GTZ KIEN GIANG BIOSPHERE RESERVE PROJECT

Effectiveness of Melaleuca Fences for Mangrove Restoration Rehabilitation Efforts

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Mangroves as coastal protection

Mangroves play a vital role in the maintenance of shoreline integrity and the response to climate change and the protection of coastal areas through mangrove protection and plantings has been promoted as a vital adaptation measure.

However, it has proved difficult to re-establish mangrove areas, and plantings have often failed. Suggested reasons for these failures include poor species selection, poor quality seedlings and a lack of protection of seedlings from wave forces during the critical establishment stage (Chu and Brown 2012).

Wave Reduction Barriers

There is increased interest in the use of wave reduction barriers in mangrove restoration efforts. Wave reduction barriers are designed to absorb and dissipate wave energy. This creates an area of still water between the barrier and the eroding bank. The still water area facilitates the accumulation of sediment and this then provides a habitat that is suitable for natural recruitment or seeding to take place (Albers 2012, GIZ 2012, Hashim et al 2011, Matsui et al. 2012, Stewart and Fairfull 2008).

The objectives of using wave reduction barriers (WRB) in mangrove restoration and rehabilitation are threefold:

(1) to protect the shoreline from erosion by attenuating wave action,

(2) to stabilise and or improve sediment deposition in the protected area , and

(3) to protect vegetation (planted or naturally recruiting) from the negative effects of wave action.

Melaleuca Fences as wave reduction barriers

The GIZ Conservation and Development of the Kien Giang Biosphere Reserve Project has designed and tested coastal protection fencesat Vam Ray, Binh Son commune, Kien Giang province (Chu and Brown 2012. Satellite images show that Vam Ray is a strongly eroding area with an erosion rate of about 10m per year and this has been occurring for at least ten years.

The aim was to halt coastal mangrove tree loss from erosion and allow for mangrove forest restoration efforts. The project trialled two types of fences: a wave break fence and a sediment trap fence and the combination of both wave break and sediment trap fences. The fences tested by the project were constructed of melaleuca, a readily available inexpensive and resilient timber common in the Mekong delta that provides wide ranging environmental services.

Wave break fence

Wave break fences consist of a double line of melaleuca poles with 0.5 m between the fence layers filled with small branches constructed 3 m seaward from the edge of the mangrove forest. 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 wavesand stabilise sediment deposition thus assisting the stabilization of the eroding coastline (Chu and Brown 2012). The fences would also act to trap mangrove seedlings and prevent rubbish from the ocean drifting into planted areas and smothering newly planted seedlings.

Sediment trap fence

The sediment trap fence is designed reduce the energy of waves in areas of medium turbulence.As with the wave break fence they also trap sediment and mangrove seedlings and prevent the deposition of rubbish onshore. This fence can be used alone 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 (Chu and Cuong 2012).

Effectiveness of melaleuca fences

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

Results reported in Chu and Brown (2012) found that the fences reduced wave energy by up to 63%, retained up to 20 cm depth of sediment each year and up to 200 ton per hectare, successfully protected planted mangrove seedlings, and promoted natural regeneration even in severe erosion sites.

Wave attenuation

A study of wave energy attenuation by Chu and Brown 2012) found that the wave break fence was as effective as mangrove forest in reducing wave energy. Field measurements showed that the mangrove belt in Hon Dat reduced wave energy by 50 - 67% depending on the forest structure while the wave break fence at the Vam Ray Demonstration Site reduced the wave energy by 65%.

Sediment Deposition

The melaleuca fences were found to aid sediment deposition, with up to 20 cm depth of sediment each year and up to 200 ton per hectare retained in the protected areas (Chu and Brown 2011).

A study conducted the Can Tho University Research Institute for Climate Change found that after two years the deposition of silt behind the fences resembled the pattern of natural soil deposition in adjacent areas where mangrove forest trees are still present (Chu and Brown 2011).

Mangrove survival and growth

The project found that in high erosion areas the use a combination of wave break and sediment trapping fences produced the best results. A double layer of wave break and sediment trap fences protected up to 100% of planted or naturally recruited mangrove seedlings, even in severe erosion sites (Chu and Brown 2011).The fences also reduced rubbish deposition further assisting seedling establishment.

Comparison of melaleuca fences with other wave reduction barriers

There have been several recent attempts to use wave reduction barriers to protect existing mangroves or mangrove plantings with various degrees of success. A number of different methods and materials have been proposed for the construction of wave reduction barriers and some have been tested. The methods and their merits and disadvantages are discussed below.

Detached Concrete and Rubble Breakwater

A90 metre detached Concrete and Rubble (DCR) Breakwater was constructed by the Forestry Research Institute of Malaysia (FRIM) as part of a coastal rehabilitation project at Sungai Haji Dorani on the heavily eroded west coast of Peninsular Malaysia to protect a mangrove rehabilitation area and to facilitate sediment accretion in the protected area.

A study on how well it performed by Hashim*et al.* (2009) found that the DCR breakwater did increase substrate elevation and sediment deposition. Field monitoring showed that a significant amount of sediments were deposited in the lee of the DCR breakwater.

The study found that the DCR breakwater was not effective in protecting planted mangroves with an almost 100% mortality rate for planted seedlings. This mortality was ascribed to active sedimentation, resource use (fisherman disturbance of site), and barnacle infestation.

However, it did promote natural regeneration with evidence of considerable natural regeneration of naturally recruited seedlings (of *Avicennia marina*) after just one year. Regeneration was ascribed to the breakwater making hydrological features conducive to the natural mangrove recruitment process and thereby providing a suitable environment for seedlings.

Cost. The breakwater) was constructed along an eroding tropical shoreline at a cost of US$476 per lineal metre (Matsui *et al.* 2012).

Rock Fillets

Rock fillets are wave energy dissipating barriers constructed of rocks. They have proved successful in aiding mangrove protection and natural recruitment in the Manning and Hastings river estuaries in New South Wales, on the mid north coast of Australia with thousands of mangroves germinating behind completed rock fillets (Stewart and Fairfull 2008).

Rock Fillets have been used to help protect river banks in estuaries in New South Wales, Australia from further erosion. However, there is no available evidence of their use on coastal shorelines.

Cost. Rock fillets cost between USD80 – 120 per lineal meter to construct (Floodplain Network News 2009).

Floatingboom

To improve the success of seafront planting and rehabilitation Duke et al (2009) suggested a large floating boomcould be used to suppress erosive waves whilst mangrove vegetation becomes suitably large, dense and established.

They suggest thefloating barrier couldbe constructed locally using recycled netting and plastic containers (Figure 3). The boom would be deployed and securely moored along the shoreline fronting the rehabilitation area.

Cost. This type of wave reduction barrier is yet to be tested or costed.

Bamboo Wave Reduction Barriers

Triangle Bamboo Barrier

Villagers of a fishing community in Kok Kham, the province of SamutSakhon, built bamboo wave reduction barriers by submerging about 100 bamboo sticks, each about 5 metres (16 ft) long, in triangle-shaped groups along two km (1.2 miles) of SamutSakhon's 42 km (26 miles) of coast.

The aimwas to prevent big ripples from reaching the coast and allow mud and debris to collect on the fence to form a barrier. Anecdotal evidence suggested that sediment behind the fences at some sites swelled to 1.5 metres thick in just two years. However, at other sites where the fences were erected, the fences lasted no more than 1 year (Matsui *et al.* 2012).

Cost. The costs for one kilometre of bamboo was estimated at US$250 000 (MacIntosh*et al.* 2010).

Solid Bamboo Fence

GIZ is trialling a 10 m section of wave reduction fencing constructed of bamboo and rattan In Soc Trang Province, VietNam (Albers 2012). The fence consists of two rows of bamboo poles with bundles of brushwood between the rows.

Cost. As yet there are no available results on its effectiveness nor has it been costed.

Geotube

Geotubes are synthetic, very tough geo-textile bags, mattresses or tubes filled with sand or a sand-fluid-mixture. Due to deformations, large widths are necessary to achieve the desired heights and consequently, Geotubescan be massive constructions (Albers and von Lieberman 2011). A large advantage is the short transportation of the filling material.

Research funded by GTZ in 2008 evaluating the use of Geotube in Malaysia for wave prevention construction did notfind clear evidence of their effectiveness (KG PC and DARD 2010). A trial in Phan Thiet, Binh Thuan province, Vietnam similarly found that Geotube was ineffective for protecting coasts and mangrove reafforestation (KG PC and DARD 2010).

Cost. The costs for a Geotubesbreakwater vary very much depending on the foundation, the dimensions, the personnel costs and the costs for construction equipment. The price for a Geotube in Vietnam (incl. customs and import tax) was estimated to be around USD 300 per meter, plus construction costs, costs for the sand and personnel costs (Albers and von Lieberman 2011). A Geotube constructed wave reduction barrier in Malaysia cost USD 700,000 for one km of coast (KG PC and DARD 2010).

Concrete Fences

Prestressed concrete wave prevention fences made from flat and triangular concrete poles formatted into three rows, 1.5 meters apart with rows 1 m apart were used to break waves at Ba KhunSamut Chin, Thailand. Research funded by GTZ in 2008 evaluating their use for wave prevention and mangrove afforestation protection found that they were successful (KG PC and DARD 2010).

Cost. According to the figures available, one kilometre of coastal erosion works using concrete poles cost THB45 million, or about US$1.4 million (MacIntosh*et al.* 2011). The cost was estimated at $US 116,000 (3.8 billion Batt) for one km of fence (KG PC and DARD 2010).

Conclusion

There is currently very little available information on the effectiveness of wave reduction barriers however, from the very limited available information only the melaleuca fences have been found to effectively reduce wave energy, stabilise and retain sediment, protect planted mangrove seedlings, and promote natural regeneration even in severe erosion sites (Table 1).

Of other WRBs the DCR Breakwater, the Rock Fillet and the Prestressed Concrete Pole Fence were all found to be effective at attenuating wave action.

The DCR Breakwater and Bamboo fences were found to effectively influenced sediment deposition.GeoTubes were found to be ineffective. There was no available information for the Rock Fillets, Floating Boom and Concrete Poles.

There was no evidence that mangrove plantings had been successfully protected by any other WRB., although only DCR Breakwaters and GeoTubes were tested and found to be ineffective.

All WRBs except GeoTubes appear to promote natural regeneration.

Melaleuca fences are the cheapest of all the WRB construction methods and significantly cheaper than others. Costs here ranged from USD17 for the Melaleuca fences to USD 700 dollars per metre for Geotube constructions.

Name	Materials	Cost Lineal metre (USD)	Wave attenuation	Sediment deposition	Protect Mangrove plantings	Promote Mangrove Regeneration	Source
Melaleuca Fence	Melaleuca	17	yes	yes	yes	yes	GIZ 2012
DCR Breakwater	Concrete and rubble	476	yes	yes	no	yes	Hashim *el al* 2012
Rock Fillets	Rocks	80-120	Yes	UK	UK	Yes	Stewart and Fairfull 2008
Floating boom	recycled netting and plastic containers	Not costed	UK	UK	UK	UK	Duke *et al* 2009
Bamboo Fences	Bamboo	250	UK	yes	UK	UK	Albers 2012
GeoTubes	Filled Geotextile fabric	700	No	No	No	No	KG PC and DARD 2010
Prestressed Concrete Fences	Concrete	117	Yes	UK	UK	UK	KG PC and DARD 2010

Table 1 Types of wave reduction barriers, construction materials, costs per lineal metre, and effectiveness for: wave attenuation, sediment stabilisation, mangrove planting protection and promoting natural recruitment. UK means there is no available information.

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