# Coastal Rehabilitation and Mangrove Restoration using Melaleuca Fences

## Practical Experience from Kien Giang Province

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# ABOUT GIZ

The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) was established on 1 January 2011. It brings together under one roof the long-standing expertise of the German Development Service (DED), the German Technical Cooperation (GTZ) and InWEnt – Capacity Building International, Germany. As a federally owned enterprise, it supports the German Government in achieving its objectives in the field of international cooperation for sustainable development. We are also engaged in international education work around the globe.

GIZ operates in many fields, including economic development and employment; governance and democracy; security, reconstruction, peace building and civil conflict transformation; food security, health and basic education; and environmental protection, resource conservation and climate change mitigation.

For many years, Viet Nam has been a priority partner country for German Development Cooperation. Projects and programmes cover the following three priority areas of cooperation, which are closely interlinked with the overarching goal of Poverty Reduction:

1) Sustainable Economic Development and Vocational Training;
2) Environmental Policy, Natural Resources and Urban Development; and
3) Health.

# FOREWORD

Mangrove forests are being lost through erosion at an alarming rate in Viet Nam. Much of this loss is the result of erosion, which will continue to get worse with climate change. Mangrove forests protect households, sea protection dykes and agricultural land from destruction by sea inundation events. Mangroves provide many ecosystem services besides coastal protection, including spawning and breeding grounds for aquatic animals especially fish and shrimps.

There has been little success in mangrove forest rehabilitation through plantings especially in high erosion zones.

The Conservation and Development of the Kien Giang Biosphere Reserve Project has developed an innovative approach to coastal rehabilitation using melaleuca pole fences with bamboo matting and fish netting to reduce erosion and protect young mangrove seedlings.

The advantage of this new fence design is that it uses local materials and is easy to establish using simple equipment. It is very cost effective for coastal protection compared with existing methods of dyke development and mangrove planting. The design takes into account the current condition of the coast and forest with two lines of fences used in the most exposed situations. The fence design is sturdy enough to withstand and diminish the force of waves while also allowing water and animals to pass through. The fences also trap the silt deposited in the dry season and stop it being washed away in the rainy season.

This book documents the fence design, the method of construction and materials used, and the cost of production. It provides scientific evidence showing how the fences reduced wave energy, improved sediment retention, soil development, and how their use resulted in an excellent survival rate of planted and recruited mangrove seedlings. The fences also improved the condition and biodiversity of existing residual mangrove forests. The characteristics of the mangrove species that were successfully used at this Kien Giang site are also described.

This Manual was developed at the request of several agencies involved in coastal zone management such as the Ministry for Agriculture and Rural Development (MARD), several Provincial Department for Agriculture and Rural Development (DARDs), donors and NGOs. The manual provides information to assist with planning and implementation of coastal zone protection and mangrove forest rehabilitation. It documents over 3 years experience in Kien Giang Province which now needs to be tested in other coastal areas where conditions are very different to determine how the design principles can be applied elsewhere.

Practitioners tasked with mangrove restoration will now be able to assess how well these simple fence designs fit their coastline conditions.










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The lives of coastal families are being affected by climate change.

# SUMMARY

The fences reduce wave energy by up to 63%, retain up to 20 cm depth of sediment each year and up to 700 ton per hectare, and protect up to 100% of planted or naturally recruited mangrove seedlings, even in severe erosion sites.

Erosion is a serious issue in many coastal areas. **In Kien Giang Province around 34% of the coast is eroding**, in some areas as much as 24 m is lost each year. In addition, a further 23% of the coastline in Kien Giang is at risk of future erosion due to mangrove loss. This is a critical problem for the people living in coastal areas. Mangrove forests form a green barrier of salt-tolerant vegetation that buffers and protects valuable farming lands from storm damage and rising seas. With mangrove forests being lost due to erosion and over harvesting, the need to implement mangrove restoration activities is urgent.

Past mangrove plantings have often been unsuccessful. **In severe erosion areas, all the planted mangroves are lost within one year.** One of the main reasons for this catastrophic loss is the lack of protection of young plants from wave action and seasonal sediment movement following planting. Strong wave movement strips the seedlings of their leaves, pushes the plants over and uproots them. Seasonal sediment movement also uproots and buries seedlings.

The GIZ Conservation and Development of the Kien Giang Biosphere Reserve Project has designed and tested three different designs of coastal protection fences. The purpose of the fences is to reduce wave energy and to prevent sediment deposited in the early wet season from being swept away through wave action when strong monsoon wind events occur in the latter half of the wet season. The fences allow planted or naturally recruited mangrove seedlings to establish a more secure root system. **The fences reduce wave energy by up to 63%, retain up to 20 cm depth of sediment each year and up to 700 ton per hectare. They also protect up to 100% of planted or naturally recruited mangrove seedlings, even in severe erosion sites.**

The fence design acts like a natural barrier absorbing wave energy and allowing water and animals to move freely in and out of the protected areas. The biodiversity of plants and animals inside the areas fenced by the Project has increased significantly. As wave action is reduced and sediment becomes stable, seedlings are able to survive and grow.

The Project fences have promoted natural regeneration and animal diversity. Within two years there is a more diverse community of organisms living on the sea bed (the benthos) and density is much greater in fenced areas. In areas with two fence lines biodiversity and soil structure approaches that of the natural mangrove forest.

The fence design reduces wave energy while still allowing through movement of water, silt and organisms unlike the barriers constructed from cement or other solid materials. After two years, the deposition of sediment behind the fences resembles the pattern of natural deposition in adjacent areas where mangrove forest trees are still present.

Fences are constructed of melaleuca, a readily available inexpensive timber in the Mekong Delta. Melaleuca was selected because of the wide ranging environmental services provided by these coastal forests and for the resilience of the timber in the wet and muddy conditions of mangrove habitats.

This manual shows how the fences protect and rehabilitate the coast and improve its biodiversity. It shows how to select and construct the different fence types to suit different coastal conditions and provides a list of materials needed and costs for each type of fence.

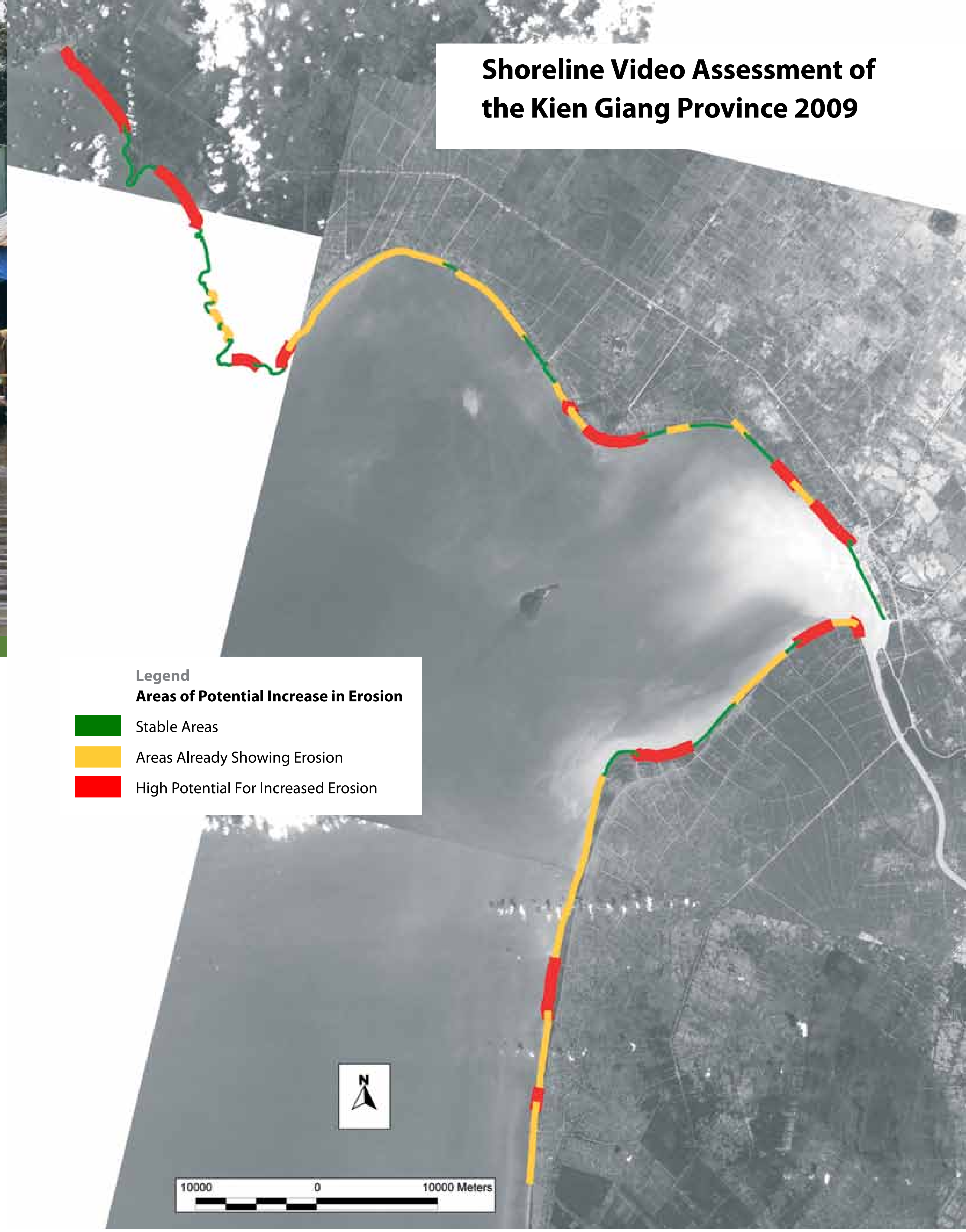
People living along a canal in Kien Giang Province.

# BACKGROUND

Located in the western part of the Mekong Delta, Kien Giang Province has 205 km of coastline. It is estimated that 34% of the coastline is eroding and at least 25% of this coastline is badly eroded (Duke et al. 2010). The shoreline has more than 5,000 ha of mangrove protection forests, forming a thin green line of salt-tolerant vegetation that buffers and protects valuable farming lands from rising seas and storm damage. This tacit coastal defense is threatened by global climate change as projected rises in sea levels take effect. The construction of canals has also changed the pattern of coastal water and sediment movement.

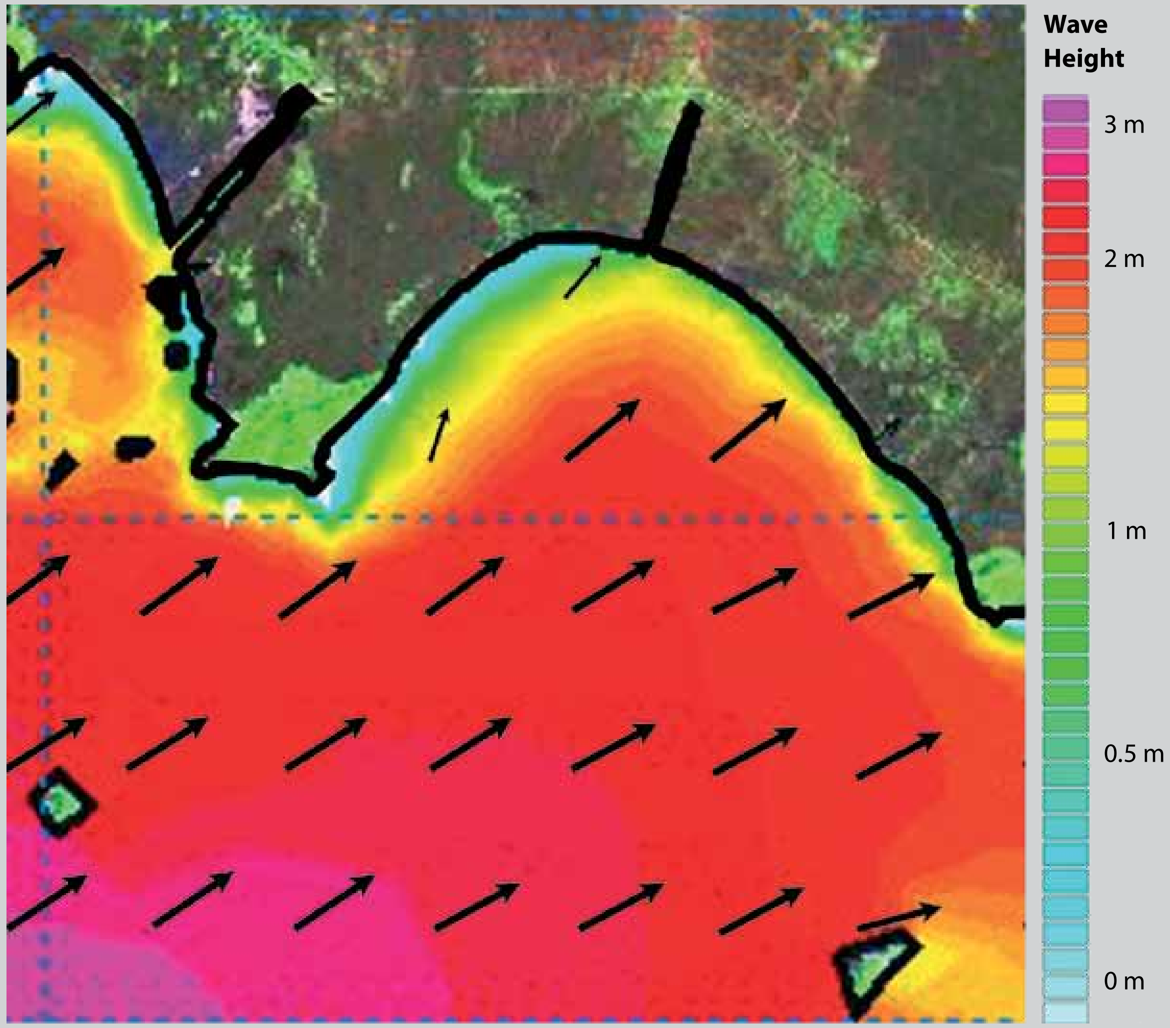
Communities need to delay and minimize the inevitable impacts of climate change. A strategy of 'buying time' or adaptation requires action now. A wide, dense forest of healthy mangroves along the shoreline is needed to break the force of waves and storms that would otherwise erode them. Coastal mangrove forests should no longer be removed or damaged in any way. Strategies and methods are required urgently to rehabilitate all threatened coastal shorelines.

Forest restoration under the 661 program was implemented in Kien Giang by the Department of Agriculture and Rural Development (DARD) and the Forest Protection Management Boards (FPMB). After 10 years, approximately 500 ha of new mangrove forests have been planted, but this work only focused on planting a single mangrove species (*Avicennia alba or Rhizophora apiculata*) **at depositional areas which had only a 50% survival rate (Duke et al. 2010). Previous efforts made at planting mangroves in high erosion sites have often failed completely (Duke et al. 2010).** Reasons for these failures are poor species selection, poor quality seedlings and a lack of protection of seedlings from mechanical forces during the critical initial stages of growth following planting.

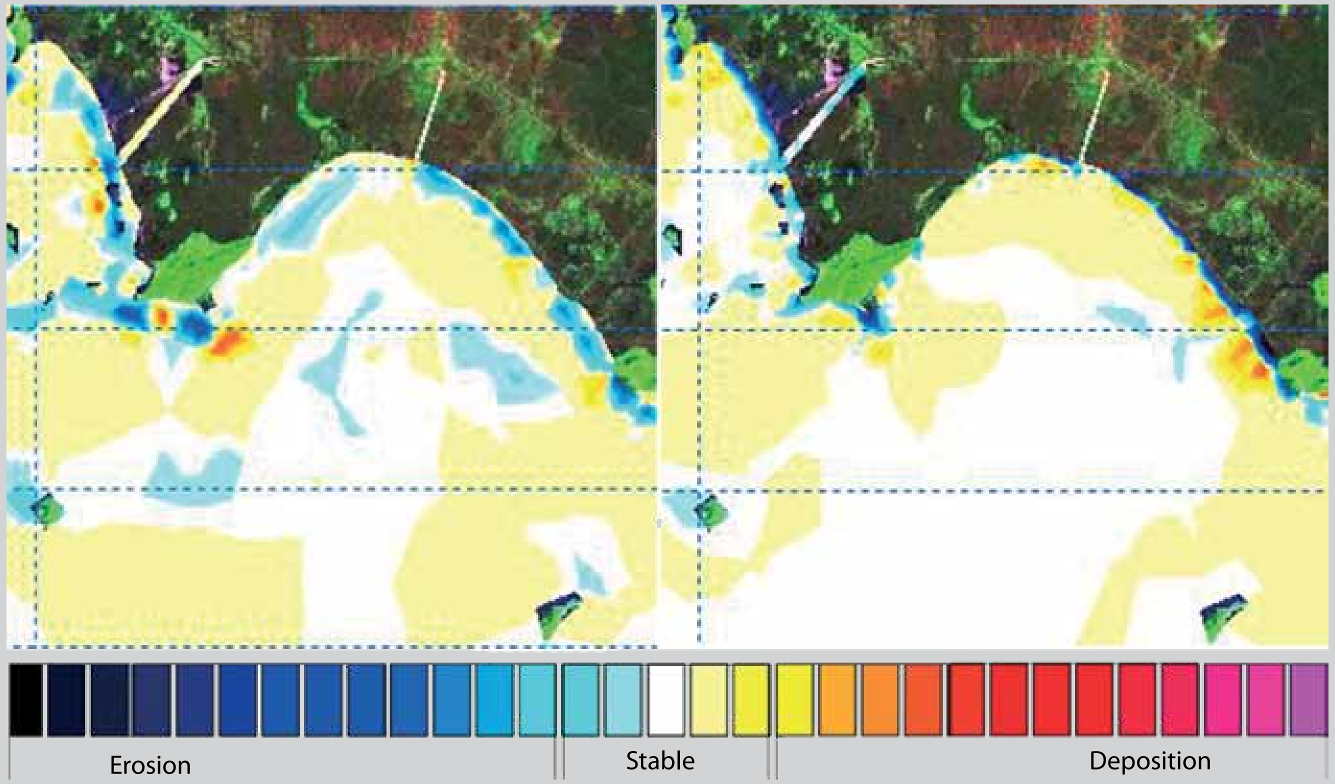



Shoreline assessment by Duke et al 2010 shows only a small proportion of the coastline is not eroding.

**Hydrodynamic model of the Kien Giang coastline showing wave height during strong wet season monsoon wind events (ADB 2011)**




**Hydrodynamic model of the Kien Giang coastline showing erosion and deposition in the two different prevalent wind conditions (ADB 2011).**




**Wave height and direction** are affected by the direction and strength of the monsoon winds. During the dry season (November to April) the NE monsoon winds are offshore and there are no waves. In the wet season (June – October), SW monsoon winds blow onshore creating waves that impact the shore.

The figure above is a hydrodynamic model of the Kien Giang coastline showing the size of waves generated by strong monsoon winds that periodically occur in the middle of the wet season (August – September).

**Erosion and deposition** occur along the coastline according to the two different prevalent wind conditions (NE and SW Monsoon) and wave height.

In the dry season because there is little wave activity there is little change in silt movement. However, there may be episodes of compaction and possibly a very small amount of dust accumulation through offshore winds during this season.

At the beginning of the wet season when typical monsoon winds are weak, sediments are deposited along the coast. During the latter half of the wet season when strong SW monsoon wind events occur, the silt is washed out and the coastline is eroded. The figure above is the hydrodynamic model output showing the sedimentation and deposition along the Kien Giang coastline.

**Seasonal sediment movement combined with wave action can cause seedlings to be buried or uprooted.**

Protection earthern dykes were breached annually before work started in the Vam Ray demonstration area.

The coastal demonstration model after two years. A dyke and melaleuca protection fences were constructed and different species of mangroves planted.

# THE PROJECT COASTAL MANAGEMENT MODEL

The Project set up a coastal rehabilitation and mangrove restoration model in Vam Ray Village, Binh Son commune, Hon Dat District, Kien Giang Province.

Satellite images have shown that in Vam Ray, the erosion rate is about 10 m per year and this has been occurring for at least ten years. **The sea dyke system was being destroyed each year.** The mangrove forests were lost allowing the sea to break through and destroy crops and orchards and threaten houses. Therefore, a concentrated effort to protect the coastal area was urgently needed.

The innovative approach adopted has used a series of melaleuca fences that are designed to reduce wave action and sea water current forces, and protect mangrove seedlings until they can become established. The fences also facilitate sediment deposition, further assisting mangrove establishment, and reduce rubbish deposition.

The fence design substantially reduces wave action and allows water and animals to move freely in and out of the protected areas. The fences have enabled coastal mangrove rehabilitation, and after 2 years no deleterious impact or change to the natural soil deposition in either direction along the coastline from the fences has been detected while there has been a substantial increase in sediment deposition behind the fences.

Community planting mangroves.

Acid sulphate soil. At the beginning of the wet season acid is washed into the waterways.

A major canal in Hon Dat District where acid water from a minor canal enters. Blue water is pH 3 and brown pH 7.

Melaleuca protection forest, Hon Dat District.

Boats transporting melaleuca poles and bamboo mats for the construction of mangrove protection fences.

# The use of melaleuca for fencing

The fences are constructed of melaleuca, a readily available timber in the Mekong. Melaleuca pole fences were selected for the wide ranging environmental services provided by melaleuca forests and for the resilience of this timber in the wet and muddy conditions of mangrove habitats. The timber is strong, does not split, is resistant to rotting and insect attack and appears to remain intact for at least 10 - 15 years.

*Melaleuca cajaputi* is a native tree to the Mekong Delta that grows well in inundating acid sulphate soils. Melaleuca forests have an important protective function. The removal of these forests in agricultural areas causes the release of acid from the soils, severely restricting crop growth. When this acid migrates from the fields and the canal banks into the waterways it causes plant (and fish) death, clearing of sediment from the water, and corrosion of infrastructure.

Farmers are reluctant to maintain their forests because there is currently a limited market for poles. The traditional use as building support pylons for houses in areas prone to flooding has been displaced by the use of concrete. The drop in demand for melaleuca timber has reduced its market value. By using melaleuca in coastal fence construction and through demonstrations of how to increase growth rates by thinning natural stands the Project is showing how to add value to melaleuca forests.

Improved income from melaleuca timber will encourage farmers to keep their forest area and to improve the management of acid sulphate soils. This will ensure the protection of coastal areas. The thinning of forests provides material for the fences and the remaining trees will grow faster and become more valuable as timber. **This not only increases the income for farmers but also avoids green house gas emission from the common practice of burning the residue from thinned trees.**


Wave break fence for high erosion areas.


Sediment trap fences for areas of low erosion and for natural regeneration.

# Fence design

## Wave break fence

Wave break fences are designed to **reduce the energy of waves in areas of strong turbulence** thus assisting the stabilization of the eroding coastline. The fences can halt coastal mangrove tree loss from erosion and allow for mangrove forest restoration through both natural regeneration and planting. They also act to prevent rubbish from the ocean drifting into planted areas and smothering newly planted seedlings.

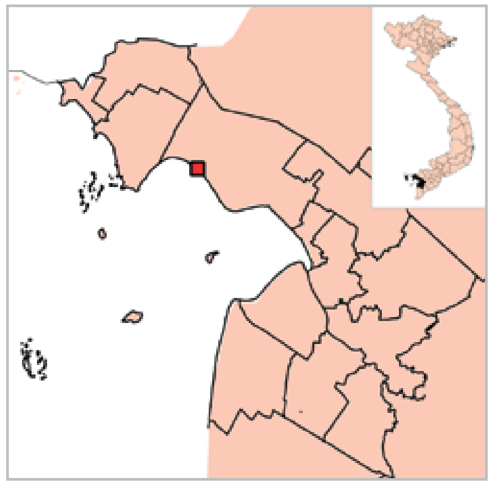
## Sediment trap fence

The sediment trap fence is designed to **reduce the energy of waves in areas of medium turbulence**, to trap sediment deposited in the wet season, and allow this material to develop enough structure to form a substrate for the root systems of seeds and seedlings to anchor and help them grow. The fences also trap mangrove seeds allowing for natural regeneration. This fence design can be established in depositional or weakly eroding areas as a cost effective way to aid in restoration through natural recruitment, or on the inside of wave break fences established in high erosion areas. As with the wave break fence they also prevent rubbish drifting into planted areas and smothering seedlings.


Location of treatments used for coastal rehabilitation at Vam Ray, Hon Dat.

# Vam Ray model treatments

The project coastal management model was established in 2009 over an area of 4 ha. Four different combinations of fences and existing mangrove stands were established. The effectiveness of these treatments in stopping erosion and allowing mangrove restoration has been monitored over the past two years.



Map of Kien Giang Province showing Vam Ray demonstration site.

## Treatments

| | | |
|---|---|---|
| Treatment 1 | **Single Fence** | Wave break fence with planted seedlings of *Avicennia spp* and *Rhizophora apiculata*. |
| Treatment 2 | **Double Fence** | Combination of wave break fence and sediment trap fence with planted seedlings of *Avicennia spp*, *R. apiculata*, *Bruguiera spp*, and *Nypa fruticans*. |
| Treatment 3 | **Mangrove + 1 silt trap fence** | Plantings behind existing mangrove belt and one side fence. Planted seedlings of *R. apiculata* and *Nypa fruticans*. |
| Treatment 4 | **Mangrove + 2 fence** | Behind existing mangrove belt and two side fences with planted seedlings of *R. apiculata* and *Nypa fruticans*. |
| Treatment 5 | **Control** | Old fence built by DARD with no planted seedlings. |


Melaleuca flower


Scientists measuring wave attenuation.

# Effectiveness of melaleuca fences

The effectiveness of the different melaleuca fence designs for wave attenuation, sediment stabilization, biodiversity enhancement and seedling growth and survival has been monitored over the past two years.



## Reduction of wave energy

Mangrove forests play a key role in coastal shoreline protection. The trees reduce the height and velocity of incoming waves through the drag forces exerted by their multiple roots and stems and they trap sediment in their roots helping to prevent coastal-erosion processes.

A recent study of wave energy attenuation was undertaken at the Vam Ray demonstration site and nearby natural mangrove forests. This showed that the wave break fence is as effective as mangrove forest in reducing wave energy. Field measurements found that the mangrove belt in Hon Dat reduced wave energy by 50 - 67% depending on the forest structure while the wave break fence reduced the wave energy by 65% (Nguyen Hai Hoa 2011).

Technician numbering sediment accumulation monitoring pole.

## Sediment accumulation and stabilization

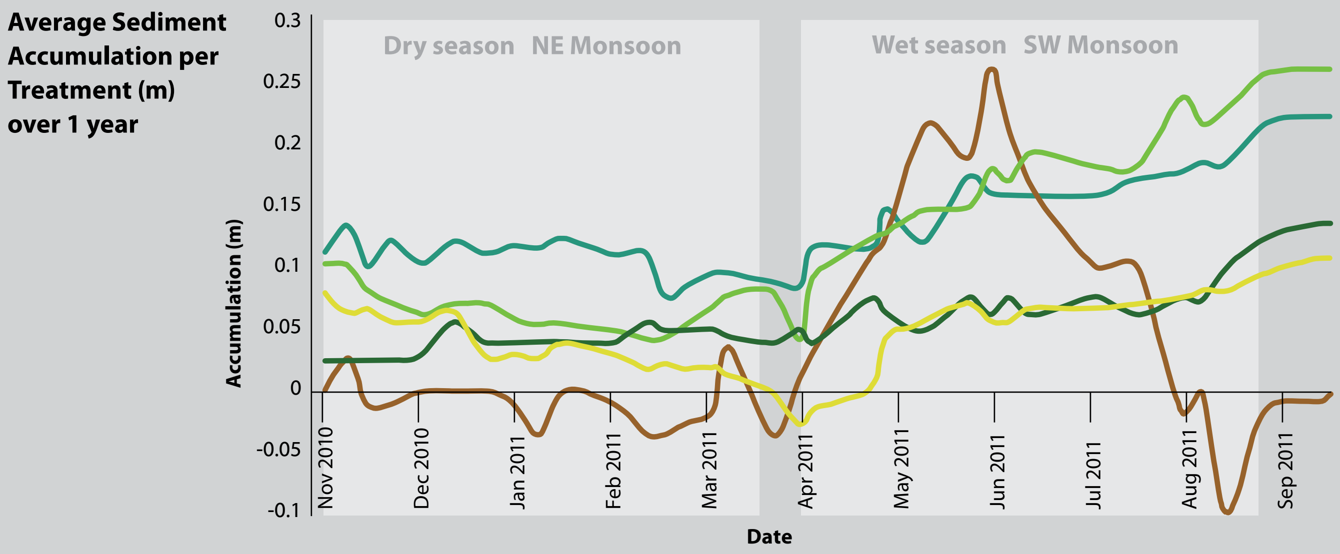
Melaleuca fences stabilize sediments and lead to a net accumulation of sediment over time. The fences prevent sediment deposited early in the wet season from being swept away later through stronger wave action when strong monsoon winds occur in the latter half of the wet season.

In each treatment, sediment accumulation (mud elevation) and stabilization were monitored. Two meter long granite posts marked with 10cm increments were hammered upright into the mud until firm. Photos of each post were taken at low tide once every one to two weeks depending on tides and weather. The photos were used to determine changes in the relative elevation of the mud. Change in elevation = level at time of measurement – level at previous measurement. The change in mud elevation over time was averaged by treatment and is shown in the graph above.

The total sediment accumulated in each treatment over one year (2010 - 2011) is shown in the graph.



**Changes in sediment elevation over time at treatment sites.**




Sediment accumulates in the wet season (graph). Soil structure improves with time (photo).

### Control site

Measurements taken in the control site (area with existing DARD fence) for the period November 2010 – November 2011 show the influence of wind direction and strength.

Through the dry season (November to April) when winds are offshore and there are no waves, there is little change in mud elevation.

In the wet season (June – October) the large changes in sedimentation are related to the strength of the onshore SW monsoon winds. In the early part of the season monsoon winds are light and the small waves that are generated bring sediments onto the coast resulting in deposition at the site. In the middle of the wet season stronger winds bring larger waves that erode sediments. The result is that at the control site although there were large changes in sedimentation during the year there was no change in the net balance of sediments between November 2010 and November 2011.

### Treatment 1

The single fence treatment did not show the same large seasonal fluctuations in mud accumulation seen in the control site, indicating that the wave break fence reduced the energy of the waves during the windier months of the late wet season.

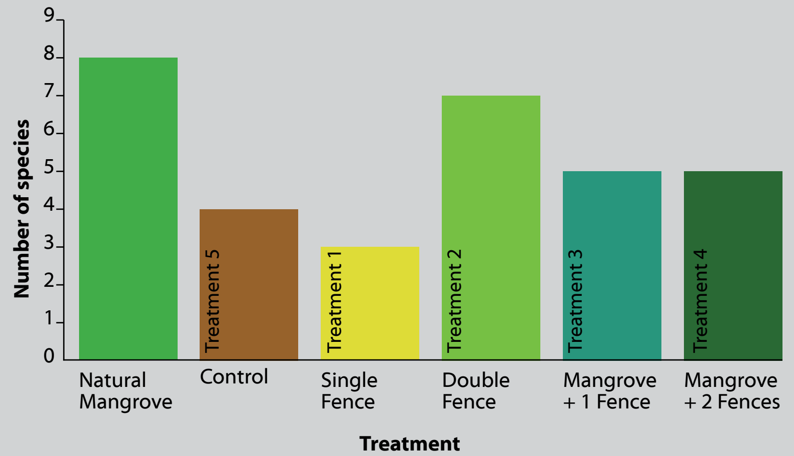
This fence also resulted in decreased mud accumulation through the dry season. As there is no wave action during this period it is likely that the decrease in elevation is due to consolidation of the fine sediments. The firming soil structure is favorable for seedling establishment.

### Treatments 2, 3, 4

In contrast to the control, the areas behind two fences (treatment 2) or behind the protective mangroves (treatments 3 and 4) all showed a net accumulation of sediments between November 2010 and November 2011.

There was little change during the dry season and increased sedimentation in the early wet season. Deposition during the late wet season was reduced but there was not the marked erosion that occurred in the control. Further deposition also occurred towards the end of the wet season.

**Benthos diversity in treatments and natural mangrove forest.**
**Number Diversity (Number of Species)**



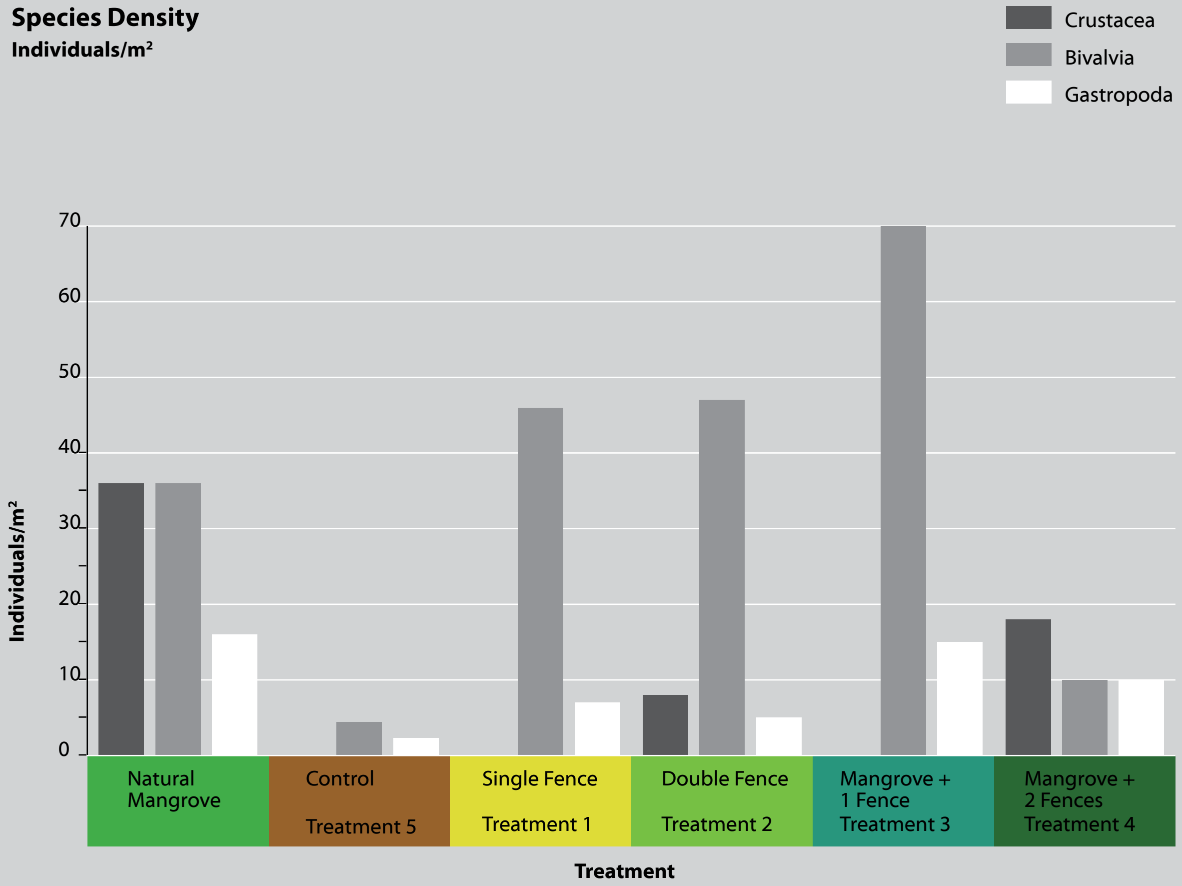

Mudskipper

Crab

Snails

Crabs and seedlings

Clams




Benthos diversity in treatments and natural mangrove forest.

Benthos density in treatments and natural mangrove forest.

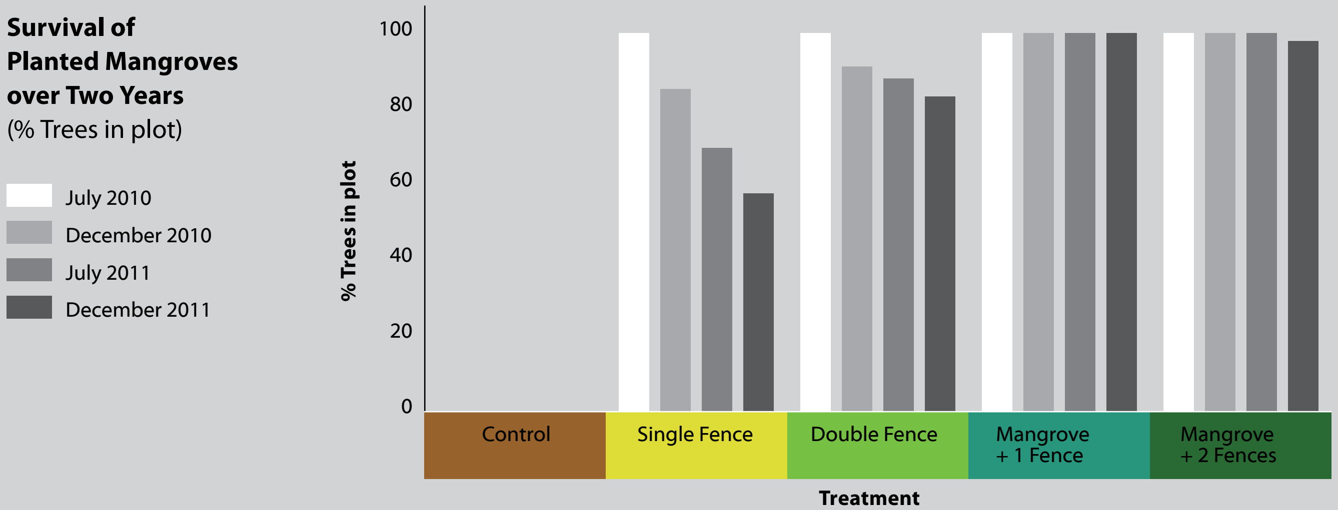
## Increase and changes in biodiversity

The melaleuca fence design while attenuating wave energy, still allows animals to move freely in and out of the protected areas. Recent studies conducted by the Can Tho University Research Institute for Climate Change indicated a marked difference between treatments with benthos diversity (number of different species) and density (number of individuals/m²) substantially higher in the fenced areas compared to the control area (Can Tho University 2011). The study was conducted two years after the fences were established.

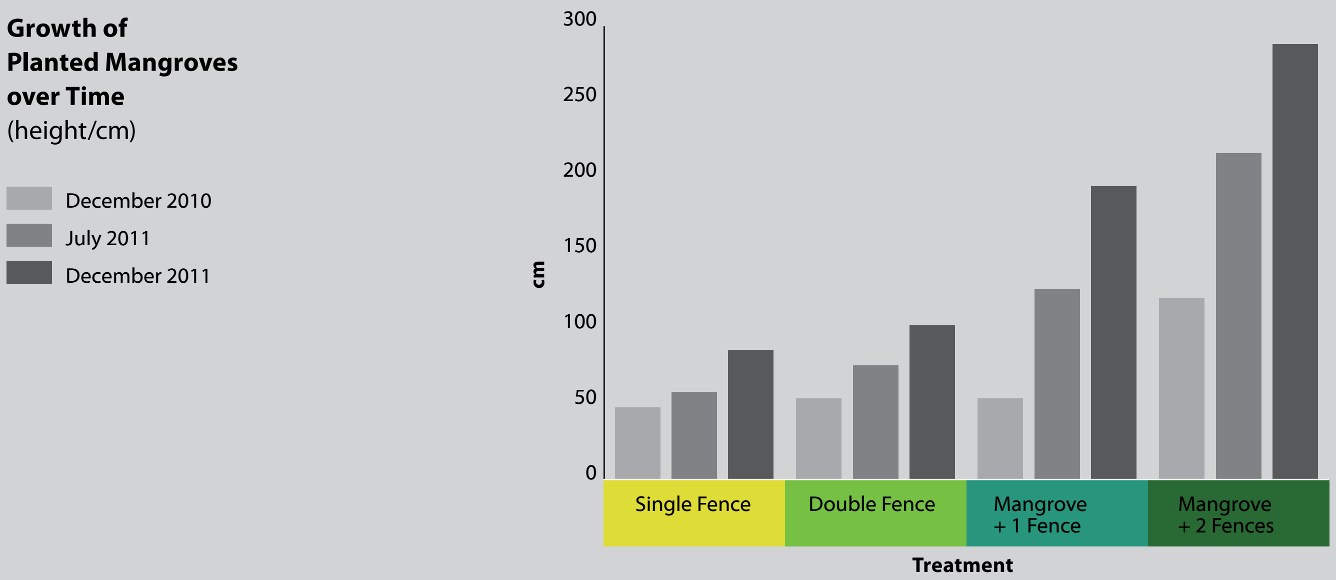
As expected, most diversity is found in natural mangroves. After only eighteen months the biodiversity in treatment 2 (wave break plus sediment trap fence) approached the diversity of the nearby natural mangrove forest. Refer to the graph above.

Crustaceans (eg. crabs), bivalves (eg. clams) and gastropods (eg. snails) were almost totally absent from the control site (DARD fence) but occurred in large numbers in all Project fenced treatments. Refer to the following graph.

**Survival of Planted Mangroves over Two Years**
(% Trees in plot)




**Growth of Planted Mangroves over Time**
(height/cm)




Project fences increased the growth and survival rates of planted mangroves.

## Increased survival and growth of seedlings

Melaleuca fences increase the survival rate of newly established seedlings by reducing their exposure to wave action, which reduces fluctuations in the seasonal pattern of sediment deposition and decreases the chance of seedlings being smothered by rubbish.

Planted seedlings survived and grew best in the areas with the greatest protection against wave action and sediment disturbance. Refer to the graph on mangrove growth. Almost all planted seedlings survived in treatments that had a mangrove belt in front and sediment trap fence to the side (Treatments 3 and 4).

The survival rate for seedlings in the double fenced areas (Treatment 2, wave break plus sediment trap fence) was also very high at around 82%. Refer to the graph on mangrove survival.

The survival rate in the strong wave area with the single wave break fence (Treatment 1) was reduced but still considerable at 57%.

Naturally recruited seedlings of *Avicennia* in areas behind all Project fence types.

The area planted behind mangroves has developed into a secondary mangrove forest with vines and other flowering plants after two years.

## Natural regeneration of mangroves

Recent studies conducted by the Can Tho University Research Institute for Climate Change indicated that natural recruitment in the Project fenced areas was substantial with most occurring in the areas with the greatest protection against wave action and sediment disturbance (Can Tho University 2011). After two years, the control site shows no evidence of recruitment.

### Treatment 1

Areas with single fences showed recruitment of 500 plants per ha after two years.

### Treatment 2

Areas with double fences had higher levels of recruitment (1100 plants per ha).

### Treatments 3 and 4

Areas with mangrove plus sediment trap fence had recruitment levels of 2200 – 3700 plants per ha and up to 300 plants per ha after only 3 months.

Recruited seedlings grew at a substantially faster rate than planted seedlings. In treatment 3 and 4 (behind mangrove belt), the naturally recruited seedlings had twice the growth rate of planted seedlings and more than twice the growth rate of planted *Rhizophora apiculata* and *Nypa fruticans*.

In treatments 1 and 2 all recruited seedlings were *Avicennia*. In treatments 3 and 4, *Avicennia* were immediately recruited and grew quickly and after 15 months, many seedlings of later successional species (e.g., *Bruguiera spp* and *Ceriop spp*) were recruited. This vegetation has developed into a secondary forest with vines and other flowering plants only two years after setting up the fences.

Cost effective nursery under natural mangroves

Avicennia flowers

Seedlings in nursery are watered with the tide.

*Avicennia* fruit

## Species performance

It is best to plant vigorous seedlings that have been held in a nursery for less than twelve months. The seedlings are best grown in seashore mud under natural shaded conditions of a mangrove forest and watered with sea water as the tide rises.

The project has germinated seed and planted eleven different mangrove species and monitored their performance. It is our aim to establish a seed source for a range of mangrove species including three rare mangroves at the Vam Ray demonstration site.

### *Avicennia* *A. alba* and *A. marina*

*Avicennia* seem most able to withstand high energy waves and would be the best choice for planting as a pioneer species in exposed areas along the coastal fringe.

- Best planted as first line of defense in coastal fringe.
- Seed production is prolific, they have a high germination rate and seeds quickly anchor in the mud and then grow rapidly.
- When planted seedlings grow quickly.
- Naturally regenerated *Avicennia* plants grow up to two and a half times faster than planted seedlings.
- The root system (pneumatophores) of *Avicennia* is able to colonise 1 square meter of mud after only 2 years.
- Stems are supple and bend in the waves.
- If plants are pushed over, shoots grow upwards from the stem.
- When planted together the plants protect each other from wave damage.



*Rhizophora* flower

*Bruguiera* flower

*Rhizophora* fruit

*Bruguiera* fruits

### *Rhizophora* *R. apiculata* and *R. mucronata*

*Rhizophora apiculata* is a common choice for large scale plantings. It is easy to establish in areas that are not exposed to high wave energy. *Rhizophora mucronata* is not common in Kien Giang.

- Best planted behind *Avicennia* in the mid to high tide area.
- *Rhizophora* has numerous large, viable and fleshy seeds with large energy reserves that support ready establishment.
- When planted they grow at a medium rate.
- Stems and root system are brittle and easily washed away.
- Waves push them over – but aerial roots quickly establish and push the plants upright again.
- *Rhizophora* is only able to claim a 40 - 50 cm square area of mud after 2 years, a third of that by *Avicennia*.
- *Rhizophora* wood has high calorific value and can be converted to charcoal. This makes it an important plantation species for income generation and use as a renewable energy source by coastal households.

### *Bruguiera* *B. cylindrical* and *B. sexangula*

*Bruguiera* is an early colonizer and grows as a small tree, in the mid-high intertidal zone or downstream estuary areas. The seed is cigar-shaped, similar to that of *Rhizophera*.

- Best planted in the mid-high intertidal areas and areas already established by *Avicennia*.
- The seeds are prolific, fleshy and easy to grow.
- Plant into areas behind the coastal fringe.
- When planted grows at a medium rate.
- We have recorded natural recruitment which occurs after *Avicennia* canopy closure.


*Xylocarpus granatum* flowers


*Lumnitzera littorea* (red mangrove) flowers


*Sonneratia alba* flower


*Nypa fruticans* flowers


*Xylocarpus granatum* fruits


*Lumnitzera littorea* (red mangrove) fruits


*Sonneratia alba* fruit


*Nypa fruticans* fruits

## *Xylocarpus granatum*

*Xylocarpus* is known as the cannonball mangrove. It is listed in Viet Nam as rare. Like other members of the family *Meleaceae* (mahogany trees), the timber has high economic value. *Xylocarpus* grows above high tide level.

- Best planted above high tide.
- Cannonball shaped fruits fall and split to reveal seeds.
- Seed is easy to germinate but the rate of seedling production is limited because mother trees are rare.
- When planted they grow at a medium rate.
- The value of timber makes this an excellent species for livelihood development.
- We are currently supporting a local researcher from the International University in HCM City to attempt to tissue culture *Xylocarpus granatum*.

## *Lumnitzera*

*L. littorea* (red mangrove), and *L. racemosa* (white mangrove)

Both *Lumnitzera* species are listed as rare mangroves. They grow as shrubs to a small tree. They grow best in high intertidal areas and have no economic value.

- Best planted above high tide.
- In both species, seed is prolific but difficult to germinate. We had only 5-7% germination rate.
- When planted they grow at a medium rate.
- Have no economic value but the seed is a valuable food for the local field rats (a valued local food).
- We are currently supporting a local researcher from the International University in HCM City to try to tissue culture the red mangrove. Research is also needed on the germination of seed.



## *Sonneratia alba*

*Sonneratia* grows into a tall tree and is able to tolerate long periods of fresh water. In Kien Giang *Sonneratia* grow along canals and tidal rivers, within sheltered bays. It is often dominant in the sea fringe near the outlet of canals but also occurs at mid to high tide levels. *Sonneratia* is best planted in depositional areas and not in high erosion sites.

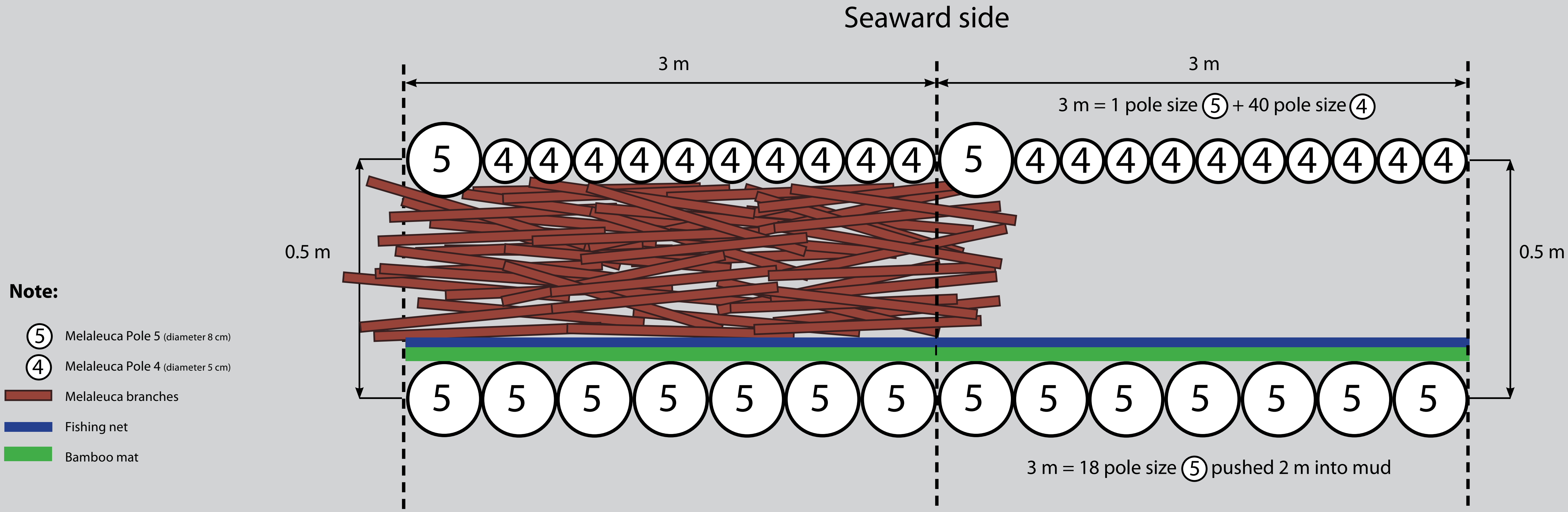
- Best planted in deposition areas, sheltered bays or along canal banks.
- Seeds are large and fleshy and are commonly used in soups.
- Seed production is prolific and they have a high germination rate.
- When planted they grow at a medium rate.
- Trees have a small buttress and no pneumatophores. The root system has limited ability to trap sediment or reduce wave action.

## *Nypa fruticans*

*Nypa* is a palm that grows to a height of 10m. The leaves are used locally for housing and roofs and the seeds are a valuable source of carbohydrate. The stems are often used to form a strong barrier to water turbulence and reduce the erosion in canals. *Nypa* has limited use in the coastal areas because they only survive in brackish areas where waves are weak.

- Best planted in brackish water along canals or in areas protected from wave action.
- Seeds are prolific, large and fleshy and germinate easily.
- When planted they grow quickly.
- Useful for livelihood development. Local people commonly plant *Nypa* for their own needs and to sell products (leaves and seeds).

## Wave break fence




# DESIGN, FUNCTION AND CONSTRUCTION OF WAVE BREAK FENCES

For areas where coastal erosion is medium to high.

Reduce wave energy by 65 %

## Wave break fence for coastal erosion protection and mangrove restoration

The wave break fence is a double layer fence with 0.5 m between the fence layers. The space between each fence layer is filled with small branches and twigs that are able to move with the waves and absorb their energy.

The wave break fence is for use in areas of strong wave action, where coastal erosion is assessed as medium to high. Wave break fences are designed to reduce the energy of strong waves and trap sediment, stop erosion and allow the eroding coastline to rebuild.

When used in areas of high erosion the wave break fence should be constructed approximately 30 m from the shoreline or located where the water depth is approximately 1 meter at high tide. In areas of low erosion or deposition, fences should be built at the low tide mark.

In Kien Giang it is best to construct the fences when water covers the mud. This makes it easier to push the poles in deeply.

The wave break fence design is currently being tested to protect mature stands of mangroves in actively eroding areas from being washed away. These fences are constructed 3 m seaward from the edge of the mangrove forest.

### Functions of the wave break fence

- Wave break fences are designed to reduce the energy of strong waves and to trap sediment, allowing the eroding coastline to build up and erosion to cease.
- These fences can be used in combination with a sediment trap fence type 1 in strongly eroding areas to allow establishment of mangrove seedlings.
- The fences can be used to halt loss of mangrove forest and allow for natural mangrove regeneration.
- The fences prevent rubbish from the ocean drifting into planted areas and smothering newly planted seedlings.

### Design

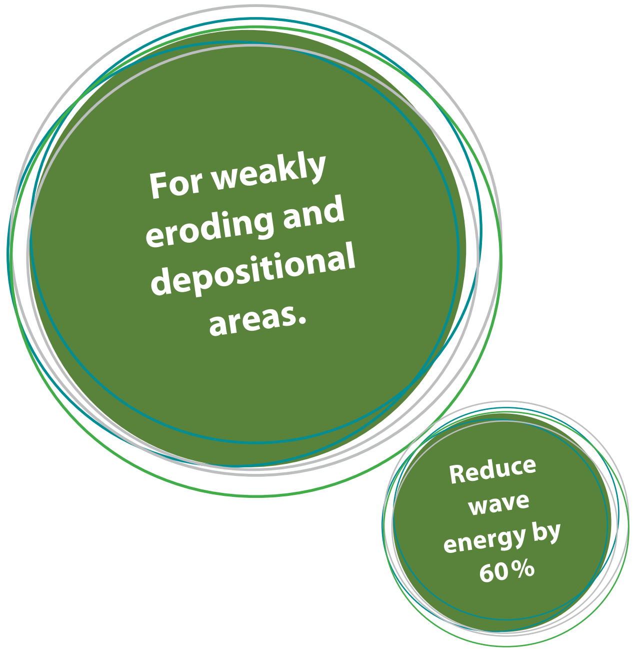
Two rows of melaleuca poles 0.5 m apart are pushed into the mud to a depth of 2 m parallel to the coastline. Bamboo mat and gauze fishing nets are attached to the inside row of poles. After attaching the bamboo mat, small diameter poles are added into the gap between the rows to a depth 0.5 m above high tide level. More of these poles are added as they settle into the mud.

The fence runs parallel to the coastline to reduce onshore wave action. The fences have strong ends at right angles to the coastline to reduce the action of strong, along shore currents.

### Construction Method

1. Set up a string line to guide pole placement.
2. Install the first row of poles. This is a row of large diameter melaleuca poles (pole size 5). Place them closely together so they are touching each other. Push them 2 m into the mud using a banging device. This row has to resist most of the wave energy and must be very strong.
3. Attach bamboo mats to the seaward side of these poles.
4. Attach small gauge fishing nets (gauze) over the outside of the bamboo mat. The fishing net provides some protection for the mats and stops debris from entering.
5. Install the second row of the poles to the seaward side of the first row. This row is placed 0.5 m from the first layer. This row does not have to withstand as much mechanical energy and is constructed with a combination of pole size 5 and size 4. Place a pole size 5 every 1.5 meters. Fill the gaps with smaller sized 4 poles.
   Each 1.5 meter block of large poles will be bound together by cross poles and tied with galvanized, rust resistant wire for added strength.
6. Add small logs/sticks/tree branches between the rows to a depth of 1 m.

# DESIGN, FUNCTION AND CONSTRUCTION OF SEDIMENT TRAP FENCES



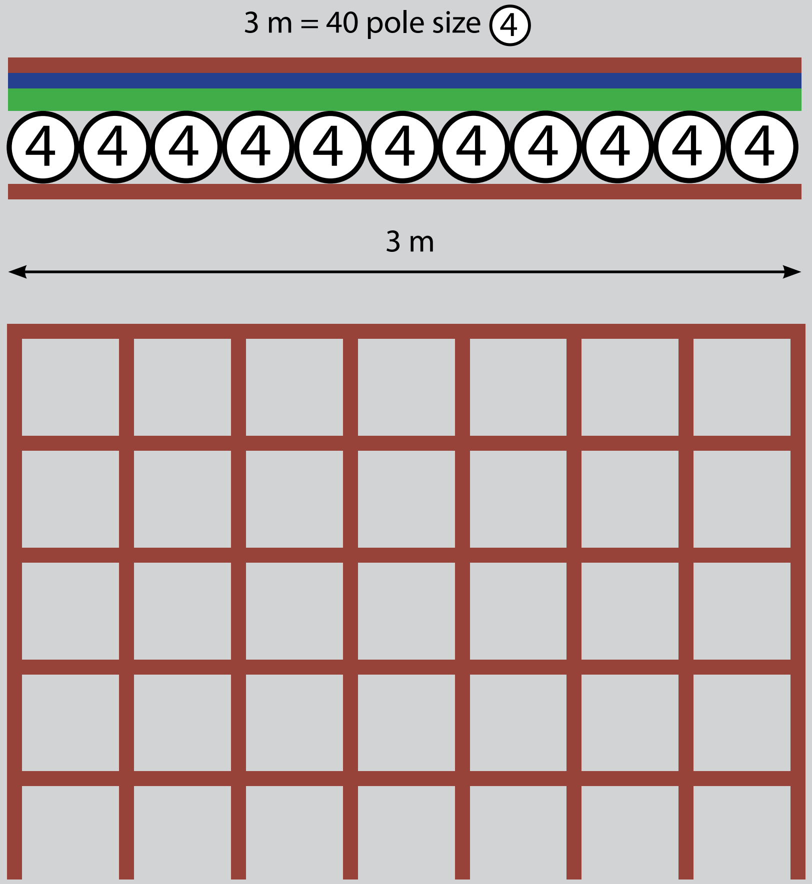

The sediment trap fence is designed to trap sediment and allow the substrate to develop sufficient structure to enable the root systems of seeds and seedlings to anchor and grow.

**This fence design can be established in depositional or weakly eroding areas** as a cost effective way to aid restoration through natural recruitment, or on the inside of wave break fences established in high erosion areas to protect planted seedlings. The reduced wave action allows the additional sediment to stabilise in less than one year and provides favorable conditions for natural regeneration.

**Functions of sediment trap fences**

- The sediment trap fence is designed to reduce the energy of waves in areas of medium to low turbulence.
- These fences can be used in combination with a wave break fence in strongly eroding areas to allow establishment of mangrove seedlings near to dykes.
- The sediment trap fence is also used to block wave action that runs parallel to the coastline, along canals; or on deposition areas to allow natural recruitment of mangroves seeds and their establishment.
- The fences trap sediment deposited in the wet season, allowing the coastline to build up.
- The fences prevent rubbish from the ocean drifting into planted areas and smothering seedlings.

## Sediment trap fence
## TYPE 1




**There are two designs of sediment trap fences and they are used for different purposes.**

## Sediment trap fence TYPE 1

This fence is used in combination with the wave break fence in high erosion areas with strong wave action to facilitate the establishment of planted seedlings. This fence is located inside the wave break fences – directly in front of dykes and 20 m from the coastline or at a depth of 50 cm at high tide. This fence can also be used in deposition areas for speeding up natural recruitment.

### Design

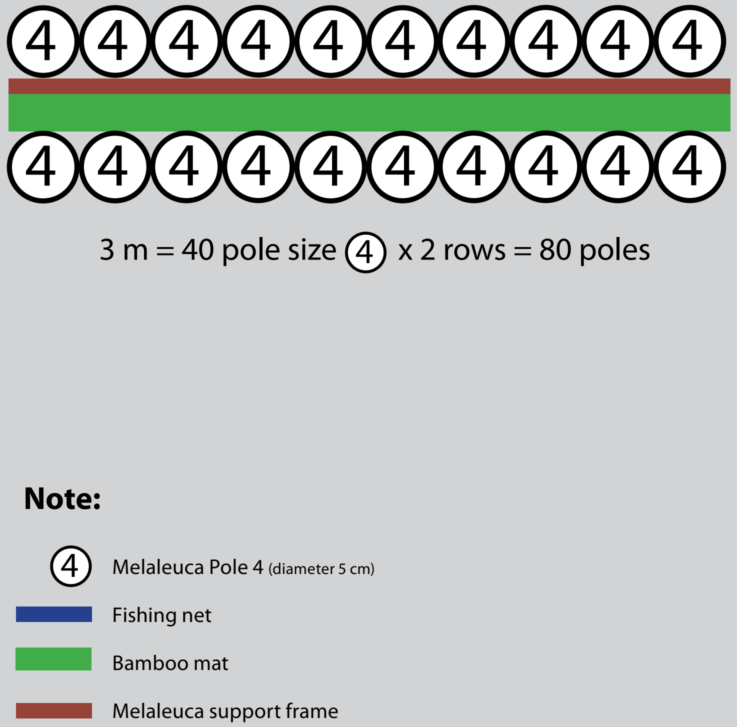
The fence has one row of small diameter melaleuca poles (pole size 4) placed close together. A layer of bamboo mats (1.0 m high, 1.5 m long) and protective gauze is placed in front of this row. Support frames made from small diameter poles are attached to the front and to the back of the row of poles. This frame holds the mat in place.

### Construction Method

1. Set up a string line to guide log placement.
2. Install a row using pole size 4. Place them closely together so they are touching each other. Bang them 2 m into the mud.
3. Prepare melaleuca support frames. The outer frame has dimensions of 3 m long X 1.5 m high. Divide this frame into squares of 50 cm.
4. Attach bamboo mats to the seaward side of the poles.
5. Attach small gauge fishing nets to the outside of the bamboo mat.
6. Install the two grid frames. One onto the front and one onto the back of the row of poles. The bamboo mats are covered and held in place by the grid frame.



## Sediment trap fence
## TYPE 2




## Sediment trap fence TYPE 2

This fence type is used in weak erosion or depositional areas to facilitate natural regeneration.

### Design

The fence has two rows of small diameter melaleuca poles (pole size 4) placed close together. A layer of bamboo mats (1.0 m high, 1.5 m long) covered with fishing net gauze is placed between the two rows.

### Construction Method

1. Run a string line to guide pole placement.
2. Install the first row. A row of pole size 4. Place them closely together so they are touching each other. Force the poles 2 m into the mud.
3. Attach bamboo mats to the seaward side of the poles.
4. Attach small gauge fishing nets to the outside of the bamboo mat.
5. Install the second row. A layer of pole 4 to the seaward side of the first row. Place them closely together so they are touching each other. This places the mat and gauze between the two rows.
6. Add small logs/sticks/tree branches between the rows to a depth of 50 cm.

## Wave Break fence

| Items | Unit | Quantity | Unit price (VND) | Total (VND) | Total (USD) |
|---|---|---|---|---|---|
| **Melaleuca pole 4** (outside row) | pole 4 | 13,000 | 10,500 | 136,500,000 | 6,498.45 |
| **Melaleuca pole 5** (outside row) | pole 5 | 340 | 13,500 | 4,590,000 | 218.52 |
| **Melaleuca pole 5** (inside row) | pole 5 | 6,000 | 13,500 | 81,000,000 | 3,856.22 |
| **Melaleuca pole 3** (cross-bar, outside row) | pole 3 | 1,330 | 5,000 | 6,650,000 | 316.59 |
| **Bamboo mat** (1.2 m wide) | meter | 1,000 | 16,700 | 16,700,000 | 795.05 |
| **Fishing net** (1 m wide) | meter | 1,000 | 5,000 | 5,000,000 | 238.04 |
| **Stainless steel wire**, Ø = 3 mm | kg | 120 | 160,000 | 19,200,000 | 914.07 |
| **Small branches/sticks** | cubic meter | 1,000 | 20,000 | 20,000,000 | 952.15 |
| **Labour** | man day | 567 | 120,000 | 68,040,000 | 3,239.23 |
| **Total Cost (1 km of fence)** | | | | **357,680,000** | **17,028.33** |

# FENCE COSTINGS

The tables show materials and labour needed to construct 1 km of fence. Costings were calculated November 2011.

## Sediment trap fence TYPE 1

| Items | Unit | Quantity | Unit price (VND) | Total (VND) | Total (USD) |
|---|---|---|---|---|---|
| **Melaleuca pole 4** | pole | 13,000 | 10,500 | 136,500,000 | 6,498.45 |
| **Melaleuca pole 3** (for making frame) | pole | 3,000 | 5,000 | 15,000,000 | 714.12 |
| **Bamboo mat** (1.2 m wide) | meter | 1,000 | 16,700 | 16,700,000 | 795.05 |
| **Fishing net** (1 m wide) | meter | 1,000 | 5,000 | 5,000,000 | 238.04 |
| **Nails** 7 - 8 cm | kg | 78 | 28,000 | 2,184,000 | 103.98 |
| **Stainless steel wire**, Ø = 3 mm | kg | 50 | 160,000 | 8,000,000 | 380.86 |
| **Iron wire** to tie fishing net into bamboo mat | kg | 7 | 30,000 | 210,000 | 10.00 |
| **Labour** | man day | 267 | 120,000 | 32,040,000 | 1,525.35 |
| **Total Cost (1 km of fence)** | | | | **215,634,000** | **10,265.84** |

## Sediment trap fence TYPE 2

| Items | Unit | Quantity | Unit price (VND) | Total (VND) | Total (USD) |
|---|---|---|---|---|---|
| **Melaleuca pole 4** (for making rows) | pole 4 | 26,000 | 10,500 | 273,000,000 | 12,996.91 |
| **Melaleuca pole 3** (cross-bar to fasten top of 2 rows) | pole 3 | 680 | 5,500 | 3,740,000 | 178.05 |
| **Bamboo mat** (1.2 m wide) | meter | 1,000 | 16,700 | 16,700,000 | 795.05 |
| **Fishing net** (1 m wide) | meter | 1,000 | 5,000 | 5,000,000 | 238.04 |
| **Stainless steel wire**, Ø = 3 mm | kg | 60 | 160,000 | 9,600,000 | 457.03 |
| **Labour** | man day | 332 | 120,000 | 39,840,000 | 1,896.69 |
| **Total Cost (1 km of fence)** | | | | **347,880,000** | **16,561.77** |

# CONCLUSIONS

- Mangrove restoration in high erosion areas is greatly facilitated by the use of protective melaleuca fences. Practical methods for fence establishment have been developed. The next step is to test how these techniques can be scaled up for mangrove forest restoration, coastal rehabilitation and shoreline erosion control.
- Similar to the natural protective mangrove forest, melaleuca fences reduce wave energy and thus play a vital role in reducing coastal erosion.
- The melaleuca fences protect seedlings and increase survival through the critical period following planting.
- Melaleuca fences promote the natural regeneration of mangrove forest seedlings.
- Mangrove restoration using fences were found to enhance the biodiversity of benthic species.
- The cost of building the melaleuca fence is much less than for barriers using other materials such as bamboo, rock or concrete.
- Using melaleuca for fence construction will increase the value of melaleuca and encourage local farmers to maintain melaleuca plantations.
- Provision of these environmental services will increase incomes, support coastal protection and rehabilitation and improve adaptation to climate change.
- The increased mangrove forest growth will also mitigate the effects of climate change by reducing greenhouse gas emissions.
- Promoting natural recruitment in depositional areas through fence building may be a better choice than the common practice of planting trees.
- By promoting natural recruitment, the fences reduce the costs of planting and also improve the quality of the restoration program.
- The mangrove restoration techniques developed by the GIZ Project are being used for the mangrove restoration program developed by Kien Giang Province for the period 2011 - 2020 (Sub FIPI, 2010).

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