Developing Resilient Mangrove Forests on Tanakeke Island - South Sulawesi

Abstract: Mangrove forests on Tanakeke Island play an important role in terms of provision of timber products to the local community, as there are few to no alternatives for timber and fuel available to a majority of the island's population. Protection of the conservation values of Tanakeke's mangrove forest may be compatible with carefully planned local timber extraction, but mangrove timber harvest is not currently managed in a sustainable manner. Coupled with large-scale conversion to aquaculture, timber extraction has degraded the social, economic and ecological value of the islands mangrove resources. Together with Ecological Mangrove Rehabilitation, a plan for timber extraction should be prepared based upon careful assessment of the forest resource, coupled with community-led experiments on appropriate silviculture practices. This is to be attempted through the development of silviculture field schools together with groups of twenty-five community members.

There also exists the opportunity to increase the efficiency of timber post-harvest; such as improved fuelwood use and charcoal making. By validating the production function of the mangrove forest, an economic value to the timber resources is allocated which provides an incentive for management and protection of the resource. If community access and control of the resource is strengthened, income generated will benefit individuals, families and the community as a whole, while preserving ecological functions which also ensure the provision of economic goods and services to the community at-large. The management objective in this case is simply to validate community managed timber extraction, by basing it on empirical experiments, and demonstrating long-term improvements in mangrove and associated habitats.

This document was produced by Mangrove Action Project - Indonesia as part of the Restoring Coastal Livelihoods Program supported by Canadian International Development Agency (CIDA) and OXFAM - Great Britain. Published in Makassar, South Sulawesi, 2010.

Background

The island of Tanakeke is a coral atoll located off the southwestern tip of South Sulawesi Province. There are four major villages on the island, split into 21 sub-village with a population of around 6000 Makassar fisherfolk. Many of the 21 sub-villages exist directly in the inter-tidal zone, with no land to speak of. These communities rely on fresh water from sources on nearby islands, and build their houses on top of rubbish piles, covered over with drift wood and sand. Currently, the major livelihood option for the islanders is sea-weed farming, which is undertaken over seagrass beds and other sub-tidal habitats.

Coastal ecosystems around the island include the full complement of mangrove forests, tidal mudflats, seagrass beds, and coral reefs. All coastal ecosystems are degraded to varying degrees; coral reefs – by the hands of dynamite and cyanide fishers (an illegal industry centered in the small islands off the shore of Makassar) as well as over-fishing, seagrass beds due to the seaweed farms under which they grow, and mangroves due to conversion to aquaculture ponds and unregulated clear-felling for local use and sale to mainland Sulawesi.

Historically, around 1700 hectares of mangroves flourished in the intertidal zone of Tanakeke Island. The past few decades, and especially between 1995-2005, have seen the conversion of 1200 hectares of original mangrove forest into aquaculture ponds. These ponds were operated initially as shrimp ponds, before reverting to a mixture of fish and shrimp, and are now largely abandoned.

Figure A. Map of Takalar District with Tanakeke Visible

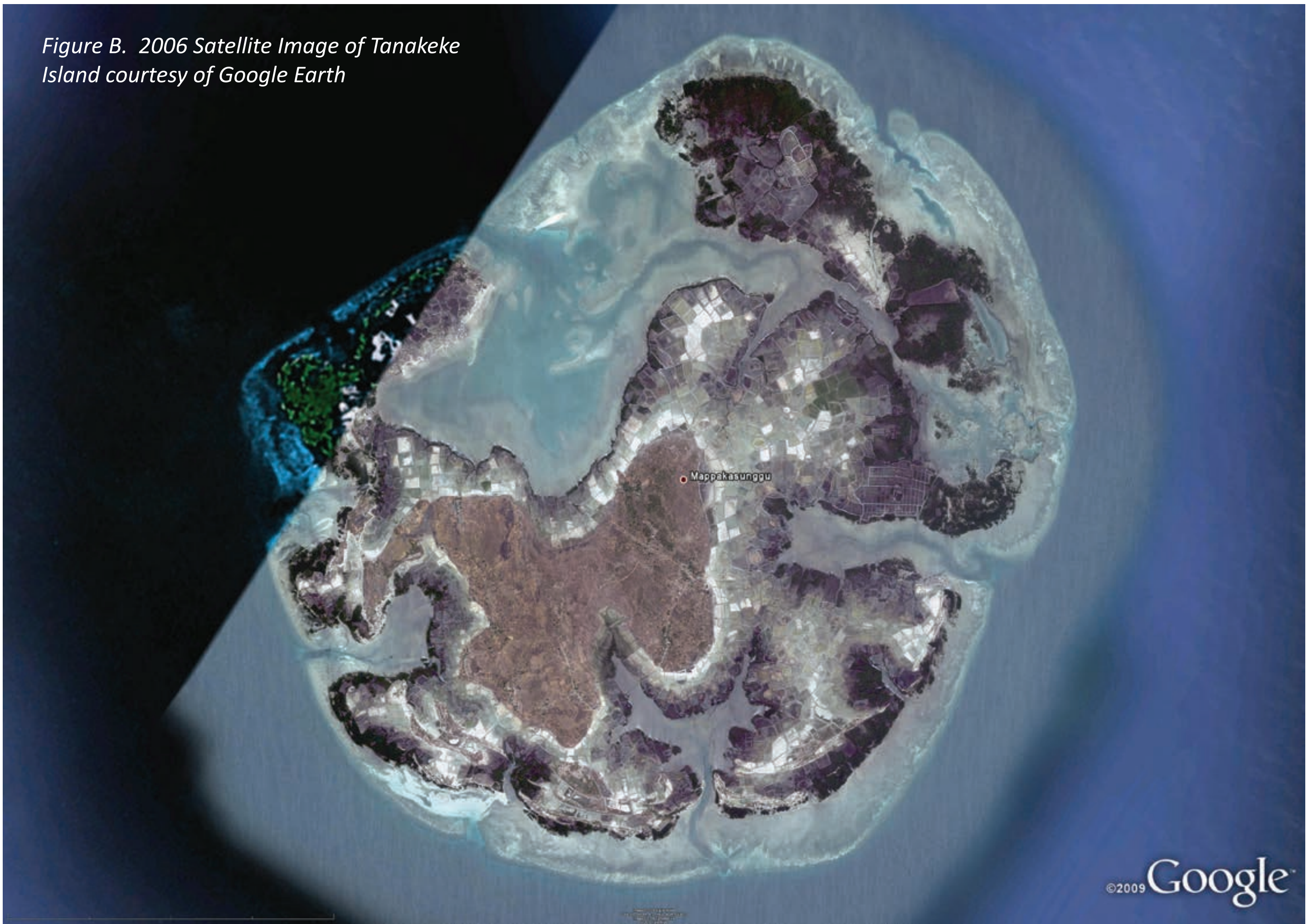

Figure B. 2006 Satellite Image of Tanakeke Island courtesy of Google Earth

Figure C. Excavated pond and solid dike wall of transmigration area on left (note coppiced Avicennia *forest in background), in comparison with slightly excavated pond and hand built walls on the right. Hydrological rehabilitation of the pond on the right is significantly easier and cheaper than the transmigration built pond.*

Around 800 hectares worth of ponds are owned by local community members with some remote ownership (community members or outsiders living on the provincial mainland), while 400 hectares were developed by the department of transmigration. Many of the latter ponds are still being operated by transmigrants and some local community members. These ponds were excavated more deeply, with strongly built dike walls, and have withstood physical degradation from tidal flow (see Fig. C). Community built ponds, on the other hand, have much shallower bottoms, and less sturdy dike walls. Without annual maintenance, the dike walls break down, the pond bottoms silt up, and mangroves begin again to take root inside of the ponds.

The forest at Tanakeke is considered a carbonate mangrove forest (Hutchings and Saenger, 1987), dominated by sandy substrate of reefal origin, low in organic matter. This is somewhat similar to the over-wash forest described by Lugo and Snedaker in their 1974 classification (see Fig. E), but Tanakeke Island mangroves are not inundated daily by each high tide, but rather only by spring and high gravitational tides (Tanakeke Island tides are predominantly strictly dirunal, i.e. one high and one low tide per day). In the past, there were likely 20-25 species of true mangroves present in the area, and remnants of 18 species are evidenced today (Figure D). Where mangrove forests currently occur on the island, they are predominantly monospecific stands of one of two *Rhizophora* species (*R. apiculata* and *R. stylosa*). This came about for several reasons, both natural and anthropogenic;

- Community preference for Rhizophora trees, due to value as timber and perceived value as fisheries habitat. This has led to mangrove clear-felling for Rhizophora timber, and clear felling of alternate species such as Avicennia marina. In either case, clear-felling is usually followed-up by planting of 10 Rhizophora propagules for each tree felled, leading to an overly-dense, dwarfed monospecific stand of trees.
- Loss of lower mangrove (adjacent to sub-tidal zone) – due to clear felling and difficulty of replanting due to high velocity currents and waves.
- Lack of usual back-mangrove species due to lack of back mangrove area/hinterland/terrestrial area – as Tanakeke is an atoll.

Latin Name	Local Name
1. *Acanthus ilicifolius*	kali kali
2. *Acanthus ebracteatus*	kali kali
3. *Avicennia alba*	api api
4. *Avicennia marina*	api api
5. *Bruguiera gymnorrhiza*	tancang
6. *Bruguiera parviflora*	
7. *Ceriops decandra*	tenggar
8. *Ceriops tagal*	tenggar
9. *Exoecaria agallocha*	buta buta
10. *Lumnitzera racemosa*	
11. *Pemphis acidula*	sengigi
12. *Rhizophora apiculata*	bakau
13. *Rhizophora mucronata*	bakau
14. *Rhizophora stylosa*	bakau seribu
15. *Sonneratia alba*	perapat
16. *Sonneratia caseolaris*	bogem
17. *Sonneratia ovata*	perapat
18. *Xylocarpus moluccensis*	kira kira

Figure C. Species Currently Present on Tanakeke Island

Fig D. Classification of mangrove environments using physiographic characteristics (in Ecology of Indonesian Seas, adapted from Lugo and Snedaker, 1974)

Ecological Mangrove Rehabilitation on Tanakeke

A major goal of the Restoring Coastal Livelihoods Project (known as "RCL," supported by CIDA and OXFAM-GB) is the rehabilitation of 500 hectares of mangrove forest in South Sulawesi between 2010-2014. MAP– Indonesia, uses a 6-step method known as Ecological Mangrove Rehabilitation (see Figure E), to reforest degraded mangrove habitats in full partnership with local stakeholders. This process has been co-developed by MAP and the method's originator, Roy Robin Lewis of Florida in recent years for demonstration in several countries in Asia, including Indonesia. For more information on the 6-step EMR method see; www.mangroverestoration.com, or www.mangroveactionproject.org.

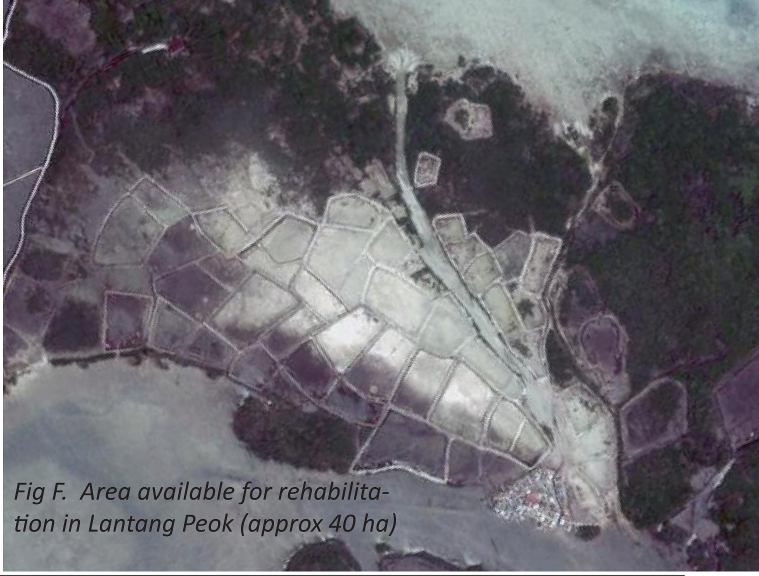

Fig F. Area available for rehabilitation in Lantang Peok (approx 40 ha)

Figure E. 6 Steps to Successful Ecological Mangrove Rehabilitation (EMR):

Work together with local communities, NGOs and government to:

1. Understand both the individual species and community ecology of the naturally occurring mangrove species at the site, paying particular attention to patterns of reproduction, distribution, and successful seedling establish ment;
2. Understand the normal hydrology that controls the distribution and successful establishment and growth of targeted mangrove species;
3. Assess the modifications of the mangrove environment that occurred and that currently prevent natural secondary succession;
4. Select appropriate restoration areas through application of Steps 1-3, above, that are both likely to succeed in rehabilitating a forest ecosystem and are cost effective. Consider the available labor to carry out the projects, including adequate monitoring of their progress toward meeting quantitative goals established prior to restoration. This step includes resolving land ownership/use issues necessary for ensuring long-term access to and conservation of the site;
5. Design the restoration program at appropriate sites selected in Step 4, above, to restore the appropriate hydrology and utilize natural volunteer mangrove recruitment for natural plant establishment;
6. Utilize actual planting of propagules or seedlings only after determining through Steps 1-5, above, that natural recruitment will not provide the quantity of successfully established seedlings, rate of stabilization, or rate of growth as required for project success.

Local communities of Tanakeke Island learned of EMR through MAP-Indonesia assessments as well as attendance of a 4 day workshop on mangrove rehabilitation (report available on RCL and MAP websites) held at the Environmental Education Center of Puntondo (PPLH-Puntondo, located - as is Tanakeke - in the district of Takalar). The entire sub-village of Lantang Peok has agreed to attempt the rehabilitation of their abandoned shrimp ponds (totaling 30 hectares and directly impacting the recovery of additional 10 hectares) together with MAP-Indonesia early in 2011 (see Figure F). Three additional sub-villages have pledged their abandoned ponds for rehabilitation in subsequent years. One of these, Rewataya, is especially desperate to rehabilitated their ponds. The ponds were developed only 6 years ago, and the sub-village has experienced increasingly extreme tidal flooding. Their remnant mangrove buffer between their ponds, their village and the sea, is a paltry 1-2 rows of trees thick. They have already attempted to rehabilitate their own ponds by direct planting, as well as planting out to see, but their efforts are not satisfactory. A separate report on Ecological Mangrove Rehabilitation specifically for Tanakeke Island is being created and will be made available when finished on the RCL and MAP websites.

In short, the six steps of EMR have been undertaken by MAP with full involvement of local community and additional project partners, leading to a rehabilitation and monitoring plan. The plan involves the strategic breaching of dike walls, to encourage tidal flow through naturally shaped, meandering creeks, throughout the 30 contiguous hectares of abandoned ponds. As derelict ponds commonly experience natural re-vegetation by mangroves, it is expected that natural revegetation will be adequate to rehabilitate the area. Communities are interested in planting some areas, to compare the results of plantings versus natural revegetation. MAP-Indonesia will also reintroduce historically-lost species of mangroves, by gathering a variety of mangrove fruits and seeds from other parts of Sulawesi, and releasing these propagules into the rehabilitation area on high tides. Monitoring of mangrove rehabilitation success/failure will take place quarterly in the initial year after rehabilitation, and then annual beyond the duration of the RCL project.

Management Issues

As part of the planning process for rehabilitation, community members are determining how the area is to be managed into the future. Women and men alike from Lantang Peok have decided that improved management of their mangrove resources, both current, as well as in the future rehabilitation area, is necessary. The community is being led in determining management practices by PUKAT – a community based organization with members from all four villages and all 21 subvillages on Tanakeke, including several village and sub-village heads. Together with PUKAT – the community is determined to build on existing mangrove management practices, while at the same time learning new techniques to improve the health and value of their mangrove resources.

Existing traditional mangrove management regulations include;

❍ Living mangroves can only be cut by the owner (or family that has a traditional claim on the mangrove forest area in question).

❍When a living mangrove is cut – five to ten mangroves (always Rhizophora) are planted back.

❍Dead mangroves can be harvested for firewood by anyone in the community at-large, without need for permission by traditional "land" owner.

❍All fisheries products from a mangrove area are open-access to the community at-large.

❍ All non-timber forest products (honey, fruit, etc.) are open-access to the community at-large.

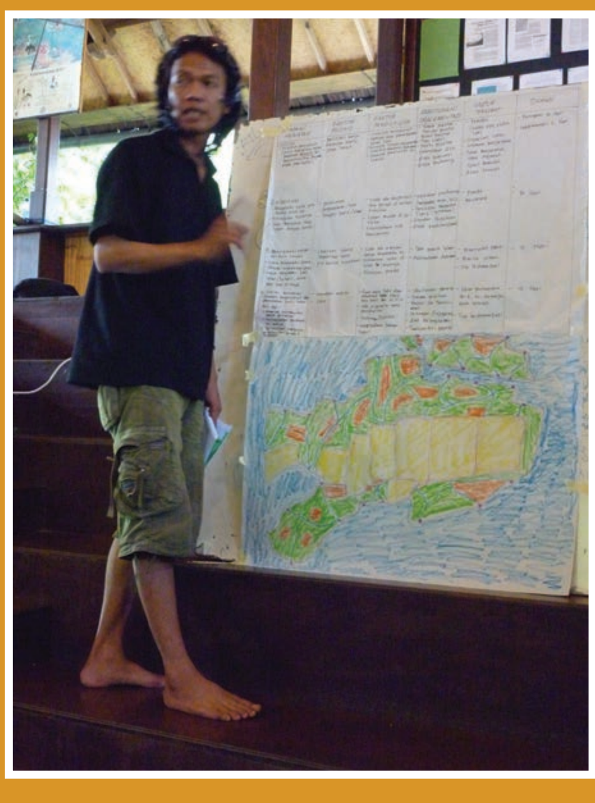

Figure G. Field work and planning during an EMR workshop at the Environmental Education Center of Puntondo.

❍Hutan Pengandrian – a village communally owned forest – where community members could take timber during financially difficult times. This needed to be reported to the Galaran – a village board. This is uncommon now, as most mangrove areas are under individual use/ownership rights.

These traditional regulations have been written up formally in a Perdes in 2004 in the village of Mattirobaji and only covers the island of Bauluang. There is also a document of mutual understanding (Dokumen Kesepahaman) for the village of Macinibaji, but this was never formalized into a Perdes. It is the intent of the RCL project, to build on traditional mangrove management, vis-à-vis fisherfolk centered action research, to assist community members in incorporating new information with traditional regulations, and to formalize these updated regulations at various government levels up to the Kecamatan or District level. The mechanism to learn new mangrove management skills and knowledge, and to determine best practices will be a form of Coastal Field School (see RCL website or MAP website on Coastal Field School) focusing on the silvicultural management of mangrove timber.

These traditional regulations have been written up formally in a *Perdes* in 2004 in the village of Mattirobaji and only covers the island of Bauluang. There is also a document of mutual understanding (*Dokumen Kesepahaman*) for the village of Macinibaji, but this was never formalized into a *Perdes*. It is the intent of the RCL project, to build on traditional mangrove management, vis-à-vis fisherfolk centered action research, to assist community members

in incorporating new information with traditional regulations, and to formalize these updated regulations at various government levels up to the Kecamatan or District level. The mechanism to learn new mangrove management skills and knowledge, and to determine best practices will be a form of Coastal Field School (see RCL website or MAP website on Coastal Field School) focusing on the silvicultural management of mangrove timber.

Silviculture Field School

Field Schools were first developed by the FAO in conjunction with practitioners of community based integrated pest management (Community IPM). Initial field schools engaged groups of 25 rice farmers, in actively researching a rice crop for an entire cropping cycle. Experiments on soils, soil nutrient management, irrigation regimes and integrated pest management were run by the farmers themselves, week to week. The goals of the farmer field school - to grow a healthy crop, to develop critical thinking skills amongst participants, to reduce dependence on external inputs – are a valid today as when developed 25 years ago. Field schools have since branched into many disciplines, from Agroforestry to Micro-finance, yet the core principle of learner centered education remains constant.

The RCL project is striving to bring field school methodology to the coastal area – with a focus on inter-tidal resource management. Two types of field schools are being run;

Type A – focuses on improved management of a natural resource,
Type B – focuses on post-harvest processing and development of micro-enterprise and small business.

Numerous villagers on Tanakeke Island utilize mangrove wood, for individual use as well as commercial sale. This will be discussed in more detail in the next section. Silviculture Field School, will engage twenty-five female and male participants in developing mangrove forest management and harvesting practices, based on the results of their own experiments. Participants will first be involved in a gendered analysis of current mangrove management and felling practices, to uncover the different roles men and women play with regards to these livelihood activities. Next, participants will learn about the scientific method, before developing scientific experiments mostly revolving around harvesting regimes of mangroves. Experimental and control plots will be chosen, and a comparison between clear-felling, group felling and selective cutting will take place. The group will try different densities of cutting (1 out of 20 trees, 1: 10, 1:5, 1:2, 1:1), coppicing experiments (possible with *Avicennia* spp. and *Sonneratia* spp.,. etc. The effects of these felling regimes on growth of remaining trees, re-establishment of new mangroves, and even indicator fauna will be studied as well. Conclusions based on the findings of these experiments will be used to help develop management regulations for various forest types on the island.

Figure H. Tidal creeks are highly valued by local fisherfolk, as places to catch wild shrimp and other fisheries products, nursed by the mangroves.

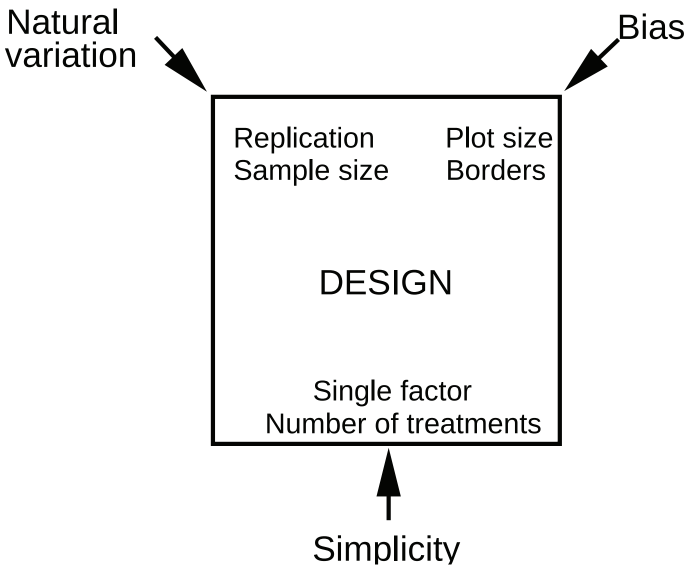

Figure I, Silviculture Study Design

The design of a study is influenced by three principles. An understanding of *Natural Variation* helps foresters decide on the need for replication and on the sample size. An understanding of *Bias* helps participants to plan the appropriate plot size and border zone. Finally, the principle of *Simplicity* helps to reduce the design to the essentials only, with a single factor and a limited number of treatments.

Building Social, Economic & Ecological Resilience

Ecosystem resilience is the capacity of an ecosystem to tolerate disturbance without collapsing into a qualitatively different state that is controlled by a different set of processes. A resilient ecosystem can withstand shocks and rebuild itself when necessary. Resilience in social systems has the added capacity of humans to anticipate and plan for the future. Humans are part of the natural world. We depend on ecological systems for our survival and we continuously impact the ecosystems in which we live from the local to global scale. Resilience is a property of these linked social-ecological systems (SES). "Resilience" as applied to ecosystems, or to integrated systems of people and the natural environment, has three defining characteristics:

- The amount of change the system can undergo and still retain the same controls on function and structure
- The degree to which the system is capable of self-organization
- The ability to build and increase the capacity for learning and adaptation

For decades, the community of Tanakeke has been reliant on the use of their mangroves for both goods and services. Strictly, with regards to timber, there are no other viable timber options available to most communities aside from mangrove timber. Mangrove wood has a variety of local uses on the island (Figure J);

- fuelwood
- charcoal (for commercial sale to mainland)
- housing and pier construction
- fish traps
- seaweed farming poles

From a *social perspective*, there already exist clear rules, which take into account issues of equity, regarding mangrove use. For instance, familial ownership of a forest area dictates who may harvest timber, while dead trees are available as an open access resource. Social contrivances alone, however, have not saved the mangrove forest, as external factors such as the trend of aquaculture development or the economic necessity for clear-cutting, have severely degraded a mangrove resource which has value to the community at-large. Indeed, fisheries products and non-timber forest products in mangrove areas, still remain open access, but the degraded condition of the islands mangroves means that there is less of economic value to go around. Whereas a healthy mangrove forest is calculated to contribute between $9900 – 20,000 per hectare per year, these values decrease significantly with mangrove forest degradation. Social systems, including governance (internal and with external stakeholders) need to be enhanced to ensure that a broad swath of community have access to and control over mangrove resource of high value. Additional considerations that need to be underscored are that the most impoverished and vulnerable community members, and especially women,

Figure J. Mangrove timber uses on Tanakeke Island.

From Top to Bottom; Fuelwood, Charcoal, Housing and Pier Construction, Fish Traps, Seaweed Farming Poles.

Figure K. As key users of mangrove wood, women's roles in decision making need to be strengthened,

need to be assisted in developing roles that lead to increased access to and control over mangrove resources.

From an *economic perspective*, we need to look at both timber and non-timber forest products separately. There is a trend on the island of less total timber available over time, and timber of lower quality (smaller diameter). This is largely the result of forestry practices. To say that forestry practices are poor is an improper assumption, for without some form of social protection and ecological understanding, the resource might be totally decimated, whereas the island still maintains around 500 hectares of decently functioning mangrove forest. It is hoped that lessons learned during Silviculture Field School will impact on mangrove forest management as a whole, discovering ways in which to harvest wood without degraded major system functions (fisheries habitat, filtration, storm and surge protection, provision of non-timber and timber products, etc.).

Once harvested, each product stream or use for timber can be looked at together with the community, to learn of potential efficiencies in terms of post-harvest processing that may help in terms of cost savings, increased earnings, ecological improvements and improved social value. These post-harvest processing strategies will be explored during the second phase of coastal field school (Type B). Examples of potential post-harvest processing strategies and issues are provided on the following pages.

From an ecological perspective, the mangroves of Tanakeke should not be compared, in terms of structure or biomass, to mangrove types associated with mainland features such as basin or riverine mangroves. The lack of organic matter restricts growth potential. Species composition is also restricted due to the conspicuous lack of a back mangrove and interface with hinterland, as many mangrove species and especially associates are normally found in such a zone.

Human impact on the mangroves has taken place both directly and indirectly due to the large-scale construction of aquaculture ponds. The ponds themselves have replaced vast areas of mangroves, limiting the areas total productivity and ecological diversity as a whole. The intricate system of dikes and canals, has also disrupted normal hydrologic flows in existing mangrove areas, degrading their potential as well. Some areas are unnaturally cut off from tidal inundation, and develop highly saline soils and reducing growth potential. Other areas are exhibit poor drainage, and mangrove species suffer from waterlogged sediment, high in hydrogen sulfide from anaerobic processes. A reduction in species type, and primary production, decreases the value and complexity of the resource.

Reduction of mangrove coverage due to conversion to ponds, increases human pressure on existing mangrove forests for timber and non-timber forest products. All of

Figure L. Clear cutting just inside a tidal creek, with natural revegetation apparent. How does this individualistic practice impact the value of mangrove goods and services to the public at large?

Example A) Efficient Fuelwood Use

Fuelwood bundles of *Rhizpohora* wood are sold locally on the island for 5000 rupiah. Ten researchers from MAP, engaged in a participatory ecology survey, used three of these bundles a day to grill fish and cook rice for their 20 day survey. To grill fish, a pile of wood is burned down into embers, on which the fish are cooked for an average of 5-10 minutes over an open fire. Likewise, when boiling water or cooking in a pot, mangrove fuel is burnt inefficiently over an open fire, usually set on three stones or bricks. A MAP consultant from the Indonesian Improved Cookstove Network feels that a 50-67% efficiency in fuel-wood use can be achieved by designing fuel efficient cookstoves and grills with village women.

Fuelwood on Tanakeke Island is consumed daily for cooking fish, rice and boiling water. Currently, all methods of cooking are performed over an open fire, a highly inefficient practice.

More than 50 woman in Lantang Peok village are interested in learning how to make and use fuel-efficient cookstoves.

JKTI, the Indonesian Improved Cookstove Working Group, holds trainings like this one pictured in Tiwoho Village, North Sulawesi, where groups of women develop portable and permanent, fuel efficient cookstoves out of local materials. Groups of up to 25 gather once a week after training, to make cookstoves for fellow group members in a round-robin fashion. Fuelwood saving can be significant, as well as time saved during cooking.

Example B) Improved Charcoal Making

Traditional charcoal production on Tanakeke Island is an inefficient process in terms of wood consumption. The simple technology of low-oxygen combustion in a shallow pit dug in the ground produces only 10 kg of charcoal for every 100kg of dry wood carbonized. Various efficient processes exist, such as kilns constructed out of used oil drums, or professionally designed earthen kilns, but these technologies need to be assessed to determine their appropriateness (are local materials available to make and repair the kilns, are the kilns too costly to build? to operate? is the end product worth the extra effort?).

MAP-Indonesia is linked to a charcoal production network through Yayasan Dian Tama of Kalimantan who offer extension services as well as 12 and 17 day trainings in kiln building, charcoal production, charcoal vinegar production and exporting charcoal products. In terms of marketing, the majority of charcoal is purchased by agents on the mainland and used directly in Makassar for grilling specialty foods. One of these users (Sop Konro Karebosi – Jl. Lompo Batang) commented that mangrove charcoal is sometimes difficult to source, and diameter and quality are variable and decreasing over time. Significant marketing opportunities exist for a variety of mangrove charcoal products, the demand of which can be increased further by proving linkage to sustainable management.

Continued assessment of charcoal making on the island is needed to determine the appropriate level of intervention in this activity – which can impact the health of mangrove resources, as well as the economy of some of the poorest villagers on the island.

Top Left) Current charcoal making practice in Tompotanah, Tanakeke Island; Bottom Left) Making high quality charcoal in a used oil drum at Yayasan Dian Desa, Yogyakarta; Top Right) Mangrove Charcoal production at Malaysia's Matang Mangrove Forest Reserve - in operation over 100 years, Bottom Right) Various value added products made from mangrove charcoal and charcoal vinegar at the Matang Reserve.

the anthropogenic forces act to decrease the resilience of the system. The loss of most mangrove species, and even habitat types, reduces the complexity of the system, also reducing redundancy of ecological roles. This reduces the ability of the ecosystem as a whole to withstand shocks and disturbances, both sporadic (earthquakes, storms, etc.) and incremental (sea-level rise, ocean temperature change, changes in rainfall patterns, etc.).

Clearly, to have some mangrove trees present as a “buffer” is not enough, as the community of Rewataya is experiencing. Minimally, whole mangrove systems, with all native representative species and normal hydrologic flows need to be valued by the Tanakeke Islanders, as high value ecological services can only be derived from whole ecosystems, not individual trees.

There is no need to close this thought piece with grandiose generalizations. It is enough to note that the local communities of Tanakeke value their mangroves, but they do so amidst many other pressures and diversions. It is clear also, that communities are interested in both personal sacrifice (financial, time) to restore their mangroves. What is unclear, is whether or not the numerous individuals, groups, organizations and institutions who are directly related to the fate of the mangroves of Tanakeke, will be able to coordinate effectively and to learn from past mistakes and current trials in order to achieve a more resilient future for the mangroves and the fisherfolk who rely on their goods and services. It is not enough to consider only short term economic pressures, traditional social contrivances, or the mere presence of some mangroves, but rather to understand how social, economic and ecological factors interact, and to manage the mangrove system to capitalize on potential synergies of these three interdependent sub-systems.

Fig M. Discussing the affect of current mangrove management practices on forest production with PhD Jim Davie (top), a Participatory Bioodiveristy Competition helped collect baseline data for future monitoring of ecosystem productivity after mangrove rehabilitation and improved management (middle and bottom).

Endnotes

i Silviculture is the practice of controlling the establishment, growth, composition, health, and quality of forests to meet diverse needs and values of the many landowners, societies and cultures.

ii www.resalliance.org/576.php

iii Constanza et Al, 1997, Ronnback, 1999, 2000

References

Hutchings, P. and Saenger, P. (1987). *Ecology of Mangroves*. University of Queensland Press, St. Lucia, 388 pp.

Lugo, A.E. and Snedaker, S.C. (1974). The ecology of mangroves. *Ann. Rev. Ecol. Syst*. 5; 39-64

Thom, B. G. (1982). Mangrove ecology - A geomorpho logical perspective. In: Clough, B.F. (ed), *Mangrove Ecosystems in Australia; Structure, function and management*. Australian Institute of Marine Science and Australian National University Press, Canberra, Australia, pp. 3-17.