FINAL EVALUATION REPORT

Jan, 2011

Project Number	
Project Title	Demonstrating Ecological Mangrove Rehabilitation at Krabi Estuary Ramsar Site, Thailand
Country	Thailand
Selected Year	2007
Implementing Organisation	Wetlands International – Thailand. See Appendix 1 for details
Partner Organisations	Mangrove Action Project Dept Marine & Coastal Resources
Net Res	
Project Duration	2 Years

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Location, Sector & Cost

A former aquaculture pond in Bang Lang Da village, Tambon Ta Ling Chan, Muang District, Krabi Province THAILAND. Size: 0.7ha
8º 00’24.80’’N, 98º 58’42.88’’E

This location is in the Krabi Estuary RAMSAR site.
RAMSAR site no: 1100, established: 2001.
Wetlands Type: estuary, mangrove forests, seagrass, and mudflats.
Mangrove Forest Official Status: National Forest Reserve

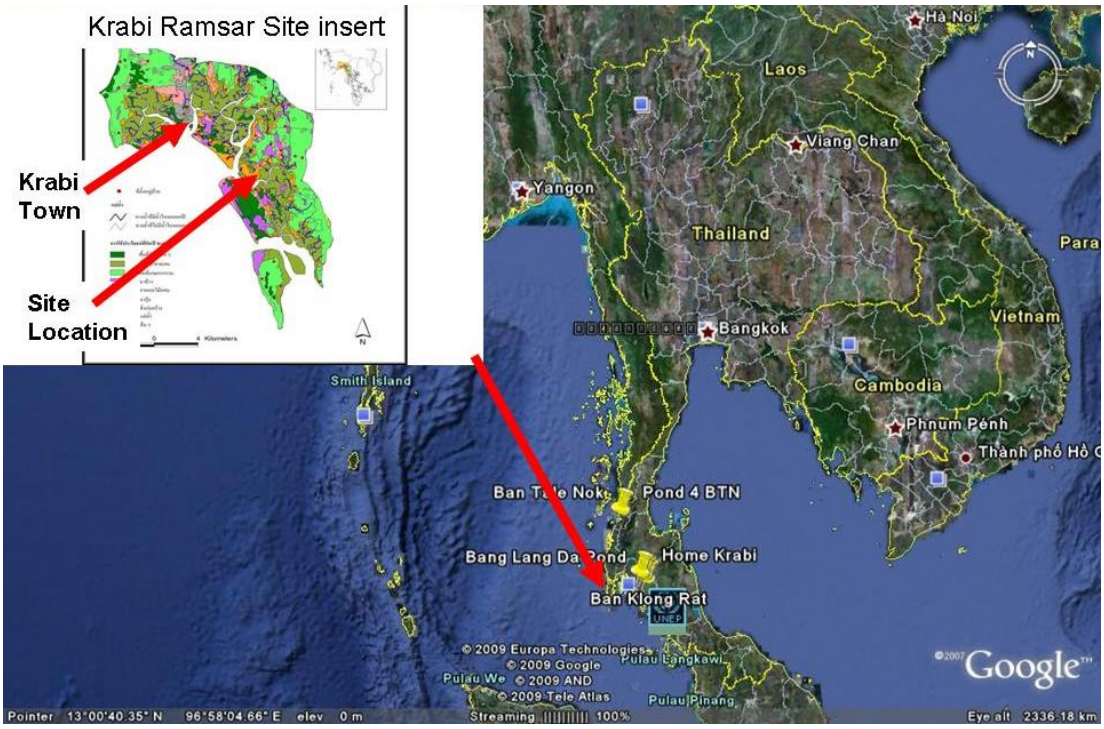

Figure 1. Map showing Thailand and location of Krabi. Insert shows Krabi town and Site location

Issue / Sector

Marine and Coastal Resources, Forestry / Mangrove, Livelihoods

Total Cost to APFED

$19,150

Acronyms

APFED	Asia Pacific Forum for Environment and Development (donor)
BLD	Bang Lang Da (village where activity took place)
CP	Control plots (left empty to monitor natural regeneration)
DMCR	Dept for Marine and Coastal Resources (Thai government agency responsible for mangroves)
EMR	Ecological Mangrove Restoration
MAP	Mangrove Action Project (an NGO)
MMU	Mangrove Management Unit (field offices of the DMCR)
NGO	Non-governmental organisation
TP	Test Planting plots
WI-T	Wetlands International - Thailand

1. Outline of the Evaluation Study

1.1 Project Background

The boom and bust of the shrimp aquaculture industry has been the largest single factor responsible for the loss of mangroves world-wide. In the 1980s and 1990s it was hoped that aquaculture would be a great way for poor coastal communities to lift themselves out of poverty and into a sustainable way of life. Institutions from the World Bank downwards promoted it. This resulted in huge areas of mangrove being 'converted' (i.e. destroyed) to form aquaculture ponds.

Though technically possible much of the shrimp farming was run at unsustainable levels of intensity. The multiple and significant problems arising from intensive aquaculture have been well documented by many writers. Primavera (1995) provides an excellent summary of the issues. Chemical build-up, acidification, nutrient build-up, bacteria and virus outbreaks caused production to tail off dramatically after only a few years, leading eventually to pond abandonment. Pond failure would leave the local village with unproductive and highly degraded land, from which they could earn nothing, nor benefit from any of the natural resources that the former mangrove would have provided. As a consequence, the former local shrimp farmer would often be heavily indebted and thus, as a way to pay off the debts, would sell the pond to a seafood company or 'outsider', who would move in cheaper labour from northeast Thailand or Burma. So if the pond re-starts production, no economic benefit is gained by the local people, but they suffer from all the negative externalities.

A glance at the satellite imagery of the Krabi Ramsar site (see Appendix II) reveals just how extensive the aquaculture industry is, even within a Ramsar site. In southern Thailand there are now extensive areas of abandoned of idle shrimp aquaculture ponds due to problems stated above and/or the poor economics of shrimp farming. In Southeast Asia mangroves continue to be lost at a rate of 1 - 2% annually, while much of the remaining mangrove forest is degraded. Aquaculture pond abandonment in former mangrove areas is a worldwide phenomenon, but given time pond mud walls erode and with luck a pond can naturally regenerate back to mangrove once tidal flushing is re-established. However, in Thailand, the mangrove loss to aquaculture does not stop at pond abandonment, as the Land Development Dept is now encouraging further conversion from former aquaculture pond to oil palm growth (see Figure 2).

Figure 2. Former mangrove area, converted to aquaculture, and now oil palm, supported by the Land Development Office. Bang Lang Da, Krabi.

In Thailand, the government department responsible for mangroves is the Department for Marine and Coastal Resources[1] (DMCR). It is having a challenging time due to inadequate resources and inappropriate targets. That notwithstanding, the DMCR is prone to see mangroves as an extension of forestry, thus their solution to mangrove degradation is seedling nurseries, planting at high densities with a very limited selection of species in any available space and thinning, with mixed results.

Similarly many well-meaning and well-funded donors have been supporting mangrove planting in the Krabi estuary. And after the Asian tsunami of 2004 several multi-million dollar projects were initiated around South and Southeast Asia. However these often suffer from a lack of technical expertise, ignoring issues like hydrology, and thus a few months later little from their efforts remain. Indeed most projects fail or fail to meet their objectives (Lewis 1990, Erftemeijer & Lewis 2000, Salmo, Torio & Estaban 2007). This lack of technical ability is unfortunate. Ellison (2000) and Walters (1998) suggest that in general there has been very little knowledge transfer from the academic / scientific world to those actually working on the ground.

1.2 Project Overview

Figure 3. One of many meetings between NGO staff and the local villagers

Starting in Oct 2007 this project attempted to set up an Ecological Mangrove Rehabilitation demonstration site within a former aquaculture pond in Bang Lang Da village, Krabi Estuary, SW Thailand. As mentioned earlier, abandoned ponds are a significant issue in the tropics but restoring them back to mangrove can be difficult. The pond at BLD had been open to tidal flushing for 2-3 years but little natural regeneration had taken place, despite the presence of plenty of mangrove seeds and propagules.

The project was also to support local livelihoods if necessary. Unfortunately the start of work was delayed due to site control issues. While the EMR project progressed, the level of participation has been lower than hoped due to staffing and management issues at WI-T. However the relationship between the team and the village is excellent.

1.3 Study Objectives

- Use an alternative method called Ecological Mangrove Restoration (EMR) to restore a degraded mangrove habitat caused by shrimp farming and pond

[1] In Thailand mangroves are the responsibility of the Dept for Marine and Coastal Resources (DMCR). This department has divided up the Thai coastline into 39 sub-units. Each unit has a field office, called a Mangrove Management Unit (MMU). MMU27 is responsible for this Tambon of Ta Lin Chan where Bang Lang Da is found.

construction, paying much more attention to the published science. This method would facilitate nature to regenerate mangroves with minimal (financial) input to produce a more bio-diverse mangrove than traditional methods of restoration.

- κ Thus demonstrate that with technical input, training and will, a lack of money should not inhibit communities working on their own from repairing damaged areas of mangrove, including former aquaculture ponds, which often have significant barriers to rehabilitation.
- κ Create an EMR demonstration site for interested visitors and future EMR training in Thailand.
- κ Build awareness of need to consider and rework the hydrology and topography when restoring areas degraded by man's activity
- κ Use a multi-stakeholder approach during the entire process, involving local government, villagers, NGOs, and private business such as shrimp farm operators.
- κ Empower and build the capacity of local people so that they become examples of agents of change in a bottom-up approach to neighbouring communities in and near the RAMSAR site, hopefully leading to the establishment of a local community network.

1.4 Scope of Work

In a coastal area like Bang Lang Da, there are several problems and stresses that affect villages, mangroves and the local environment. Though being cognisant of them, this project attempted to deal with only a few issues (see Section 1.3). Challenges mentioned in the proposal that this project did not attempt to address included;

- κ Land tenure problems and the overlapping laws and jurisdictions
- κ The lack of scientific understanding of the local carry capacity of the environment and of the resistance / resilience of the environmental services
- κ Quantifying these ecosystem services
- κ The lack of legal protection for a Ramsar site
- κ The continued promotion of aquaculture, oil palm in former ponds, aquaculture encroachment, poor and unsustainable aquaculture techniques
- κ The quality and reliability of official mangrove statistics

1.5 Study Period

Due to a delayed start in agreeing land control of the project site, the project started in Oct 2007 but was been extended until Dec 2009. Some additional data been collected from the site Jan 2011 (see Section 2.3).

2. Methodology

2.1 Evaluation Questions

- How much mangrove has been rehabilitated?
- Has a demonstration site been established?
- Was there an improvement in the awareness and understanding of the importance of the science behind EMR and in particular the hydrology?
- Was the process participative?
- Was the capacity of the local people improved and was a conservation network formed?
- Were alternative livelihoods explored?

2.2 Methodology

2.2.1 Ecological Mangrove Restoration

For the implementation of the mangrove rehabilitation process, the team has followed MAP's EMR methodology, as described on their website [2]. This involved

- Engaging with local people to discuss plans, find out what they wanted to do, explain EMR, find out the local history of the site, discuss participation
- Agree a Memorandum of Understanding with the owner of the pond to agree to convert the pond back to mangrove
- Survey the site, including areas outside the pond to understand the changes that had occurred to the area, and the species present and desired
- Plan the implementation
- Amend the topography of the land to make it suitable for mangrove growth and improve the hydrology of the site: hand digging
- Monitor the growth of the resulting mangroves and amend the land preparation as necessary

Figure 4. Excavated channel, following original stream to improve hydrology, with labelled hills for mangrove growth and monitoring

2.2.2 Demonstration Site and the Importance of Hydrology

The site was labelled as far as possible to aid explanation (see Figure 4). All visitors were accompanied so as the detail of the project and the learning could be disseminated. During tours with visitors and other NGOs interested in mangrove rehabilitation (see Appendix IV), the process of EMR was explained and the

[2] More details of the mangrove restoration methods used can be found at MAP's website: http://mangroveactionproject.org/map-programs/restoration/six-steps-to-successful-mangrove-restoration

importance of appropriate hydrology and topography explained.

2.2.3 Participation, Livelihoods and Empowerment

The discussions took several forms, informal and more formal. The stakeholders were involved in discussions as far as possible, to the level they wanted to be involved, and encouraged to put forward ideas, livelihood plans, comments and local knowledge about mangroves. During the course of these discussions EMR was explained in appropriate terms.

Livelihood discussions were limited due to a lack of WI-T staffing and management support.

Local NGOs received presentations about the progress of the project and the science behind EMR. The DMCR asked only to be briefed as 2009 saw an internal reorganisation. However they joined the team for the school conservation event and provided valuable support (see section 3.5)

2.3 Schedule of Study

Throughout 2007 WI-T and MAP were in dialog with the DMCR and villagers from **Ban Talin Chan**. The DMCR had suggested an area it controlled in this village that it wanted to rehabilitate and asked if the project could take this site on. While the project team was applying to APFED for funds, the negotiations with the local community to work at this site appeared to be very positive. However, towards the end of 2007 it became apparent that permission from the village to control this site for the long term would not be forthcoming. Thus Ban Taling Chan was abandoned.

After considering two other sites, an abandoned 0.7ha aquaculture pond in a former mangrove area in **Ban Lang Da** (BLD) village was found (see Appendix II). Bang Lang Da is the adjacent village to Ban Ta Lin Chan, still in the Krabi Ramsar site.

Site Search Oct 2007 – Early 2008
Discussions with Ban Talin Chan re site and site control
Mid 2008 Ban Talin Chan abandoned
Mid 2008 – Feb 2009 search for a new site

Phase One Feb 2009 – April 2009
Discussions with the local people & DMCR
Field trip and capacity building for WI-T staff to Koh Phra Thong, Phang Nga
Field Survey, inc basic soil survey
Reference Site Survey. Mapping. Planning of implementation
Debris clearance

Phase Two April 2009 – Dec 2009
Site work and iterative correction of land preparation
On-going dialog with the local people
Visits and study tours by interested parties
Discussions with local people about livelihood development

Joint EMR training with another MAP project held at Ban Talay Nok (Ranong Province) and BLD
Set-up of monitoring and evaluation

Phase Three June 2009 – on-going
Replication of the EMR techniques developed at BLD at Ban Talay Nok
Adoption of EMR techniques by a local NGO (Projects Abroad). WI-T staff acting as consultants and site guides
School Event

Post-Hoc. Jan 2011
Final data collection

3. Results

3.1 Project Implementation

3.1.1 Inputs

Inputs included WI-T and MAP staff time and use of equipment (auto-level, survey kit, salinity meter etc). There was a significant financial contribution from MAP in staff time at the earlier stages when many community level meetings were held to discuss local environmental issues, possible restoration sites and land tenure issues. WI staff carried out the bulk of the project EMR implementation, adjusting the site's hydrology. Informal training on EMR techniques by WI-T and MAP staff and advice and desired species preference from local people. APFED funding support was important for undertaking this pilot project as there were no other major funders involved.

It was anticipated that the villagers would spend more time working on site, but in the event the rehabilitation part of the project became a more research-based programme, testing low-cost methods of EMR implementation and executed by project staff, though with volunteer help from the villagers.

3.1.2 Activities

Unfortunately much time was lost finding the current site when permission for the first was refused. Therefore some of the later activities happened only after the end of APFED's involvement. However activities conducted were;

- Repeated discussions and interaction with the local community, which often turned into informal EMR discussions and training
- Site survey, reference site survey, site debris clearance
- Significant topographical, hydrological site work and seed 'dibbling'
- Several study tours by outside groups conducted around the pond
- Combined EMR training with conservation group members from Ban Talay Nok, Ranong Province
- EMR manual translated into Thai
- EMR manual 2nd Edition for use in training sessions (process on-going)
- Schools conservation education day (8th Feb, 2010), in Bang Lang Da and Ban Talin Chan
- Discussions concerning several livelihood options and possible study tours, but to date, the village has not identified alternative livelihoods that it wants to pursue.

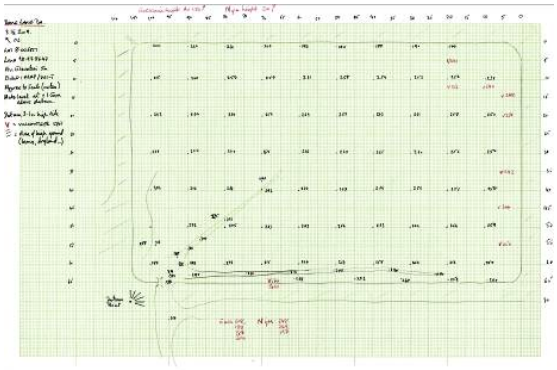

Figure 5. Initial site survey with spot heights of pond

The specific mangrove results of the restoration work have been detailed in Appendix III.

3.1.3 Outputs

- Meetings with the community, in all sorts of forms, from formal meetings with the local Imam, to lunchtime discussions with study tours. Physical output: meeting notes, if appropriate, circulated to the rest of the WI-TO / MAP team
- Demonstration site, labelled, including control plots etc
- Thai translation of current EMR manual printed, and part-completed 2nd edition of the EMR manual (much more technical for DMCR staff and mangrove workers)
- Results and learning disseminated on the MAP's website, a mangrove e-group and by blog
- Training sessions from another MAP project held partly at Bang Lang Da
- Several study tours from a variety of countries have visited the site and learned about the importance of hydrology and topography
- Schools event and site visit

Figure 6. WI Staff teaching with the aid of a mangrove and wetland ecology game

3.2 Relevance

This project did not attempt to directly target the most needy but to establish a demonstration site that was easily accessible to interested parties. The issue of mangrove conversion and restoration is completely relevant to the village of Bang Land Da. It is surrounded by aquaculture ponds and many of these ponds are abandoned and are therefore useless as a resource to the local people (see Appendix II). However, the most needy are most likely to actively use and extract resources from the remaining mangroves, including crabs, *Nypa* palm products (see Figure 7), fish, shrimp, wood etc, so a healthy mangrove resource is crucial to many of the villagers.

Figure 7. BLD Community leader's family using Nypa leaves to make roofing panels

Within the budget available, and due to certain unfortunate WI-T management issues, the team had to focus on the Ecological Mangrove Rehabilitation project and implementation of the demonstration site. Despite the lack of an obvious livelihood need, the challenges and problems of the village were obviously far more complex and broad-ranging than the scope of this project (see Section 1.4). As it emerged, of

prime concern to them was solid waste management and rubbish collection, rather than livelihoods. This has recently been partially dealt with, with the provision of large bins for each household and an agreement by the municipality to collect rubbish, in return for a monthly fee. Rubbish and plastic bags were also covered in detail at the school event, but what is really needed is a change of attitude towards disposal of personal rubbish by the local people.

Water quality issues relating to aquaculture was the other issue mentioned most frequently by local people. This was being investigated by the project team, in conjunction with the neighbouring village of Ban Talin Chan, but again is outside the scope of the APFED project.

3.3 Effectiveness

3.3.1 Achievement of the Project Objectives

Due to the loss of time at the start of the project some of the activities took place only after the end of the APFED support period. However, much has been completed already;

- The EMR process started well, with mangroves growing again in the pond over a certain area (see Appendix III for some specific growth data). There is a wide variety of species growing onsite, with more biodiversity to come.
- The site was easy to use for teaching as the hills, channels, control plots etc were well labelled [3].
- Within the mix of mangrove growing back is a representation of Nypa palm, which was the species requested by the villagers. Tough fibrous Nypa leaves are used in livelihood occupations to make thatch roofing sections and cigarette papers (see Figure 8).
- Feedback from the EMR training at Ban Talay Nok, which included joint sessions in BLD, was very positive. Facilitating fellow Muslim villagers from the two different communities to talk amongst themselves was very effective.

Figure 8. Roof sections made by the community in Bang Lang Da, from local Nypa palm leaves

[3] During the project period control plots were roped off and labeled and hills & channels clearly marked. Unfortunately the signs have since been degraded by sun and salt and washed away, and the control plot poles were stolen.

- κ Though not measured quantitatively or qualitatively, there was and still is a good working relationship between the project team and the villagers of Bang Lang Da, which has lasted way beyond the two years of the APFED funding.

The process has enjoyed some degree of participation as it became clear that there would be only limited funds to pay villagers to help in the land preparation. However, the pond proved to be an extremely useful test-bed for WI-T staff to personally assess various low-cost techniques for rehabilitating the pond effectively and so the project became more research-orientated.

The team has not had the opportunity to further train and empower the local people in EMR techniques. However, the villagers were very happy to host the project, as they appreciated its value and understood its goals.

The livelihood discussions have revolved around crab rearing. Though ideas have been discussed within the village these did not materialise into a request for action from the village. Other livelihood options seem to be less attractive to the villagers (see Section 3.6).

3.3.2 Attribution of Outputs on the Project Objective

Continuous meetings held with various village members have built trust and understanding. From the outset the village appreciated the nature of the project and the team was careful to control expectations. As the rehabilitation part of the project evolved into a more research-based scheme, the villagers fully appreciated what was being developed, and could see that their desired species of Nypa palm was starting to grow on site. A good example of the strength of the relationship was the villagers' willingness to present their independent crab rearing activities to visiting study tours (see Figure 9).

Figure 9. Bang (Mr) Don presenting his crab group activities to local school children

The restoration activity and several specific actions have produced a useable demonstration site that has significantly helped disseminate the idea of EMR and encouraged study tours to pay more attention to the science that supports EMR (see Appendix IV). This has been broadened by use of the internet.

The dissemination of environmental issues and general wetlands values has been pushed further by the local school event, as well as talking with the local children on an *ad-hoc* basis.

The Thai translation of the current EMR manual and part-completed 2nd edition will be central to future EMR training sessions MAP will conduct around south and southeast Asia. 13 have been conducted to date, the next one planned for Myanmar, Mar 2011.

3.4 Self-Reliance of the Project

As the site work progresses, more and more of the pond will be able to naturally regenerate on its own, thus returning to sustainable mangrove that attains its own equilibrium. From this mangrove local people will be able to use Nypa palm and other resources in a manner that supports their existence and livelihoods, but does not degrade the site.

Further EMR training will encourage and empower the local villagers and others to take on other sites around them to facilitate their restoration. This requires additional funding.

The use of the demonstration site as a teaching tool has not been limited to the two years of the project funding but has been used after the end of the project and will be used in the future.

3.5 Participation

Participation by the local people at the start of the project, enabled the project team to initiate the mangrove rehabilitation work and build a solid relationship. Agreement from the villagers, suggestions of what species they wanted, local history and suggestions of what species could grow where, were all invaluable.

The change in the nature of the rehabilitation project, from more community rehabilitation to research, and the lack of funds, precluded the village from taking much of an active role in the day-to-day site work. But the project team took great pains to keep the village informed of what was going on and they in turn have taken an interest.

Feb 2010 saw a local school event, run in combination with conservation group leaders of both Ban Talin Chan and Bang Lang Da and DMCR. Though not a specific objective, improving the local children's understanding of mangroves and environmental issues will help improve what happens in the village (see Figure 10).

Figure 10. WI & MAP staff using the project as a teaching aid during a schools education event

In terms of livelihoods, the project team encouraged the village to lead this process of internal discussion, analysis, filtering of ideas, producing proposals and implementing action. Though many ideas have been discussed, this has resulted only limited action. The reasons for this are discussed in Section 3.6, below.

3.6 Conclusions

Though the mangrove work has been partially successful, the time lost and management issues have significantly hampered efforts by the project team to work on the 'softer' elements, like participation and empowerment. The lack of pressure

from the villagers of Bang Lang Da to provide livelihood help is likely due to the proximity of Krabi town and the jobs available within, as well as a large road building project nearby, which has been a significant source of jobs. However there have been several very useful outputs, which have already helped MAP and WI-T's work in other projects, like the experience gained, techniques tested, manuals produced and the demonstration site. Details of these are documented in Appendix III.

4. Lessons Learned

- Land tenure and project site control is perhaps the most difficult process in mangrove rehabilitation, taking up an open-ended amount of time, and time at the start of a project.
- Many techniques have been developed and tested to actually implement EMR successfully in the field at very low cost. This includes the stability of the hills, appropriate sizes of channel dimensions, man-hours needed to excavate a given length of channel and so on (see Appendix III for details).
- Careful setting of expectations (and in particular the availability of only very limited funds) helped to avoid disappointment later on in the project. This was particularly important in post-tsunami Thailand, where previous projects had been much more liberal with funds.
- A project team should not assume that there is a livelihood need in a community. Nor should it assume that a lack of livelihood opportunities is a cause of environmental degradation.
- Interaction between villagers from different parts of Thailand worked well in a training situation.
- Partly as a result of this project, Wetlands International – Thailand went through a significant management change.

5. Recommendations to the Implementing Organisation (by NetRes)

- Project time lengths longer that two years should be considered as not all rehabilitation projects fit neatly into this arbitrary time unit.
- The end-of-project form is repetitive and needs better structure and annotation to aid completion
- Reconsider why the application form asks for 'innovative' projects when it's hard enough to run a normal project, and so much of the published mangrove science is still being ignored by NGOs and practitioners in the field. Innovation is not as necessary as better application of current knowledge

6. References

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APPENDIX I - IMPLEMENTING NGOs' DETAILS

Wetlands International – Thailand

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APPENDIX II – Satellite Map of BLD and Surrounding Area

Satellite Image of Bang Lang Da. (Site Marked by Pin)

Figure 11. Google Earth image of part of Krabi Estuary, including Project Site (pin)

APPENDIX III – Results, Non-Scientific Data and Lessons Learned

Figure 12. Pond survey, March 2009. Open for 3 years but very little natural regeneration.

This site was chosen as it was a typical aquaculture pond, carved out of former mangroves. The pond had been abandoned for 5-7 years and the mud walls round the blocked sluice gate had eroded, thus allowing tidal flushing for 2-3 years before the project started. However, despite the availability of propagules and seeds, the pond floor was not regenerating (see Figure 12). A site survey supported the hypothesis that the pond was not regenerating due to the substrate being too low, relative to sea level – almost Watsonian (1928) mudflat. Mangroves surrounding the pond were growing at levels higher than the pond floor. Therefore the restoration part of the project attempted to correct this by raising the height of some of the substrate and improve the drainage.

Figure 13. Pond excavations as of Feb 2010

Hills Stable, Channels Less So

Most of the effort has been focused on repairing the topographical damage - widening and lowering the channels across the pond to improve drainage and with the spoil creating a series of hills, of drier and firmer substrate.

Approximately 32 hills have been dug and 60m of channel improved or dug. Each of the hills is about 1m high by 3m across, weighing about a tonne. This has provided more substrate at the appropriate height for mangrove growth and better drained soil. Many of these hills have quickly been colonised by crabs.

Despite misgivings by local people, once settled, and water squeezed out of the clay by its own weight, the hills remained relatively stable (see Figure 14) losing between 10-20cms height over 18 months. For example, Hill A, the first hill produced, has settled and lost only 16cms in height, between March 2009 and Jan 2011. Though the sample is small, vegetated hills seemed to be more resistant to erosion, possibly from the protection the leaves offer from the rain.

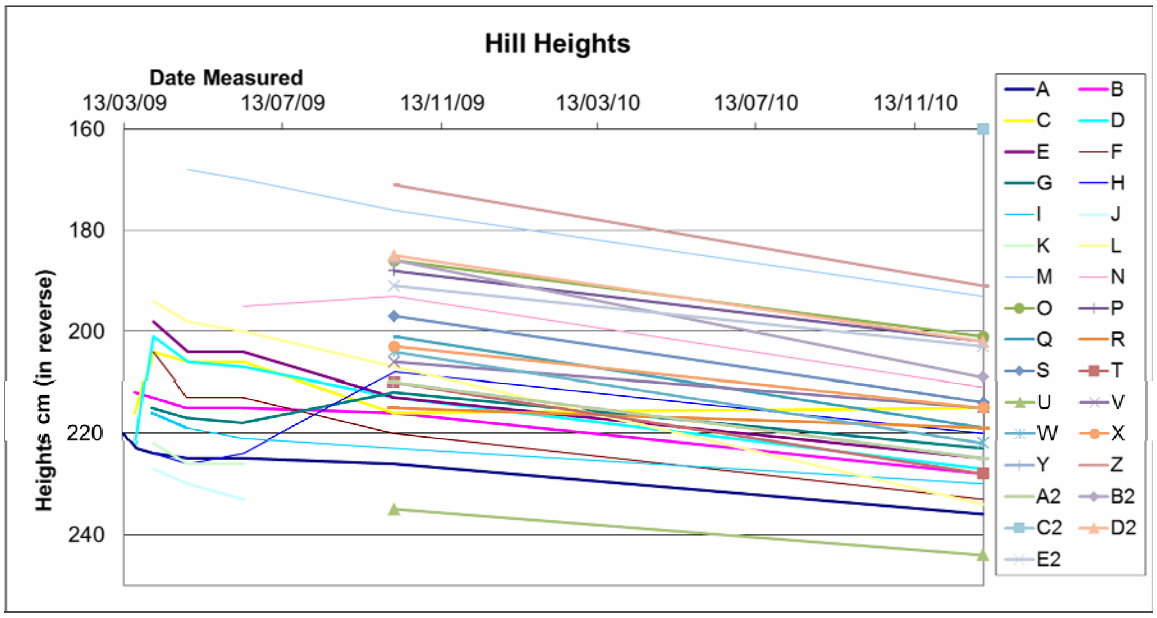

Figure 14. Hill heights over time, March 2009 – Jan 2011

Digging the channels and producing the hills was hard work, and required the sides of the hills to slope only gently, otherwise the sides would buckle out. Thus producing much higher hills required disproportionately larger amounts of digging. However this is a viable method for amending topography changed by pond conversion, and could be a livelihood opportunity[4], or done mechanically.

The channels, on the other hand, were less stable. Testing revealed that channel sides needed to be sloped at very shallow angles, and nearby surface 'sloppy' mud skimmed off and piled onto the hill. The pond contained so much fine clay material, and the process of working and walking in the channels churned up the mud so much, that the channels tended to fill in more quickly than the hills subsided and eroded.

[4] MAP and WI-T have successfully used local labour to excavate another site in at Ban Talay Nok, Phang Nga province. The link goes to a short film of the project. http://www.youtube.com/watch?v=qKL3KJE3Xsw

Plant Growth from Dibbled Propagules

A random sample of hills was dibbled with various mangrove propagules. The first hill to be dibbled[5] was Hill C. This received *Rhizophora apiculata*, dibbled on 22nd March 2009.
Figure 15 and Figure 16 below shows Hill C's encouraging and continued growth.

Figure 15 also shows that though propagules were dibbled around the base of the hill, mid-way up and on top of the hill, the heights attained by the surviving plants suggest that lower plants were slightly taller than the higher and mid-level plants.

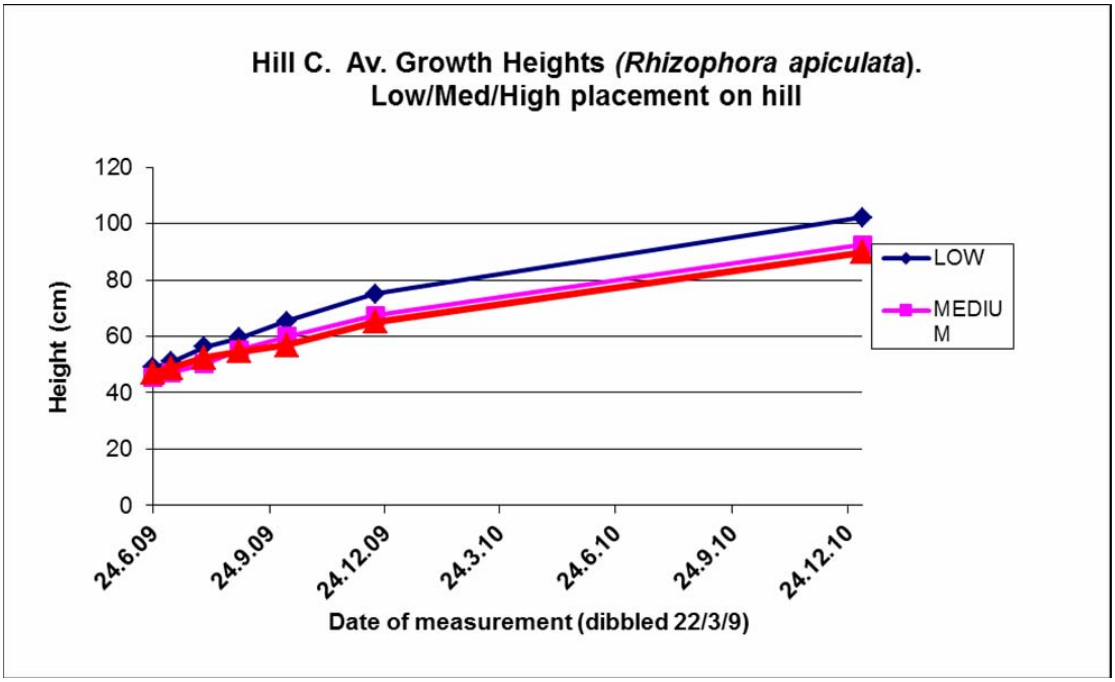

Figure 15. Plant growth on Hill C (*Rhizophora apiculata*)

This pattern of good growth on the hills is repeated for *Ceriops tagal* and *Bruguiera cylindrica. Nypa fruticans* has been slower to establish itself, and some of the Nypa hills have failed (eg X, R), but is still growing on Hill H and D, average height 90cms.

Figure 16. Hill C, Jan 2011, 22 months after dibbling

Growth Comparisons

To compare dibbling on hills to dibbling into unaltered pond floor,

[5] 'Dibbling' is a process of inserting a seed or propagule directly into the mud, rather than either scattering them on the water, or growing the seeds up in a nursery. This was done to keep all costs to a minimum, and was a technique a village conservation team could easily repeat.

four ‘Test Planting’ plots were established. TP1&2 received *R. apiculata* propagules. Much to everyone’s surprise both these plots thrived, despite very little other natural regeneration on the pond floor of any species.

Figure 17. Test Plot 1. *R. apiculata*. Jan 2011

Initially, the TP plants struggled up quickly to gain more height, at the expense of far fewer leaves, and leaves that were 50% of the size of those on Hill C. However, almost two years after the event, the leaf size difference has largely gone. Similarly, TP1 average height is 100cm (see Figure 17) and TP2 110cm to Hill C’s 95cm average, so now all about similar height.

Dibbling *Avicennia marina* on Hill P initially produced limited growth of approximate 10 plants from 50 propagules around the base of the hill. In the adjacent Test Planting plot 4 where 50 *A. marina* propagules were dibbled into the soil, only one plant survived. Eventually, all the *A. marina* died on hill and plot. Predation by crabs is suspected.

B. cylindrica was dibbled into Hills F and L. *Ceriops tagal* was installed in Hill E (see Figure 18). Both were dibbled into Test Plot 3. Sadly all the B. cylindrical on Hill L died, but both E (av. height 34cm) and F (av. height 60cm) survived. Compared to the Test Plot 3 dibbled directly into the pond floor, growth seems to be marginally easier on the hills.

Debris. A Possible Cause of Plant Death

Of constant concern was debris that floated into the pond from the outside. Hills E and L appeared to have sustained impact damage, and the tops of both hills had been cleared of dibbled plants, but the plants lower down the slopes surviving (see Figure 18). There was a lot of debris in the corner of the pond, and occasionally with a high tide and change of wind direction, this would shift to the other end (see Figure 19). It is suggested that this movement, and debris in general, killed off some of the plans, and also reduced the amount of successful natural regeneration within the pond.

Figure 18. Hill E. *Ceriops* missing from the top, but surviving around the base. Jan 2011.

Figure 19. Debris that had drifted into pond, Jan 2011. Largely Nypa palm midriffs.

Control Plots: Remained Empty

Seven 3x3m Control Plots were installed over the pond to monitor natural regeneration on the pond floor. Though the rods demarking the plots were eventually stolen, the plots remained empty.

Figure 20. Control Plot 2. 3x3m. 7 in total. Picture 2009

Almost No Natural Regeneration So Far

It was anticipated that with hill substrate at a more appropriate height for mangroves, some propagules and seeds would volunteer onto a hill and start to grow. The site is not propagule-limited: towards the end of the rainy season many seeds of several species arrive in the pond, (see Appendix V). At the top end of the pond, which was on average 30 cm higher than the lower parts of the pond near the sluice gate, many propagules were seen to start growing in the pond floor, but would die off after a few months. The reason for this die-off is not clear as pH was never more acidic than 6, and salinity always between 22-35ppt. Leaves on the new arrivals did not seem to be suffering unduly from pest damage, though there was a considerable amount of water scum deposited on the leaves. Thus a suggestion is that the regeneration at the top of the pond was also damaged by debris floating over the pond.

Figure 21. Hill E2 Jan 2011. Dibbled with *Sesuvium*, growing vigorously. Dibbled Oct 2009

Only one *Xylocarpus moluccensis* arrived on a hill (C) and set root. It is suggested that once a hill is produced, rain and inundation erode the hills' creviced surface, and in combination with a baking sun, produce smooth hard hills, which the seeds just cannot stick to. Sadly only one hill (E2, see Figure 21) was dibbled with *Sesuvium*, which might help to trap seeds as they float past, but as of Jan 2011 no species had taken hold within the *Sesuvium*.

APPENDIX IV – List of Visitors and Visiting Groups

Dr Balaji, Director of OMCAR, India May 2009

Prof JE Ong (ret.) and Stanley Tan from Malaysia, May 2009

IUCN Study tour from Cambodia, June 2009

Tom Hughes, Zen NGO, Malaysia, July 2009

Monica and Claudio Conti, Naucrates NGO, Italy July 2009

Dr Barry Blendell, Seagrass expert, July 2009

Ramsar Centre of Japan mixed tertiary education visit, Sept 2009

Ban Talay Nok (Phang Nga) Community EMR Training, Dec 2009

University of British Columbia Film Crew, Dec 2009

Local schools visit, Feb 2010

Final evaluation from by TEI and APFED team, Jan 2011

APPENDIX V – Species Already Growing in the Pond, Dibbled and Nearby

In the pond originally

Avicennia officinalis
Ceriops tagal
Excoecaria agallocha
Nypa fruticans
Rhizophora apiculata
R. mucronata
Sonneratia caseolaris

Further species in the immediate vicinity of the pond

Acanthus ilicifolius
Bruguiera cylindrica
Ceriops decandra
Dalbergia candenatensis
Finlaysonia maritime
Flagellaria indica
Pluchea indica
Melastoma villosum
Morinda elliptica
Scyphiphora hydrophyllacea

Introduced from further afield

Sesuvium portulacastrum
Xylocarpus granatum

APPENDIX VI - Additional Information Related To This Project

BLOG: Mangrove Rehabilitation in a Former Aquaculture Pond
http://mangroverehabilitation.blogspot.com/

MAP and WI-T have successfully used local labour to excavate another site in at Ban Talay Nok, Phang Nga province. The link goes to a short film of the project.
http://www.youtube.com/watch?v=qKL3KJE3Xsw

Wetlands International-Thailand – Demonstrating Ecological Mangrove Rehabilitation
http://thailand.wetlands.org/NEWSANDEVENT/NEWS/tabid/2109/articleType/ArticleView/articleId/2094/Default.aspx

Mangrove Action Project – Mangrove Restoration
http://mangroveactionproject.org/map-programs/restoration/mangrove-restoration

Ecological Mangrove Restoration (EMR) Yahoo e-group:
http://tech.groups.yahoo.com/group/emr_group/

Ecological Mangrove Restoration – Robin Lewis
http://www.mangroverestoration.com/

University of British Columbia journalism student's shrimp – mangrove documentary:
http://www.internationalreporting.org/shrimp/

Globe and Mail video: "The high environmental cost of global shrimp"
http://www.theglobeandmail.com/news/national/time-to-lead/global-food/the-high-environmental-cost-of-global-shrimp/article1806631/

ACKNOWLEDGEMENTS

Several people have worked hard to support this project, despite the difficulties. K' Donnapat Tamornsuwan, WI-T field officer has been unfailing in his willingness to work onsite, engage the local people and learn about mangroves. Jim Enright, K' Jaruwan 'Ning' Kaewmahanin and Roy 'Robin' Lewis of MAP have offered advice and help throughout, and ran an excellent schools project. Various people have come to dig, including K' Sunisa 'Aom' Phuangsri and Dr Balaji Vedharajan of OMCAR. Prof Sanit Aksornkoae and his team from TEI have watched over us. Finally, thank you to the people of Bang Lang Da for their quizzical good humour and support, and in particular Bang Don and his family.

All photography by Wetlands International staff, except for Google Earth images

Figure 22. Final visit by TEI staff and APFED members, MAP and WI