i>, <i>Lumnitzera</i>, and <i>Rhizophora</i> (100-200 seedlings/ha). - Planting ground dwelling plants and multi-purpose trees in the heavy siltation areas.

Long term management	<ul style="list-style-type: none"> - Establish national regulation for the strict conservation and restoration of the entire mangrove area. - Develop large scale sediment retention - Develop low impact tourism activities: mangrove walks - Establish research and education sites - Regulate a limited harvest of fish, crabs, mussel in certain areas; priority for local community. - Proposing the location as a Ramsar Site, directly under Montreaux Record
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2. Hera



Location	Dili Municipality
Proposed status	<p>National Importance</p> <p>The site is source of livelihoods for local communities The site provide protection for community from strong winds, waves, and coastal erosion.</p> <p>International Importance</p> <p>Ramsar Criterion 2: The site supports vulnerable, endangered, or critically endangered species or threatened ecological communities. Migratory, frequent water bird - <i>Numenius madagascariensis</i>, EN Ramsar Criterion 8: it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.</p>
Biodiversity	The site harbour 18 species of true mangroves
Mangrove Areas	Original area: 131 ha
Current areas	115 ha
Potential restoration area	6 ha
Beach revegetation area	16 ha
Major threats	Building construction, industrial wastes, aquaculture, mangrove cutting, animal grazing, sediment spill.
Immediate intervention required	<p>Protection</p> <ul style="list-style-type: none"> - Monitoring, controlling of the impact of industries and building construction to wetlands. - Establishment of <i>tara bandu</i> to protect the mangroves from livestock and cutting - Erecting fence to block livestock entering the natural regeneration sites. <p>Restoration</p> <ul style="list-style-type: none"> - Creating canals and bunds to traps natural seedlings - Limited re-planting activities, particularly species <i>Cerriops</i>, <i>Lumnitzera</i>, and <i>Rhizophora</i> (100-200 seedlings/ha).

	<ul style="list-style-type: none"> - Planting ground dwelling plants and multi-purpose trees in the heavy siltation areas.
Long term management	<ul style="list-style-type: none"> - Designating the mangrove area as nationally protected wetlands. - Regulating the flow of sediment to avoid mangroves. - Developing community based, low-impact tourism activities. - Regulating a limited harvest of fish, crabs, mussel in certain areas; priority for local community.

3. Tibar



Location	Liquica Municipality
Status	<p>National Importance</p> <p>The site is source of livelihoods for local communities</p> <p>The site provide protection for community from strong winds, waves, and coastal erosion.</p> <p>The site is regularly visited by around 31 water bird species, one of them, <i>Numenius madagascariensis</i>, is an endangered species.</p> <p>International Importance</p> <p>Ramsar Criterion 2: The site supports vulnerable, endangered, or critically endangered species or threatened ecological communities. Migratory, frequent water bird - <i>Numenius madagascariensis</i>, EN</p>
Mangrove Areas	Original area: 39 ha
Current areas	22 ha
Potential restoration area	22 ha
Beach revegetation area	17 ha
Major threats	Domestic wastes, pond expansion, mangrove cutting, bark extraction, animal grazing, sediment spill.
Immediate intervention required	<p>Protection</p> <ul style="list-style-type: none"> - Reducing domestic waste to wetlands. - Establishment of <i>tara bandu</i> to protect the mangroves from livestock and cutting - Erecting fence to block livestock entering the natural regeneration sites. <p>Restoration</p> <ul style="list-style-type: none"> - Creating canals and bunds to traps natural seedlings - Limited re-planting activities, particularly species <i>Ceriops</i>, <i>Lumnitzera</i>, and <i>Rhizophora</i> (100-200 seedlings/ha). - Planting grass and multi-purposes trees in the built-up area zone, hills, riverside, to reduce soil erosion and provide

	community with livestock's' feed, fire woods, fruits, medicine, and shades.
Long term management	<ul style="list-style-type: none"> - Designating the mangrove areas as nationally protected wetlands. - Regulating the flow of sediment to avoid mangroves. - Developing community based, low-impact tourism activities. - Regulating a limited harvest of fish, crabs, mussel in certain areas; priority for local community.

4. Ulmera



Location	Liquica Municipality
Status	<p>National Importance</p> <p>The site is source of livelihoods for local communities</p> <p>The site provide protection for community from strong winds, waves, and coastal erosion.</p>
Mangrove Areas	Original area: 62 ha
Current areas	45 ha
Potential restoration area	25 ha
Beach revegetation area	17 ha
Major threats	Domestic wastes, pond expansion, bark extraction, mangrove cutting, animal grazing, bait worm collection in mangroves, sediment spill from the land.
Immediate intervention required	<p>Protection</p> <ul style="list-style-type: none"> - Reducing domestic waste to wetlands. - Establishment of <i>tara bandu</i> to protect the mangroves from livestock, cutting, and bait worm collection. - Erecting fence to block livestock entering the natural regeneration sites. <p>Restoration</p> <ul style="list-style-type: none"> - Creating canals and bunds to traps natural seedlings - Limited re-planting activities, particularly species <i>Cerriops</i>, <i>Lumnitzera</i>, and <i>Rhizophora</i> (100-200 seedlings/ha). - Planting grass and multi-purposes trees in the built-up area zone, hills, riverside, to reduce soil erosion and provide community with livestock's' feed, fire woods, fruits, medicine, and shades.
Long term management	<ul style="list-style-type: none"> - Designating the mangrove areas as nationally protected wetlands. - Regulating the flow of sediment to avoid mangroves. - Developing community based, low-impact tourism activities. - Regulating a limited harvest of fish, crabs, mussel in certain areas; priority for local community.

5. Maubara Lake



Location	Liquica Municipality
Status	<p>National Importance</p> <p>The site has beautiful scenery for tourism.</p> <p>The site is regularly visited by at least 18 water bird species.</p>
Mangrove Areas	Original area: 47 ha (water body and buffer zone)
Current areas	47 ha
Potential restoration area	15 ha
Beach revegetation area	15 ha
Major threats	Domestic wastes from visitors, mangrove cutting, animal grazing, siltation from the land, exotic fish species introduction.
Immediate intervention required	<p>Protection</p> <ul style="list-style-type: none"> - Reducing domestic waste from visitors. - Establishment of <i>tara bandu</i> to protect the mangroves from livestock and cutting. - Erecting fence to block livestock entering the natural regeneration sites. - Evaluating the status of exotic fish in the lake and develop planning for their eradication. <p>Restoration</p> <ul style="list-style-type: none"> - Creating canals to encourage natural seedlings dispersal and grow. - Limited re-planting activities, particularly species <i>Avicennia</i>, and <i>Lumnitzera</i> (100-200 seedlings/ha). - Planting grass and multi-purposes trees in the built-up area zone, hills, riverside, to reduce soil erosion and provide community with livestock's' feed, fire woods, fruits, medicine, and shades.
Long term management	<ul style="list-style-type: none"> - Regulating the flow of sediment to avoid mangroves. - Development of commercial, low-impact tourism activities, assisted by experienced tourism professionals.

6. Biacou



Location	
Status	<p>National Importance</p> <p>The site is source of livelihoods for local communities</p> <p>The site provide protection for community from strong winds, waves, and coastal erosion.</p>
Mangrove Areas	Original area: 131 ha
Current areas	11 ha
Potential restoration area	1 ha
Beach revegetation area	4 ha
Major threats	Domestic wastes, pond expansion, mangrove cutting, animal grazing, bark extraction in mangroves, sediment spill from the land.
Immediate intervention required	<p>Protection</p> <ul style="list-style-type: none"> - Reducing domestic waste to wetlands. - Establishment of <i>tara bandu</i> to protect the mangroves from livestock, cutting, and bait worm collection. - Erecting fence to block livestock entering the natural regeneration sites. <p>Restoration</p> <ul style="list-style-type: none"> - Creating canals and bunds to traps natural seedlings - Limited re-planting activities, particularly species <i>Ceriops</i>, <i>Lumnitzera</i>, and <i>Rhizophora</i> (100-200 seedlings/ha). - Planting grass and multi-purposes trees in the built-up area zone, hills, riverside, to reduce soil erosion and provide community with livestock's' feed, fire woods, fruits, medicine, and shades.
Long term management	<ul style="list-style-type: none"> - Designating the mangrove areas as nationally protected wetlands. - Regulating the flow of sediment to avoid mangroves. - Developing community based, low-impact tourism activities. - Regulating a limited harvest of fish, crabs, mussel in certain areas; priority for local community.

7. Irabin de Baxio



Location	Viqueque
Status	<p>National Importance</p> <p>The site is source of livelihoods for local communities.</p> <p>The site provide protection for community from strong winds, waves, and coastal erosion.</p> <p>International Importance</p> <p>Ramsar Criterion 8: it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.</p>
Mangrove Areas	Original area: 187 ha
Current areas	77 ha
Potential restoration area	50 ha
Beach revegetation area	100 ha
Major threats	Mangrove cutting, animal grazing, agriculture expansion
Immediate intervention required	<p>Protection</p> <ul style="list-style-type: none"> - Establishment of <i>tara bandu</i> to protect the mangroves from livestock, cutting. - Erecting fence to block livestock entering the natural regeneration sites. <p>Restoration</p> <ul style="list-style-type: none"> - Creating canals and bunds to traps natural seedlings - Limited re-planting activities, particularly species <i>Rhizophora</i>, <i>Ceriops</i>, and <i>Avicennia</i> (100-200 seedlings/ha). - Planting multi-purposes trees in the built-up area zone and hills to provide community with alternatives for livestock's' feed, fire woods, fruits, medicine, and shades.
Long term management	<ul style="list-style-type: none"> - Designating the mangrove areas as nationally protected wetlands. - Developing community based, low-impact tourism activities. - Regulating a limited harvest of fish, crabs, mussel in certain areas; priority for local community. - Environmentally friendly agriculture

8. Aubeon



Location	Manatuto Municipality
Status	<p>National Importance</p> <p>The site is source of livelihoods for local communities.</p> <p>The site is home to water birds, crocodiles, and fish important for communities.</p> <p>The site provide protection for community from strong winds, waves, and coastal erosion.</p> <p>International Importance</p> <p>Ramsar Criterion 8: it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.</p>
Mangrove Areas	Original area
Current areas	260
Potential restoration area	-
Beach revegetation area	20 ha
Major threats	Mangrove cutting, animal (crocodile) hunting
Immediate intervention required	<p>Protection</p> <ul style="list-style-type: none"> - Establishment of <i>tara bandu</i> to protect the mangroves from livestock, cutting. - Discouraging community from wild hunting animal activities, particularly crocodile. - Increase awareness about the important of <p>Restoration</p> <ul style="list-style-type: none"> - The site is relatively in good condition, no need for mangroves restoration. - Planting multi-purposes trees in the built-up area zone to provide community with alternatives for livestock's' feed, fire woods, fruits, medicine, and shades.
Long term management	<ul style="list-style-type: none"> - Designating the mangrove areas as nationally protected wetlands. - Developing community based, low-impact tourism activities. - Monitoring and regulating a limited harvest of shrimp, fish and crabs in the lagoon; priority for local community. - Developing environmentally friendly agriculture and aquaculture as source of livelihoods to reduce threat to mangroves in the Lake.

9. Modomahut Lake



Location	Same Municipality
Status	<p>National Importance</p> <p>The site is source of livelihoods for local communities</p> <p>The site provide protection for community from strong winds, waves, and coastal erosion.</p> <p>International Importance</p> <p>Ramsar Criterion 1: A wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.</p> <p>Ramsar Criterion 8: it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.</p>
Mangrove Areas	Original area
Current areas	240 ha
Potential restoration area	-
Beach revegetation area	20 ha
Major threats	Mangrove cutting, animal hunting (crocodile)
Immediate intervention required	<p>Protection</p> <ul style="list-style-type: none"> - Establishment of <i>tara bandu</i> to protect the mangroves from cutting and hunting. - Increase awareness of community to protect wildlife of the lagoon. <p>Restoration</p> <ul style="list-style-type: none"> - There is no significant degradation of wetlands on the lagoon, therefore, no specific restoration activities are needed. - Planting multi-purposes trees in the built-up area zone and farms to provide community with alternatives for livestock's' feed, fire woods, fruits, medicine, and shades.
Long term management	<ul style="list-style-type: none"> - Designating the mangrove areas as nationally protected wetlands. - Proposing the areas as Ramsar Site for its unique examples as natural mangrove lagoon harbouring the giant <i>Sonnerata</i> roots in the bioregion. - Developing community based, low-impact tourism activities. - Regulating a limited harvest of fish, crabs, mussel in certain areas; priority for local community. - Environmentally friendly agriculture and aquaculture in the lake

10. Suai Loro



Location	Cova Lima Municipality
Status	<p>National Importance</p> <p>The site is source of livelihoods for local communities.</p> <p>The site representing the richest mangrove biodiversity in the South Coast.</p> <p>If needed, could be the source of mangrove seedlings (seed bank) for restoration in the South Coast.</p> <p>The site provide protection for community from strong winds, waves, and coastal erosion.</p> <p>International Importance</p> <p>Ramsar Criterion 8: it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.</p>
Mangrove Areas	Original area: 40 ha
Current areas	40 ha
Potential restoration area	35 ha
Beach revegetation area	20 ha
Major threats	Domestic pollution, mangrove cutting, animal grazing.
Immediate intervention required	<p>Protection</p> <ul style="list-style-type: none"> - Establishment of <i>tara bandu</i> to protect the mangroves from livestock, cutting. - Erecting fence to block livestock entering the natural regeneration sites. - Reduce the domestic waste dumped into the wetlands. <p>Restoration</p> <ul style="list-style-type: none"> - Creating canals and bunds to traps natural seedlings - Limited re-planting activities, particularly species <i>Lumnitzera</i>, <i>Sonneratia</i>, <i>Avicennia</i>, and <i>Rhizophora</i> (100-200 seedlings/ha). - Planting multi-purposes trees in the built-up area zone to provide community with alternatives for livestock's' feed, fire woods, fruits, medicine, and shades. - Planting beach vegetation such as Tamarind, <i>Azadirachta indica</i>, Mangos, Coconut, and Raintree.
Long term management	<ul style="list-style-type: none"> - Designating the mangrove areas as nationally protected wetlands. - Developing community based, low-impact tourism activities. - Regulating a limited harvest of fish, crabs, mussel in certain areas; priority for local community. - Environmentally friendly agriculture

11. Tafara



Location	Suai Lima
Status	National importance The sites are important habitat for crocodile.
Mangrove Areas	Original area
Current areas	
Potential restoration area	
Beach revegetation area	
Major threats	Coastal erosion, beach vegetation cutting
Immediate intervention required	<p>Protection</p> <ul style="list-style-type: none"> - Awareness campaign to avoid beach vegetation cutting and dangerous encounter with animal. <p>Restoration</p> <ul style="list-style-type: none"> - Planting multi-purposes trees in the surrounding areas to provide community with alternatives for livestock's' feed, fire woods, fruits, medicine, and shades.
Long term management	<ul style="list-style-type: none"> - Developing community based, low-impact tourism activities. - Regulating a limited harvest of fish, crabs, mussel in certain areas; priority for local community. - Planting beach vegetation such as Tamarind, <i>Azadirachta indica</i>, Mangos, Coconut, and Raintree - Environmentally friendly agriculture

Summary Information

Mangrove Species of Timor Leste and Their Management Recommendation

Species	Location	National Status	Management Recommendation
<i>Acanthus ilicifolius</i>	All locations	Abundance	Regular monitoring
<i>Acrostichum speciosum</i>	Hera and Metinaro	Very rare, threaten	Strict protection of the mother trees, nursery and replanting to maintain the population
<i>Aegiceras floridium</i>	Hera	Very rare	Strict protection of the habitat in Hera.
<i>Avicennia marina</i>	All locations in North Coast	Abundant, vulnerable	Regular monitoring.
<i>Bruguiera parviflora</i>	North Coast	Rare	Regular monitoring
<i>Bruguiera sexangula</i>	Hera and Metinaro	Very rare, Endanger (IUCN Red List)	Strict protection of its habitat in Metinaro.
<i>Ceriops tagal</i>	All locations	Abundant	Regular monitoring
<i>Dolichandrone spathacea</i>	Hera	Very rare	Strict protection of its habitat in Hera
<i>Exoecaria agallocha</i>	All locations	Abundant	Regular monitoring
<i>Lumnitzera racemosa</i>	North coast	Rare	Regular monitoring, strict prohibition for cutting
<i>Rhizophora apiculata</i>	All locations	Abundant	Regular monitoring
<i>Rhizophora mucronata</i>	North coast	Rare	Strict protection, nursery, replanting
<i>Sonneratia alba</i>	All locations	Abundant	Regular monitoring
<i>Pemphis acidula</i>	North coast	Very rare	Regular monitoring
<i>Xylocarpus</i>	South coast	Rare	Regular monitoring
<i>Nypa</i>	South coast	Rare	Regular monitoring

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