On behalf of

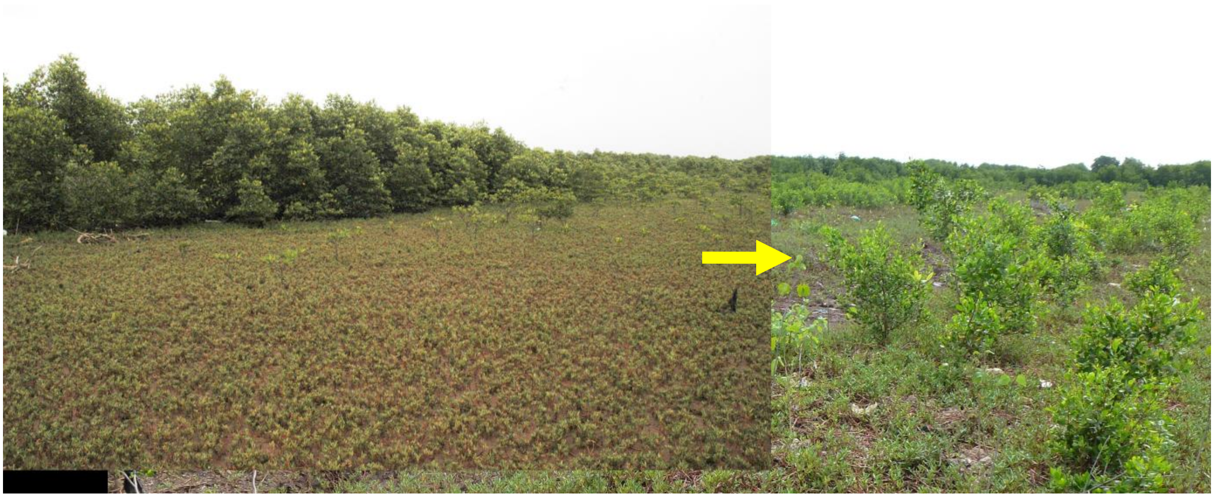
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

of the Federal Republic of Germany

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

2011 Mangrove Plantations

An Interim Report on Design, Survival and Growth



Barry Clough

Adaption to Climate Change through the Promotion of Biodiversity in Bac Lieu Province, funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU)

Bac Lieu, September 2012

Introduction

The overall objective of the project, “Adaptation to Climate Change Through the Promotion of Biodiversity in Bac Lieu Province” is to improve the resiliency of coastal ecosystems and coastal communities to the impacts of climate change. Afforestation for protection against coastal erosion, strong winds and storm surges is a key element in improving resiliency to climate change along an exposed and dynamic coastline that historically has experienced considerable erosion.

A coastal planting plan prepared in 2011 identified the coastline of Vinh Trach Dong Ward as being particularly at risk due to its high rate of erosion and lack of protective forest [1, 2]. This risk has been confirmed by a recent survey which found that the rate of coastal erosion in Vinh Trach Dong, Hiep Thanh and Nha Mat wards was 30 - 70m between 2009 and 2012 [3] (Fig. 1). If current rates of erosion persist, it is probable that some parts of the sea dike, particularly in the northern part of Vinh Trach Dong, will be fully exposed to the sea without protection from fringing coastal forest by 2025, unless efforts are made to reduce the rate of erosion and stabilise the coastal land seaward of the dike, Qualitative observations also suggest that the rate of erosion in the northern part of Vinh Trach Dong has increased since the commencement of construction of offshore wind turbines for electricity generation.

Considerable areas in Vinh Trach Dong were planted between 2000 and 2006 as part of the World Bank Coastal Wetlands Protection and Development Project, and since then some limited further planting has been carried out by Provincial authorities. However, survival rates have generally been low and the growth of those trees that have survived has been very poor.

The poor survival and growth in past planting efforts can be attributed to a number of factors, but mostly to the high elevation of the coastal fringe in Vinh Trach Dong, which means that many areas are flooded only a few times a year on the highest astronomical tides. This is exacerbated by the presence of small embankments along the edges of canals as a result of former shrimp pond development in the area, which also serve to prevent tidal flooding. As a consequence, the soil is too dry for good survival and growth, particularly of young seedlings during the dry season. Neither of the two most common species that have been planted in the past, *Rhizophora apiculata* and *Ceriops tagal*, are well-suited to these hydrological conditions.

A total area of 450 ha of higher land in Vinh Trach Dong is in need of planting [1, 2]. Given the lack of success of past planting and the high cost of planting this area, estimated to be around USD 300,000 [2], it was decided to carry out smaller trial plantations in selected areas to assess a different planting design with alternative species, which would serve the dual purpose of coastal afforestation with a more diverse range of species, and a model for future planting on difficult sites with high elevation which are very common along the whole of the Bac Lieu coastline.

Site Preparation and Planting Design

Planting was carried out at two sites, Site 1 and Site 3 (Fig. 1). Both sites had been planted with either *Ceriops tagal* or *Rhizophora apiculata* during the World Bank Coastal Wetlands Project, but survival and growth rates were poor. A third site (Site 2, Fig. 1) was selected for planting in 2012.

Prior to planting, the sites were prepared by digging canals of about 0.5m in depth and 2-3m wide to supply water to the sites on normal high tides, resulting in a parallel

Fig. 1. Coastline of Vinh Trach Dong, showing its position in 1995, 2002, 2009 and 2012, and the location of planting sites on higher land. Sites 1 and 3 were planted in 2011 and Site 2 in 2012.

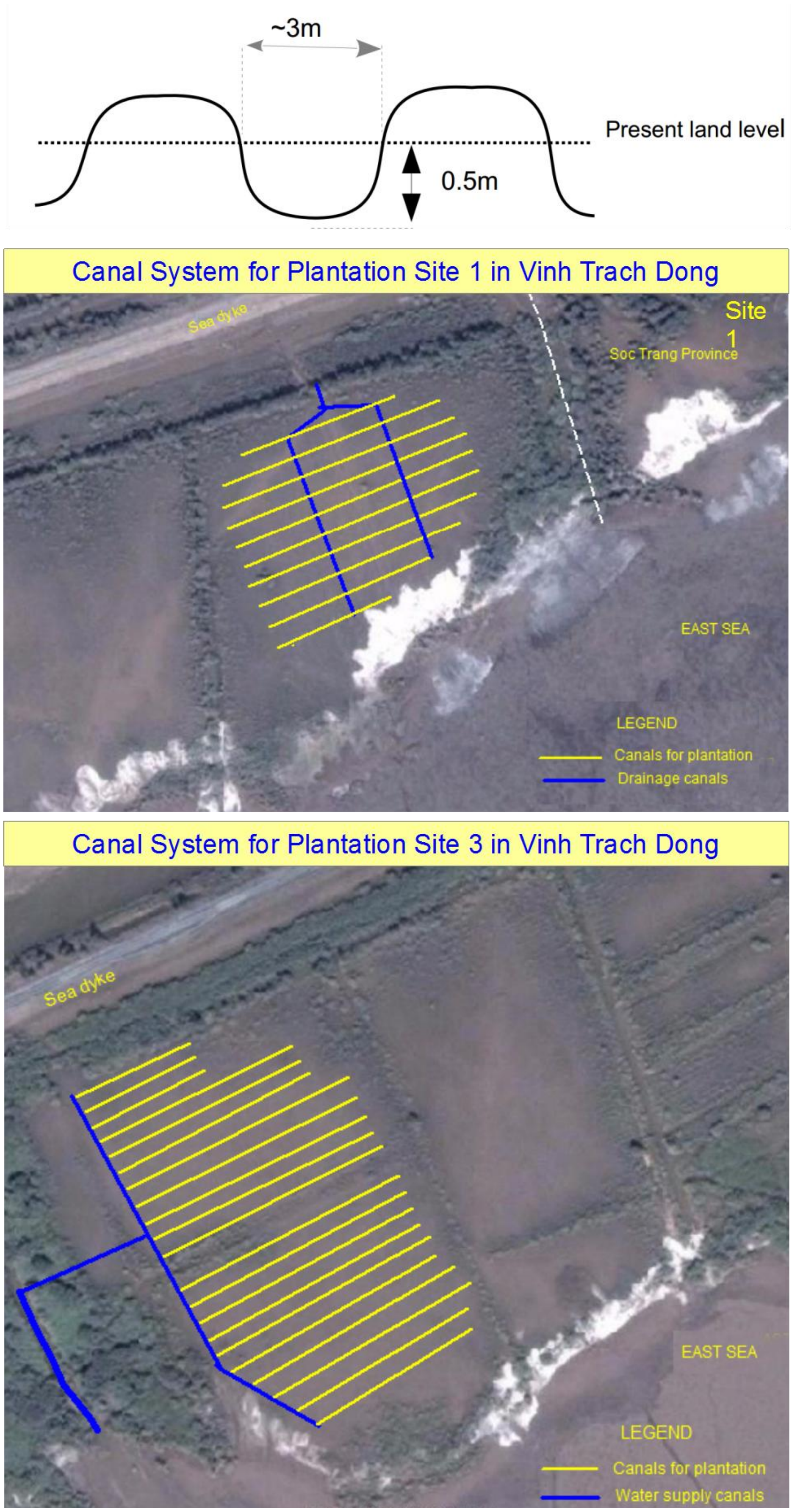


Fig. 2 Design and layout of alternating canals and embankments at Site 1 and 3

sequence of canals and embankments with a range of micro-tidal environments (Fig. 2). This approach was based on the view that some degree of tidal flooding was needed to make the hydrology of the sites more suitable for mangroves, and on observations in a number of areas, notably at Site 3, of well-developed mangroves in the infilled canals of former shrimp ponds.

Species Selection

Four local species of mangrove were selected for planting based on theiir potential suitability for the sites; *Ceriops tagal*, *Intsia bjuga*, *Lumnitzera racemosa* and *Xylocarpus moluccensis*. It should be noted that *C. tagal* is not a particularly good species for planting for coastal protection because of its very slow growth rate; even under relatively favourable conditions it grows much more slowly than most other mangrove species.

Planting with non-mangrove species such as Casuarina was also considered. However, non-mangrove species were not thought to be viable in the long-term owing to their intolerance to regular flooding by seawater, which is almost certain to be a consequence of rising sea levels in the future.

Planting

Fruits of the four species were collected locally or from elsewhere in the Mekong Delta in 2010, germinated and grown in a nursery for about 12 months before planting at the field sites. Planting was carried out in September 2011, when the nursery-grown seedlings were about 12 months old. At that stage, *Intsia*, *Lumnitzera* and *Xylocarpus* seedlings were about 50-60 cm in height, but the *Ceriops* seedlings were only 20-30 cm tall. Seedlings were planted about 1 m apart, giving an overall average planting density of about 20,000 per hectare. A summary of the area, number of seedlings and cost of planting are given later in Table 1.

Outcomes

Overall, survival was very low in the canals at both sites (Fig. 3). This was most likely a result of the very high rates of sediment deposition in the canals, which buried many of

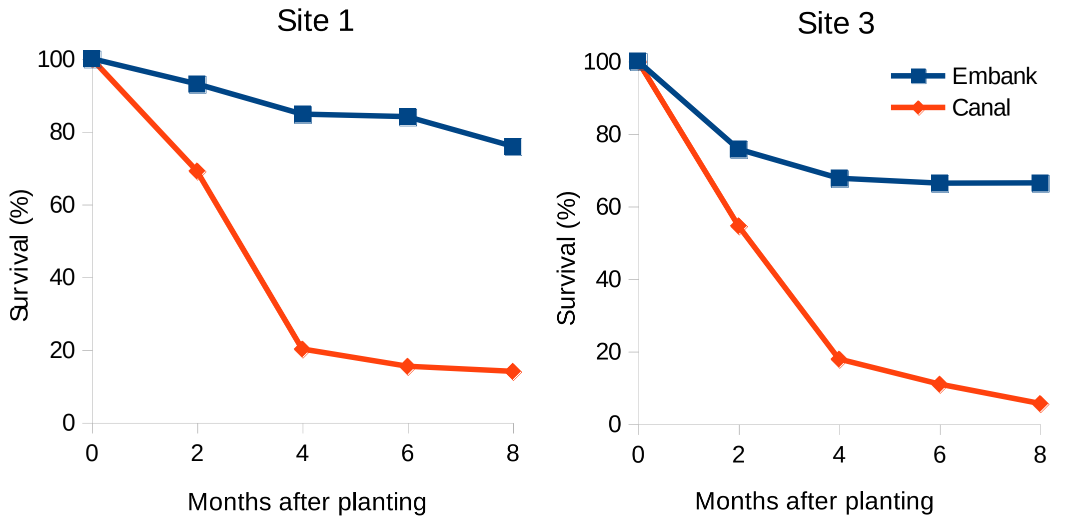
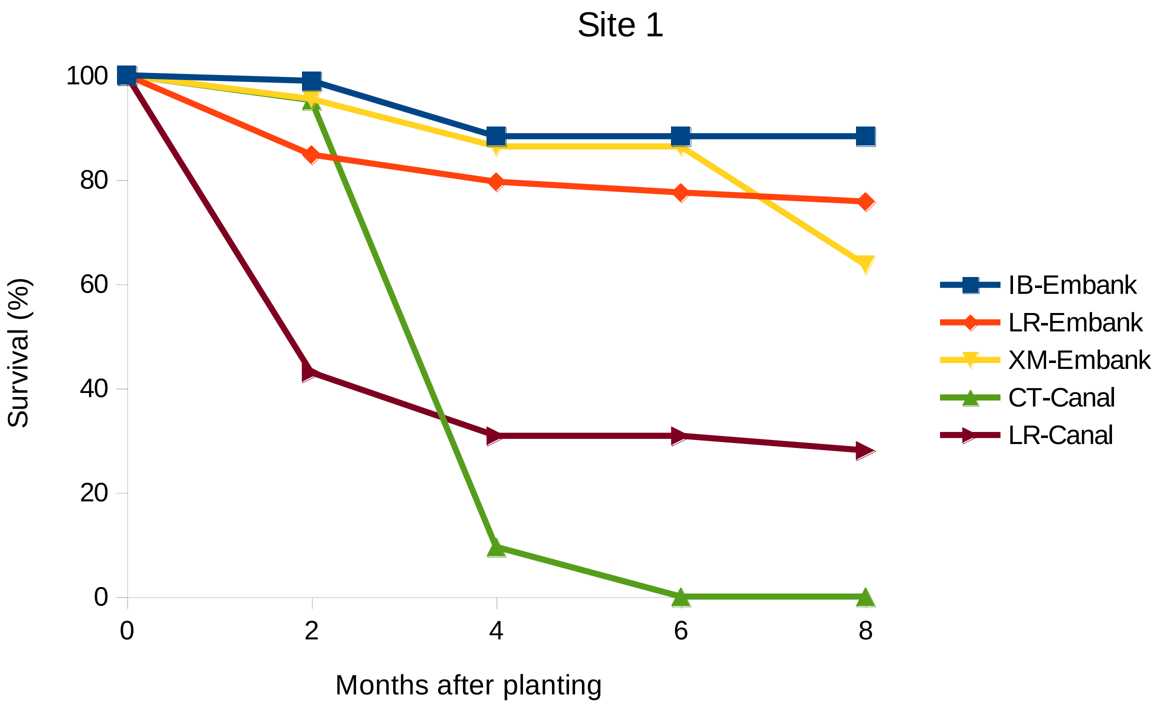


Fig. 3. Overall survival rates in canals and on embankments over the first eight months after planting at Sites 1 and 2.

the seedlings. While some sediment accumulation in the canals was expected, the very rapid infilling around the mouths of the canals was not expected. Not only did this bury many of the seedlings, it also prevented the canals from draining fully, thus leading to more or less permanent ponding of the canals, a condition that most mangroves do not handle well. After considerable infilling of the canals with sediment in 2011, *Bruguiera parviflora* and *Rhizophora apiculata* were planted in the canals in 2012, but data for survival were not available at the time of writing this report.



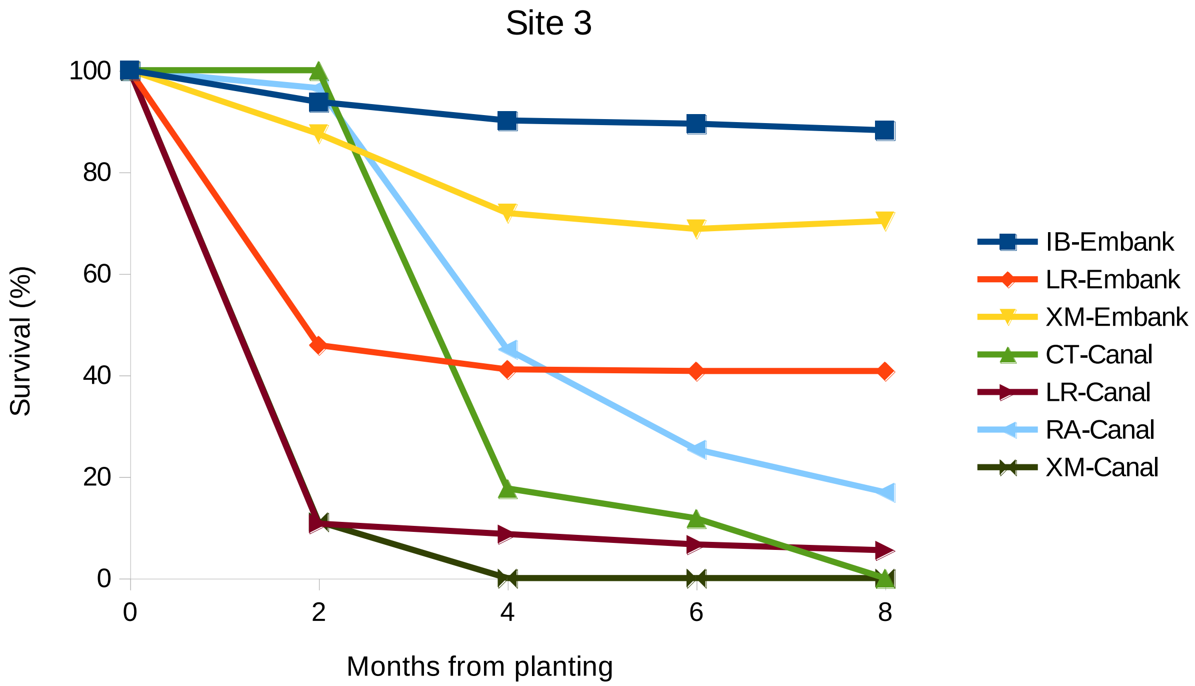


Fig. 4. Survival of individual species in canals and on embankments over the first eight months after planting at Sites 1 and 2. (CT = *Ceriops tagal*; IB = *Intsia bijuga*; LR = *Lumnitzera racemosa*; RA = *Rhizophora apiculata*; XM = *Xylocarpus moluccensis*).

On the other hand, after eight months, the overall survival rate on embankments at both sites was more than 70% (Fig. 3). Considerable seedling mortality on the embankments had been expected during the first dry season due to a lack of water, but as shown in Fig. 3, and again in Fig. 4 for the survival of individual species, most seedlings died during the first two months after planting, before the onset of the dry season. Very few seedlings died during the dry season, implying that their roots were well enough developed to tap sufficient subsurface water to survive over the dry season, even though the top 20 cm of soil was quite dry (around 30% by weight). However, it should

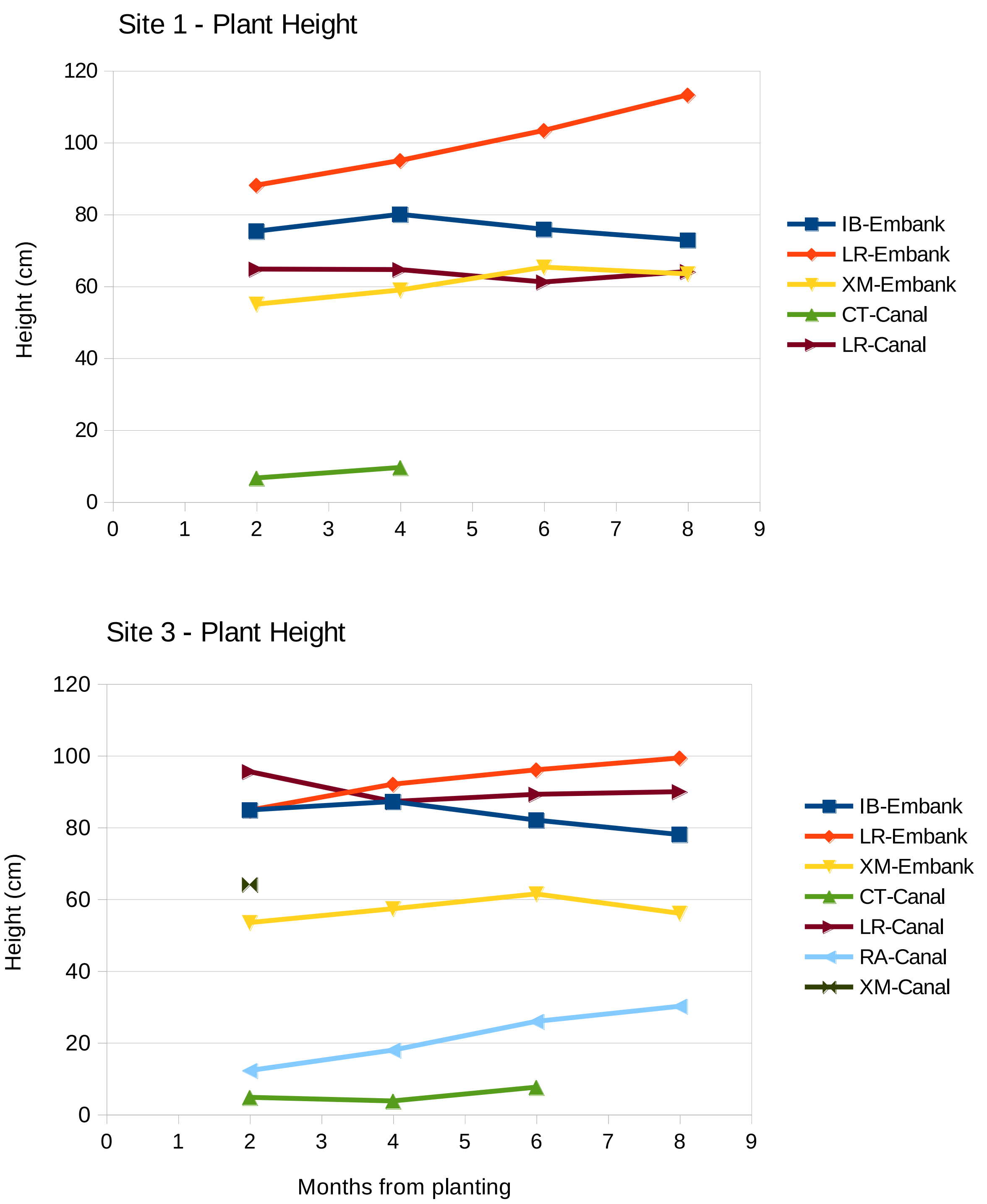


Fig. 5. Changes in average seedling height over the first eight months after planting

be noted that the dry season of 2011-2012 was atypical in that it was much 'wetter' than average, and this, too, could account for the good survival over the dry season. In addition, although unconfirmed, it is likely that water moved laterally and perhaps vertically from the canals into the subsurface soil of the embankments, thereby supplying water to seedlings with roots deep enough to tap it.

Since planting was carried out during the wet season, seedling death on embankments in the first two months after planting is unlikely to have been because of lack of soil water. The more likely explanation for this early mortality is root damage or desiccation during seedling transfer from the nursery to the planting site, and/or root damage during planting. As an example, seedlings on the roadside prior to planting at Site 2 in 2012 were observed to be extremely desiccated, which is likely to have some impact on their subsequent survival during the first few weeks after planting.

Differences in the survival rate of different species between Site 1 and Site 3 (see Fig. 4) cannot be easily explained. Both sites had similar soil water contents in the top 20 cm of soil throughout the first eight months, and there were no significant differences in soil pH between sites. However, there may be differences in soil texture and structure between the two sites. These soil parameters were not measured during the monitoring program.

In terms of height, both *Lumnitzera* and *Xylocarpus* grew well on embankments, but *Intsia* performed poorly (Fig. 5). The decrease in the average height of *Intsia* was due mainly to the death of larger seedlings, but even the remaining smaller survivors had very little foliage and seem likely to die or develop slowly. This suggests that *Intsia* is not suitable for planting on these or similar sites.

Of the other two species, over the first eight months, *Lumnitzera* showed the best increment in height (Fig. 5) and had a much better developed canopy than *Xylocarpus* (Fig. 6). Whether or not *Xylocarpus* will recover and develop as rapidly as *Lumnitzera* remains to be seen, but present indications are that of the three species planted in 2011 on embankments, *Lumnitzera racemosa* is the most suitable for planting at sites that are at or near the upper tidal limits.

The poor development of *Intsia*, and to some degree *Xylocarpus*, during the first eight months might be due partly to their normal pattern of growth as seedlings, but it could also be linked to water stress associated with poor root development. This is an aspect that has not been explored in the monitoring program, and since the rapid development of an extensive and deep root system is important for survival and growth, it would be useful to dig up a small number of seedlings of all three species on embankments to examine both the vertical and lateral extent of root development.

Given that *Lumnitzera,* and to some extent *Xylocarpus,* appear to grow successfully on embankments adjacent to canals, it is fair to question whether they would also grow equally well on high land of a similar elevation without the need to dig canals, thereby reducing the cost of afforestation appreciably? The answer to this question is unknown. As indicated above, in the 2011 plantings at Sites 1 and 3, it is highly probable that water moved laterally from the canals into the subsurface layers of the embankment, which could have been a critical factor contributing to survival over the first dry season. Without canals good survival could be more problematic and rather site-specific depending on the depth of the water table and subsurface moisture content. It would be possible to carry out small, limited scale trials on high land without canals, using plots of say at least 20 m x 20 m (up to a maximum of 50 m x 50 m), but it would be necessary for the project to invest in a soil auger or corer suitable for sampling heavy clay soils in order to assess the suitability of potential sites for the trials and the reasons for their success or failure.

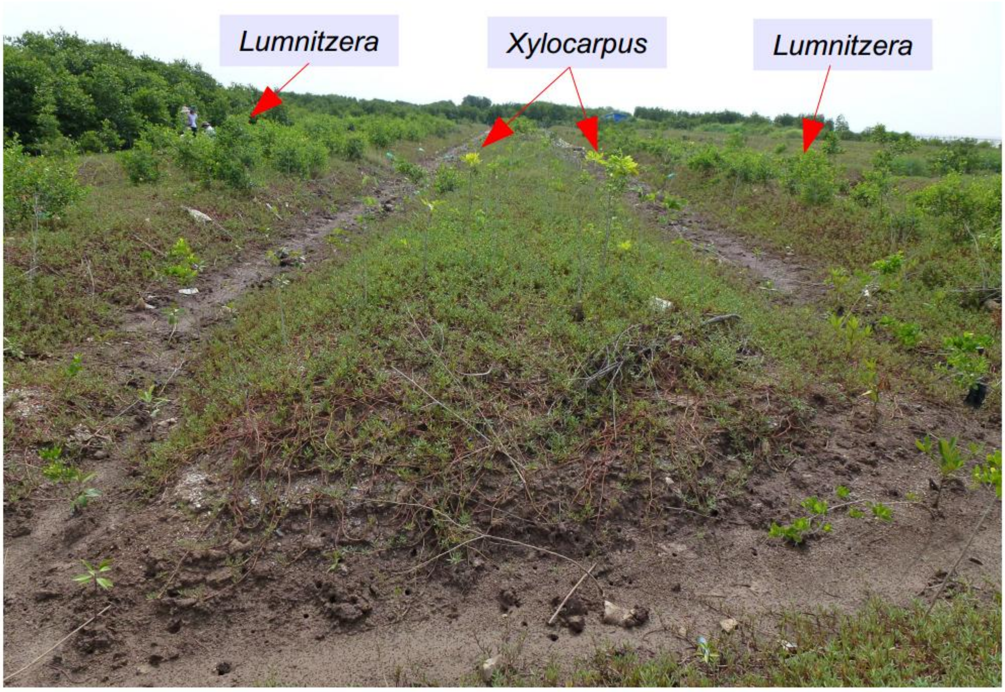


Fig. 6. Comparison of canopy development in *Xylocarpus moluccensis* and *Lumnitzera racemosa* eight months after planting. The photograph also shows the extent of sedimentation and canal infilling.

Finally, planting on elevated barren sites requires seedlings that have been grown in a nursery for at least 9 months. This adds significantly to the cost of planting such sites, with or without canals. For the planting at Sites 1 and 3 in 2011 the nursery costs were about 25% of the total cost of around USD 6,830 per hectare. Canal construction and other site preparations accounted for 38% of the total cost, and transportation and labour for planting about 37% of the total cost (Table 1). These figures serve to illustrate the need for a proper site assessment prior to planting in order to have a high chance of success and avoid wasting funds on unsuccessful plantations.

Table 1. Average cost per hectare of planting at Sites 1 and 3 in 2011. The area planted was 0.8 ha at Site 1, and 2.3 ha at Site 3. A total of about 31,500 seedlings were planted.

Item	VND ha^{-1}	USD ha^{-1} *
Site preparation (mainly canal construction)	57,245,161	2,600
Seedling costs (propagule + nursery costs)	36,834,677	1,670
Planting costs (transport + labour)	56,193,548	2,550
Total cost	15,273,387	6,830

* Based on an exchange rate of USD 1 = VND 22,000 and rounded up or down to the nearest USD 10

In conclusion, while the initial planting in canals was not successful, planting on the embankments, where the survival rate was over 70%, can be considered a success. At planting densities of 20,000 per hectare, a survival rate of 50% is sufficient to ensure effective coastal protection, provided that the survivors are evenly distributed, and continue to grow and produce well-developed canopies. On the basis of survival and growth over the first eight months, *Lumnitzera racemosa* appears to be the more promising of the three species for planting on more elevated sites, followed by *Xylocarpus moluccensis*. *Intsia bijuga*, which is less salt-tolerant and perhaps has a less well-developed root system, does not appear to be very promising for these kinds of sites. Supplemental planting in the canals after 1-2 years with *Rhizophora apiculata* and *Bruguiera cylindrica*, which has already been carried out to some extent, should further enrich species diversity and enhance coastal protection.

References

[1] Cantho University (2010) The Result of Current Land Use Status Survey and Land Suitability Classification in the Coastal Forest Area of Bac Lieu Province. *Sustainable Management of Coastal Forest Ecosystems in Bac Lieu Province (MCE)*, Project No. 08.9236.4001.00, GIZ

[2] Clough, B.F. (2011). Coastal Mangrove Rehabilitation Plan. *Sustainable Management of Coastal Forest Ecosystems in Bac Lieu Province Project (MCE),* Project No. 08.9236.4001.00 0. GIZ.

[3] Clough, B.F. (2012). Coastal Erosion 2009-2012 in Bac Lieu District (Vinh Trach Dong, Heip Thanh and Nha Mat). *Adaptation to Climate Change Through the Promotion of Biodiversity in Bac Lieu Province (BMU Baclieu)*, Project No. 10.9078.6001.00. GIZ.

1. Annex 1 – Pictorial Sequences

Site 1

Site 1 before land preparation for planting in 2011. The *Ceriops* seedlings in the photograph were planted in 2005

Site 1 in the early stages of canal dredging

Site 1 about three months after planting. Note the sediment accumulation and the poor survival of seedlings in the canals.

Site 3

Site 3 prior to site preparation. Both the *Ceriops* (foreground) and *Rhizophora* (centre) were planted in 2005. In suitable habitats, *Rhizophora* normally grows at a rate of 0.6 - 1 m in height per year.

Site 3 one to two weeks after planting. Note that it appears that many of the *Lumnitzera* planted in the canals appear to have already died.

Site 3 eleven months after planting, showing well developed *Lumnitzera racemosa* and less well developed *Xylocarpus moluccensis*.

Published by

Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

“Adaptation to Climate Change through the Promotion
of Biodiversity in Bac Lieu Province”

215, 23/08 Street, Ward 8, Bac Lieu town,
Bac Lieu province, Viet Nam
+ 84 (0) 781 39 49 451
+ 84 (0) 781 39 49 446
+ office.baclieu@giz.de
www.giz.de/viet-nam

Author
Barry Cough
Designed and printed by
(add printing company)
The project “Adaptation to Climate Change through the Promotion of Biodiversity in Bac Lieu Province” is funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU)
Updated version available in December 2013, if interested, please email Ms. Lisa Steurer through
lisa.steurer@giz.de