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COOPERATION
FEDERAL REPUBLIC OF GERMANY
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On behalf of
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
of the Federal Republic of Germany

"Sustainable Management of Coastal Forest Ecosystems in Bac Lieu province" Project (MCE)

DEVELOPMENT OF A BENCHMARK SYSTEM TO ASSESS THE HYDROLOGICAL SITUATIONS IN THE PLANTATION SITES

AND

DEFINING PERMANENT PLOTS TO ASSESS SURVIVAL AND GROWTH RATES OF THE TRIAL PLANTATIONS

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Contents

TOR for Task

1. Scope of the work

- Design a benchmark system in the plantation sites in Vinh Trach Dong commune and a control benchmark in the canal adjacent to the Mangrove Arboretum Station in Hiep Thanh commune.
- Define an adequate number of plots to permanently monitor the survival and growth rates of the trial plantations;
- Provide appropriate methods for assessment of hydrological conditions, survival and growth rates;
- Conduct a field trip to carry out the designs in the sites.

2. Expected output

- A benchmark system and a control benchmark are defined;
- Permanent plots are defined;
- A short manual for assessment of hydrological conditions, survival and growth rates;
- A field trip report;

Report

A field visit was made to the Bac Lieu coastline between Nha Mat and the the provincial border with Soc Trang Province from 28 to 30 September 2011 during a period of high lunar tides. A second field visit was made on 11 October 2011. As indicated in the Task TOR, the field visits had the following objectives:

1. To identify a position for, and design a primary (control) tidal benchmark for monitoring tides.
2. To design a tidal benchmark system for the trial plantation sites in Vinh Trach Dong commune.
3. To define permanent plots for robust long term monitoring of survival and growth rates in the trial plantations.

Tidal Monitoring

Primary (Control) Benchmarks

There are three key requirements for a primary benchmark.

1. It must be easy to get to (i.e. very accessible) on all tides and in all weather. This is not a trivial issue, because if it is not easy to access in all conditions, it is almost certain that it will not be monitored rigorously, resulting in poor and unreliable tidal data. For this reason, the primary benchmark should not be located at the sea front, thereby avoiding the need for staff to walk some considerable distance, often under difficult conditions, in order to take measurements.
2. It must provide an acceptably reliable measure of the tide height along the open coastline, in order to be comparable with official tide records from *Ganh Hao* and *Dinh An*.
3. It must be stable and immovable in order to provide reliable data over an extended period of time.

Based on these requirements, only one location is considered to be highly suitable for a primary benchmark along the coast between Nha Mat and the border between Vinh Trach Dong and Soc Trang Province. This is the main canal at Nha Mat, a large unobstructed canal that is permanently flooded on all tides, and where the proposed benchmark would be less than about 1 km from the open sea (Fig. 1). A tidal benchmark at this location has the following advantages:

- It is highly accessible in all tidal and weather conditions, being within 20 m of the permanently staffed district forestry office in Nha Mat.
- Its proximity to the sea and the size of the canal will minimise differences in the height and timing of high and low tides between the sea and the benchmark, thereby providing a measure of tide heights and times that are a close approximation to those in the open sea.

The main disadvantage of a benchmark at Nha Mat is that it will require a substantial one-off investment in infrastructure to install the benchmark, surround it with protection from passing boats or mooring and a short walkway to reach it. There may also be some administrative issues with local authorities who are responsible for managing the canal waterway, although the local forestry chief stated that this would not be a problem. There is already an existing triangular structure near to the pylon of the bridge that could be used as a benchmark, or within which the benchmark could be placed for protection, but this would require a longer, more elevated and more substantial walkway for access and could interfere with the mooring of boats close to the shore.

The canal adjacent to the mangrove arboretum in Hiep Thanh commune, referred to in the TOR, is not considered not be suitable for a primary or control tidal benchmark, as it is both shallow and narrow, leading to potentially significant differences in tidal heights and times between the

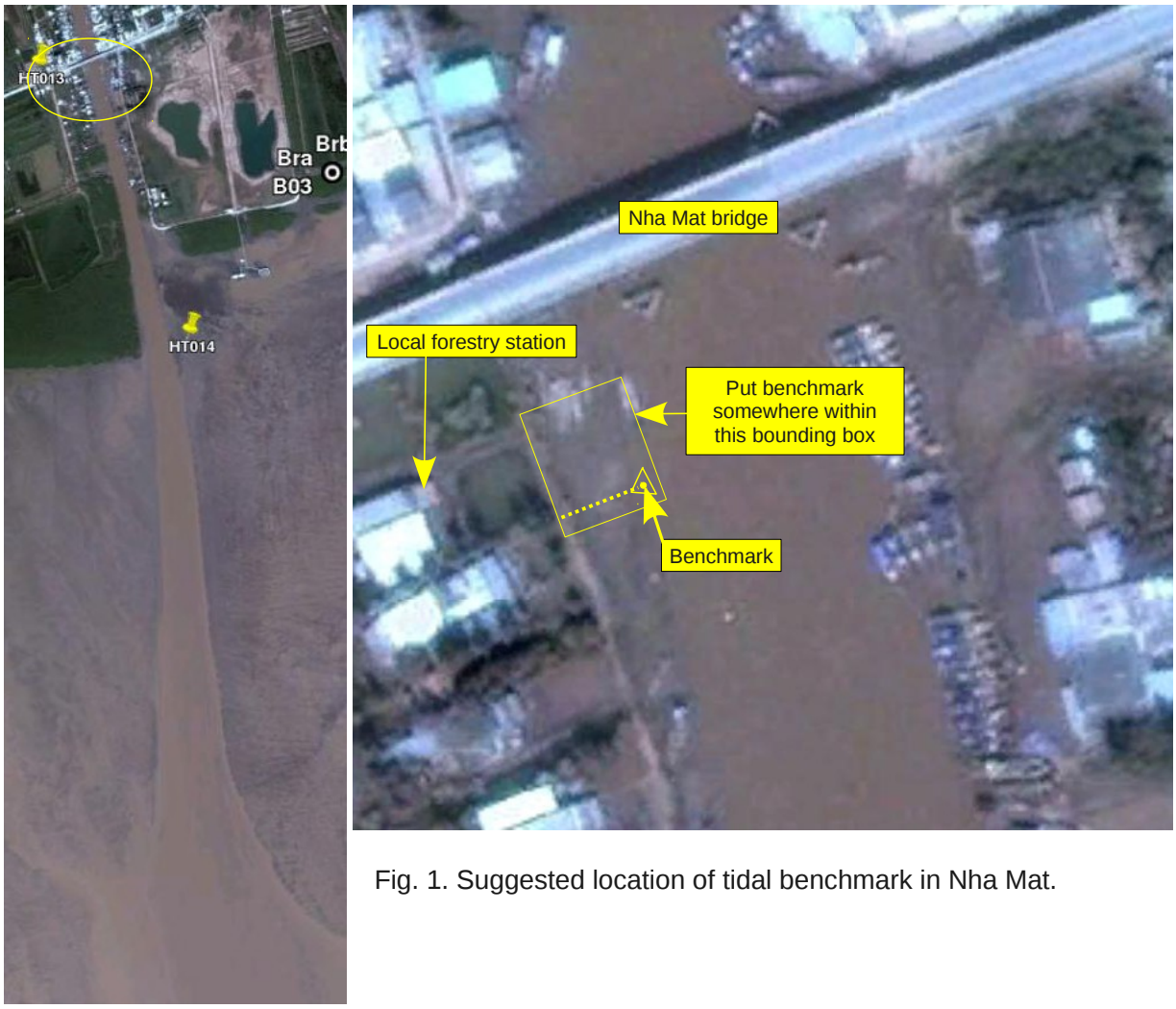

Fig. 1. Suggested location of tidal benchmark in Nha Mat.

benchmark and the open sea. Moreover, it is likely to become infilled with sediment and mangroves in the future.

Design of the Primary (Control) Benchmark in Nha Mat

The benchmark should be a good quality cement post, marked with a clearly visible scale at 5 cm intervals. It needs to be driven firmly into the bottom of the canal as deeply as possible (at least 1.5 m) and should be high enough above the bottom to record tides of 4.5 m. It should be installed far enough from the shore to show water levels at the lowest tides.

The benchmark needs to be surrounded by a protective barrier (Fig. 2).

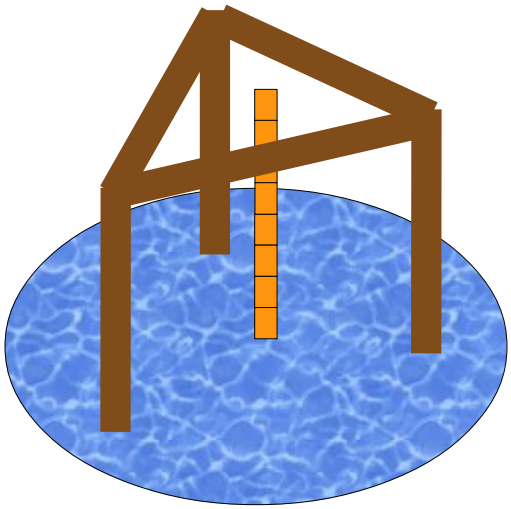

Fig. 2. Diagram of the structure of primary tidal benchmark 2 at Nha Mat.

Data Collection and Analysis at the Primary Benchmark

Required Data: The time and height of the high tides each day for at least one full year. This is the minimum needed to assess the flooding regime in the 2011 trial plantations.

Additional Data: The time and height of the low tides each day. These additional data may not be essential to assess the flooding regime in the present trial plantations, but they are likely to be necessary to match the tidal regime at Nha Mat to reference data for Ganh Hao (and Dinh Anh). In the consultant's opinion, correlating tidal measurements at Nha Mat with those at Ganh Hao and Dinh Anh is important for selecting locations and designing future plantations along the northern section of the Bac Lieu coastline; it would also provide valuable baseline information for coastal management and protection in the future.

Collecting the additional data on the time and heights of low tides would be more time consuming, would require greater commitment from those collecting the data, and would probably incur a greater cost. For this reason it is recommended that the times and heights of both high and low tides be recorded for at least the first two to three months and compared with the corresponding tidal records from Ganh Hao at the end of each month, in order to make a decision on whether or not it is worth collecting data for low tides for the rest of the year.

Benchmarks at Trial Plantation Sites

The primary purpose of benchmarks at plantation sites is to compare the water levels in the canals at plantation sites with the tide heights recorded at the control benchmark in Nha Mat, from which it will then be possible to calculate the approximate flooding frequency (days per month) at each site for each month of the year. The minimum requirement is that each plantation site has at least one benchmark (shown in red in Fig. 3) located in the main channel that supplies water to the site (shown in blue in Fig. 3).

However, significant sedimentation was observed at the mouths of some of the smaller canals (shown in yellow in Fig. 3) during the field visit from 28-30 September 2011; up to 10-15 cm of sediment has already accumulated at the mouths of some planting channels. The accumulation of sediment at the mouths of smaller channels also restricts drainage, and appears to lead to permanent ponding of water inside the channel, at least during the wet season. For this reason, it is also recommended that secondary benchmarks (shown in white in Fig. 3) be located in some planting channels at each site. These can be used to measure both water levels and sediment accumulation.

Benchmarks at each site could be made from 7-12cm diameter PVC pipe, driven firmly into the bottom of the channel to a depth of at least 50cm, and with at least 2m protruding above the bottom of the channel. The benchmarks should be permanently marked at intervals of 5cm before installation and the level of the bottom of the channel should be recorded immediately after installation.

Procedure for monitoring water levels and sediment accumulation at plantation sites

It seems a deceptively simple procedure to measure water levels at the plantation sites, say once a month on a high tide, compare them with the water level at the control tidal benchmark in Nha Mat, and then estimate the number of days per month that the site is flooded. The assumption here is that there is a gradient in canal depth from the water source (in this case the sea) to the ends of each plantation canal, and that there are no humps or slightly elevated areas in the bottoms of the canals that would interfere with water flow on any tide. This is unlikely to be the case, and as we have observed in the field, sediment accumulation and/or the wrong bottom gradient are already leading to poor drainage in some planting channels. Whether or not this affects survival and growth is one issue, but it is also a potential issue in estimating the number of times a particular channel is flooded each month, particularly during those months with low tidal maxima in the dry season, when undulations in the bottom of the canals may prevent flooding, even though tide heights at the control benchmark in Nha Mat suggest that they should be flooded. This means that it is may not be enough to monitor the water levels at plantation sites

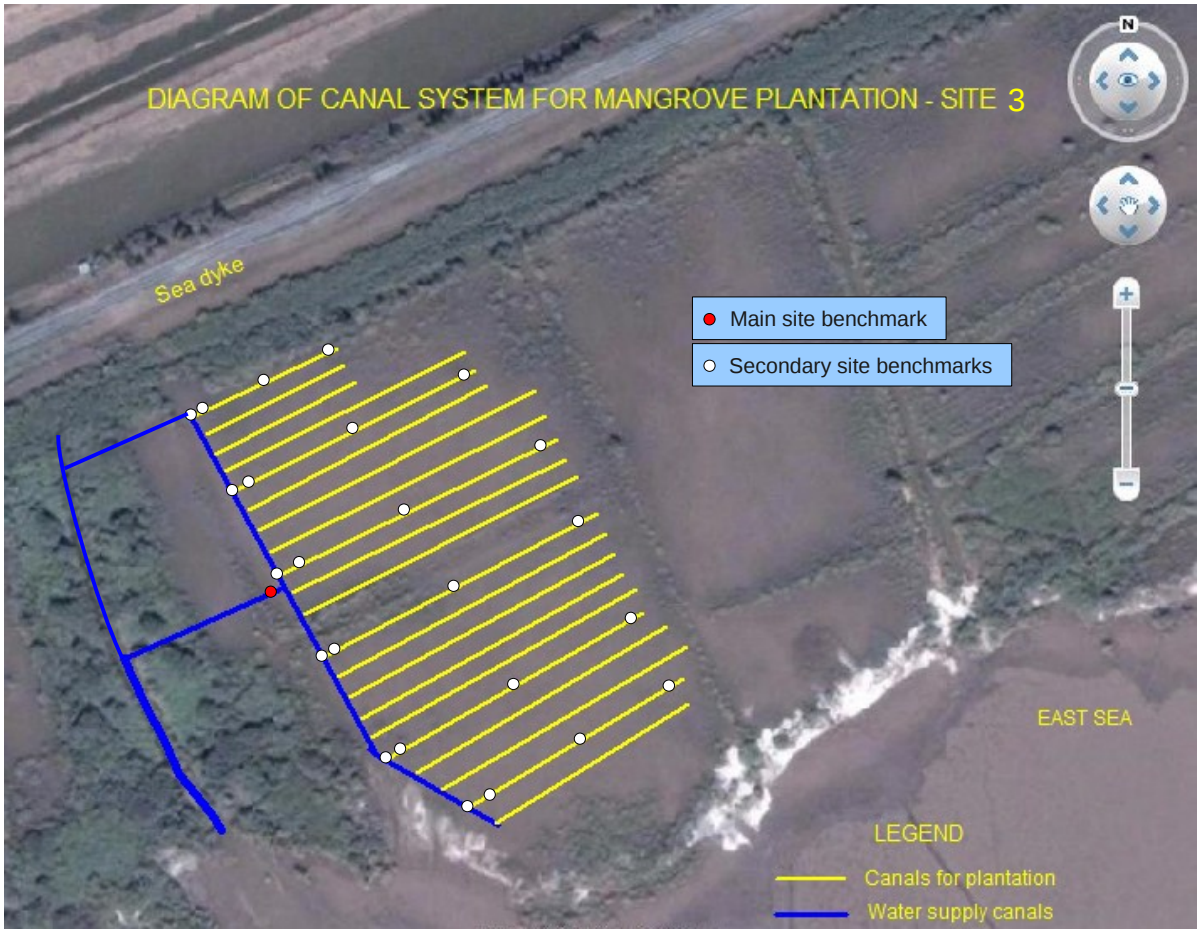

Fig. 3. Tidal benchmarks at plantation sites 1 and 3.

once or twice a month on the higher tides in order to obtain a reliable estimate of flooding frequency. In most cases, where flooding frequency exceeds 6 or 10 days a month an error of a day or two is not too important, but for a site that is rarely flooded, an error of a day or two is important in interpreting the outcome of the trial.

For these reasons, it is probably not useful to give a rigid prescription for the frequency of water level measurements at plantation sites. Two to four times a month may be enough during the wet season and in those months in the dry season with big tides (November to February), but measurements may need to be more frequent in April, May and June, particularly during those days in the lunar cycle when tidal amplitudes are small. The best procedure is to analyse the data progressively month by month and then adapt the frequency of measurement to suit.

It is very important, however, that water levels at plantations are measured at or very close to the tidal peak, in order to match them to the control benchmark at Nha Mat. We cannot be over-confident that the tidal data from Nha Mat will allow us to simulate tide heights that are intermediate between high and low tide.

A measurement frequency of once a month is sufficient for sedimentation.

Monitoring Survival and Growth at Plantation Sites

At this early stage the two main species (*Lumnitzera racemosa* and *Intsia bijuga*) planted on the recently constructed dikes at Sites 1 and 3 appear to have a survival rate of about 80%.. However, the survival of *Ceriops tagal*, *Avicennia marina* and *Lumnitzera racemosa* planted in the canals is patchy, and varies both between canals at the same site and between the two sites. A qualitative visual assessment suggests that survival is probably better in canals at Site 1than at Site 3

Given this variability, the number of plots recommended for long term quantitative assessment of survival and growth, and their placement within each site represents a compromise between the ideal and the practical.

The number of monitoring plots at Plantation Site 1 and their approximate location are shown in Fig. 4; the number of monitoring plots at Site 3 and their approximate location are shown in Fig. 5.

The locations of monitoring plots at both sites have been selected to be as representative as possible, but it should be noted that they may not represent all the physical and hydrological characteristics at either site.

Each plot should be 10 m in length, giving between about 40 and 70 planted seedlings.

Procedure for monitoring survival and growth

The first quantitative assessment of survival and growth should be carried out as soon as possible, certainly before the onset of the dry season in November. In general, survival and growth should be measured approximately every three months, giving four sets of measurements for the first year. If the first set of measurements are made in late October or early November, then a three-monthly sampling interval would mean re-measurement sometime in February, May, August and again in November, which should be effective for assessing the survival of seedlings planted on the dikes over the dry season. However, survival on the dikes needs to be checked qualitatively (i.e. visually) monthly during the dry season. If it seems that the survival rate is dropping at any point during the dry season, then additional quantitative measurements should be made, and they should be accompanied by measurement of the soil water content and perhaps soil salinity and pH.

For survival, simply count the number of survivors AND the number of dead seedlings, but be careful to make sure that the seedling is indeed dead. Both *Lumnitzera* and *Xylocarpus* can lose all their leaves and appear to be dead, and then re-sprout new leaves. It would be useful to record the number of seedlings that have re-sprouted after apparently losing all their leaves.

At this stage of seedling development the only useful measure of growth is height. Canopy cover should also be included in the monitoring program in a year or two as the canopy begins to

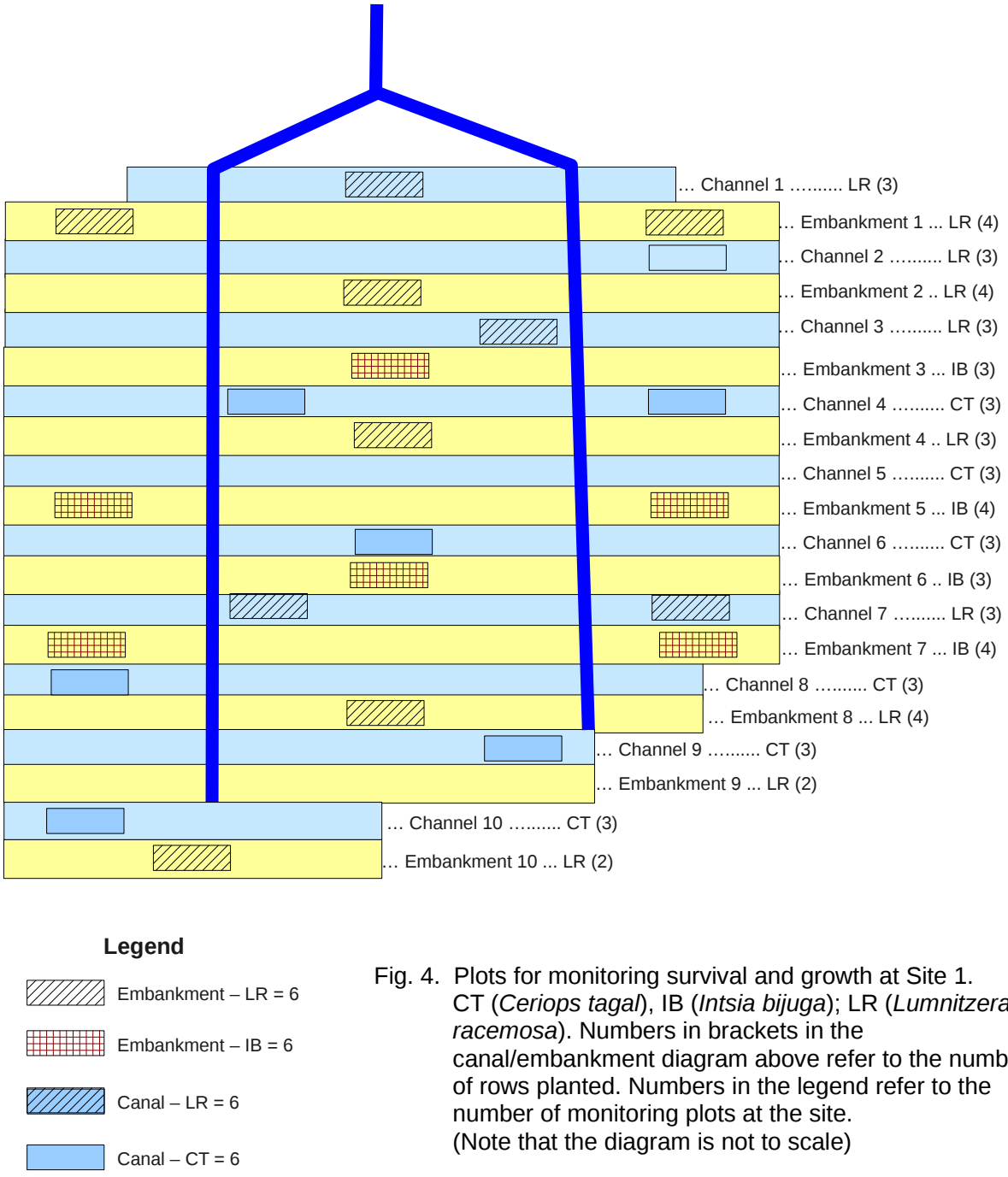

Fig. 4. Plots for monitoring survival and growth at Site 1. CT (*Ceriops tagal*), IB (*Intsia bijuga*); LR (*Lumnitzera racemosa*). Numbers in brackets in the canal/embankment diagram above refer to the number of rows planted. Numbers in the legend refer to the number of monitoring plots at the site. (Note that the diagram is not to scale)

develop, and stem diameter should be measured when the trees become large enough.

Some General Comments Planting and Monitoring

The overall objective of the present plantation trials should be to improve our understanding of what works well and what does not work well, and why, so that plantation designs for other difficult sites can be improved. This requires sharp observation of changes or events in existing plantations, and some flexibility in the types of measurements made and their frequency, in response to any such changes or events.

Based on the outcomes and lessons learned from the 2011 plantations, it should be possible to progressively improve land preparation, planting design and species for planting in 2012 and subsequent years. This is a long term approach that requires long term monitoring of tidal regimes in the project area and of the growth and development of plantations in different areas.

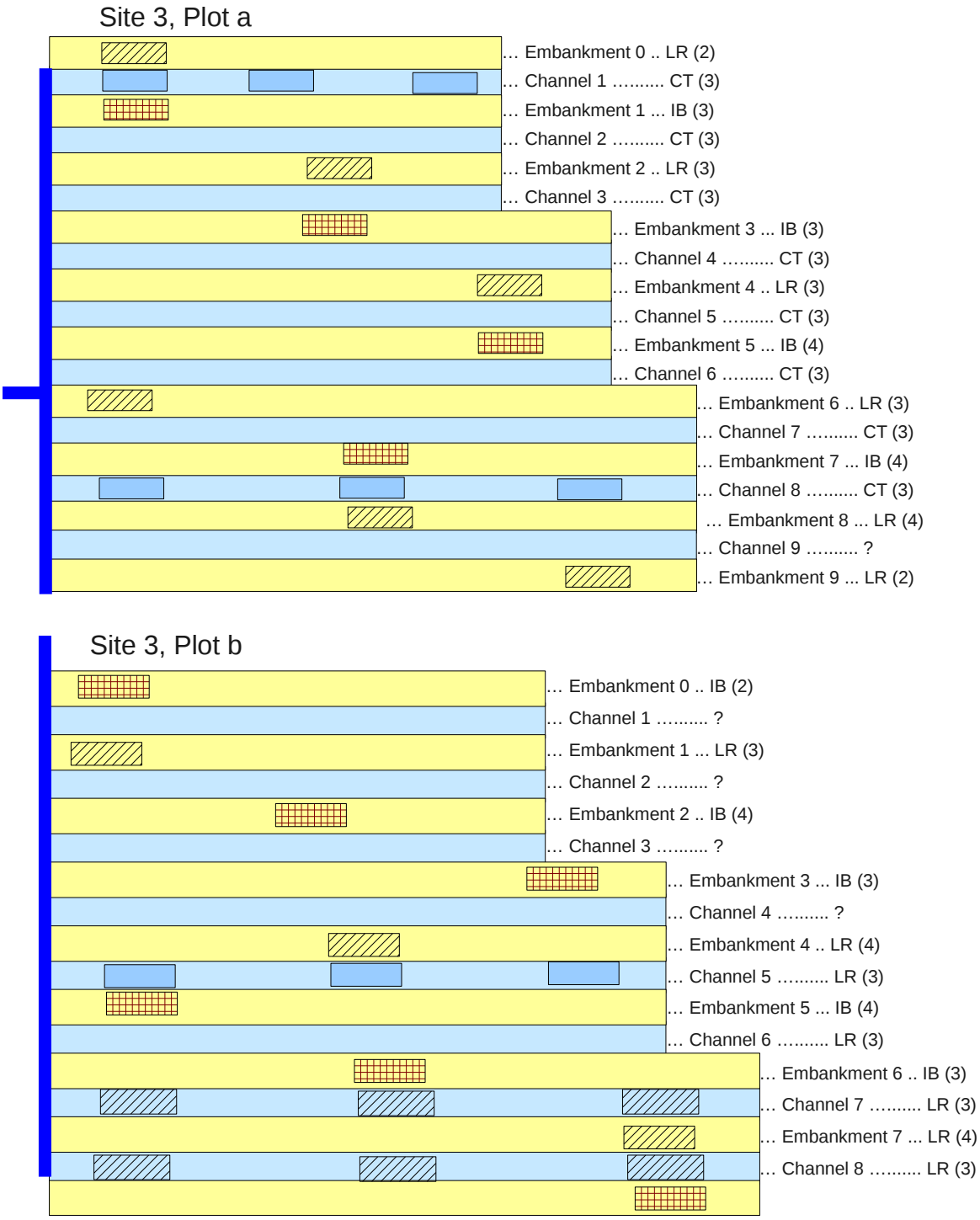

Fig. 5. Plots for monitoring survival and growth at Site 3. CT (*Ceriops tagal*), IB (*Intsia bijuga*); LR (*Lumnitzera racemosa*). Numbers in brackets in the canal/embankment diagram above refer to the number of rows planted. Numbers in the legend refer to the number of monitoring plots at the site. (Note that the diagram is not to scale)

This should include monitoring of water levels, survival and growth in plantations carried out by the project prior to 2011 – in particular, the 2010 plantations of *Rhizophora mucronata* along the sea dike just to the north of the clam hatchery, for it is important to know how well this species survives and performs under conditions of more or less permanent inundation over longer periods of time – for example, is there some upper water level beyond which it cannot survive or grow, and for how long? Perhaps there is already some local knowledge and experience from the Department of Forestry plantation adjacent to Trial Plantation Site 3, but this needs to be quantified and documented so that it can be used effectively in developing a coastal protection strategy. This could be particularly important when advising shrimp pond operators on what to plant in mixed mangrove-shrimp ponds and how to manage the pond effectively to optimise the benefits of mangroves for coastal protection and shrimp production.

The high survival rate thus far of *Intsia*, *Lumnitzera* and perhaps *Xylocarpus* on dikes at Sites 1 and 3 is encouraging. The big test will be to see how they survive the next dry season. If survival remains high after the next dry season, then the 2011 trials can be deemed a success, irrespective of the survival rates in the canals between them. The development of an effective tree canopy along the dikes will significantly improve the the chances of successful regeneration of mangroves in the channels, either as a result of natural regeneration or a simplified manual planting program that might avoid the need for a nursery.

The tidal nursery at Vinh Trach Dong has two very important benefits. Firstly, it reduces the labour needed and the cost of nursery maintenance significantly. Secondly, it produces seedlings that are better adapted to the salinity and other conditions that prevail at planting sites. One of a number of likely reasons for the higher than expected mortality of seedlings raised in the nursery in the Bird Sanctuary and then transplanted in the channels at Sites 1 and 3 is salinity shock caused by high salinities to which they were not well adapted. Using a tidal nursery to raise all seedlings for new plantations from 2012 onwards will minimise this risk.

Finally, there is the question of whether or not some kind of automatic or semi-automatic collection of tidal data at Nha Mat would improve the reliability and quality of the data. As was pointed out earlier in this report, tide data at Nha Mat must be collected on all high tides and, at least in the short term, all low tides if it is to be correlated with official tidal records from Ganh Hao or elsewhere. This of course requires that staff responsible for making the measurements get up at the appropriate time in the night to make the measurement. In the consultant's opinion there is a high risk that this will not be done reliably, which means that the primary benchmark data may be flawed (and there is no way to check!). Automatic tide gauges or water level gauges are relatively expensive, but they provide accurate and reliable data at half-hourly (or more frequent) intervals for periods of weeks to months without attendance. It would be relatively easy to construct a float-based tide gauge, similar to a maximum-minimum thermometer, that recorded the last tidal maximum and/or tidal minimum, which could then be checked and reset by staff at convenient times twice a day. Unfortunately, however, it is more difficult to find a simple method that also records the time at which the high and low tides occur. It would also be relatively easy to construct a simple, low-cost, pressure-based analog tide gauge with a remote digital readout located in the forestry station that staff could read at half-hourly or hourly intervals without having to go outside. This, however, would require a low voltage connection between the gauge itself (located in the canal) and the readout device (located in the forestry station). The latter has the benefit that problems with the monitoring system are immediately obvious and can be rectified without the loss of too much data. The short- and long-term objectives of tidal monitoring need to be clarified in order to decide which measurement option would be most appropriate. If the objective is just to provide a short-term tidal reference for the present trial plantations and perhaps those in 2012, then a purely manual system would probably suffice. But if the objective is to provide a longer term tidal baseline for coastal protection and coastal forest management that is reliable and can be correlated with official tide records from Ganh Hao or elsewhere, then an automated or semi-automated system should be seriously considered.