Rignolda Djamaluddin

Cost Effective Mangrove Rehabilitation Focusing on Restoration of Hydrology

The total mangrove areas in the Province of North Sulawesi has been approximated at 4,333 ha. Some 590 ha of these areas had been converted into shrimp ponds including an approximate 20 ha disused shrimp pond complex near the village of Tiwoho, Bunaken National Park, North Sulawesi-Indonesia. Part of these 20 ha hectares were selected to have been prioritized for demonstrating a cost effective mangrove rehabilitation focusing on the restoration of hydrology.

Some of the reasons for selection of this site include:

a) strong community involvement in mangrove conservation,

b) proximity to the Coastal Community Resource Center making the site highly accessible for study tours (a good demonstration site),

c) proximity to source of healthy and diverse mangrove seeds/propagules,

d) relative ease of hydrological rehabilitation,

e) status of land ownership as a public group ownership for community of Tiwoho.

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Town/Region	Bunaken National Park, North Sulawesi
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Rufford Small Grant

(for Nature Conservation)

In association with the Whitley Laing Foundation

Cost-Effective Mangrove Rehabilitation Focusing on Restoration of Hydrology

1. Description of Project

The total mangrove areas in the Province of North Sulawesi has been approximated at 4,333 ha. Some 590 ha of these areas had been converted into shrimp ponds including an approximate 20 ha disused shrimp pond complex near the village of Tiwoho, Bunaken National Park, North Sulawesi-Indonesia. Part of these 20 ha hectares were selected to have been prioritized for demonstrating a cost effective mangrove rehabilitation focusing on the restoration of hydrology. Some of the reasons for selection of this site include: a) strong community involvement in mangrove conservation, b) proximity to the Coastal Community Resource Center making the site highly accessible for study tours (a good demonstration site), c) proximity to source of healthy and diverse mangrove seeds/propagules, d) relative ease of hydrological rehabilitation, e) status of land ownership as a public group ownership for community of Tiwoho.

Many mangrove rehabilitation projects in Indonesia have experienced technical failure due to the incorrect assumption that degraded coastal lands that were once inhabited by mangroves can be re-established by simply replanting mangrove seedlings. The demonstration site of mangrove rehabilitation at Tiwoho had previously been experienced this technical failure after three to four times replanting undertaken by the Rehabilitation Office of Local Government working with communities. During November 2002 to May 2003 a study focused on the evaluation of the forest ecology and individual ecology of mangrove species, and the evaluation of physical conditions of the project site had been finalized. Result of this study indicated that natural mangrove seedlings are available in the mangrove, however the physical conditions (e.g. elevation, tidal circulation and inundation) of the site have been significantly changed due to the construction of shrimp ponds. Findings of the study are reported separately in Djamaluddin (2002) and Kabes (2003), and these are used as the basic information for physical rehabilitation of the site that was started on November 2004 with the support of Rufford Small Grand.

In order to rehabilitate the hydrological system, two main physical works had been carried out: (1) the closing up of two main tidal channels, and (2) the opening of inter-pond channels. Artificial plantation was also conducted at certain site where natural mangrove seedlings are difficult to establish. As a part of the project, this process of physical rehabilitation has been presented in the

2. Objectives

The present mangroves rehabilitation program at Tiwoho is designed for two main goals, as follows:

- to work together with local communities, NGOs and local government agencies to rehabilitate mangrove ecosystem in previously prioritized disused shrimp ponds,
- to demonstrate new cost-effective mangrove rehabilitation protocol in Indonesia highlighting the importance of hydrological rehabilitation.

3. Method

3.1 Map of the site

Figure 1 and 2 depict the study site and the 20 ha abandoned mangrove areas including the location of sampling points, and observed profiles taken for physical assessment of the site. As can be seen from these figures, part of the area had been converted into shrimp ponds indicated by the presence of dikes, artificial tidal channels, and six to seven remaining shrimp ponds (locally called *petak*). The remaining two open areas to the east and to the west of the location were cleared but were never converted to shrimp ponds.

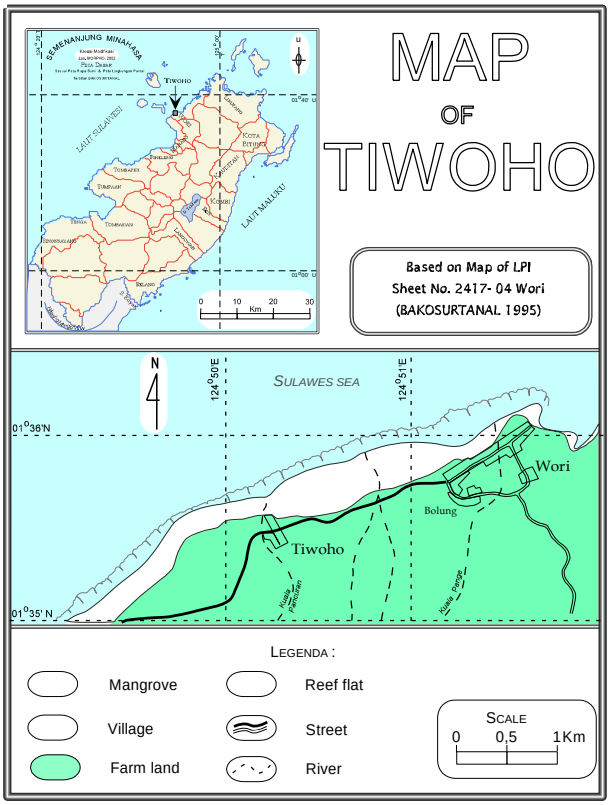

Figure 1. Map of mangroves at Tiwoho including the project site location

3.2 Rehabilitation Techniques

In brief, the rehabilitation technique applied at Tiwoho follows the five important steps suggested by Lewis and Marshall (1997), as follows:

1. Understand the pattern of reproduction, propagule distribution, and successful seedling establishment.
2. Understand the normal hydrology pattern that regulates the distribution, establishment and growth of the targeted mangrove species.
3. Assess the modification of the previous mangrove environment that occurred and currently prevent natural secondary succession.
4. Design the restoration program to initially restore the appropriate hydrology and utilize natural volunteer mangrove propagules recruitment for plant establishment.
5. Utilize actual planting of propagules, collected seedlings, or cultivated seedlings after determining steps 1-5 that natural recruitment will not provide the quantity of successfully established seedlings, rate of stabilization, or rate of growth of saplings established as goals for the restoration project,

Steps 1 – 3 listed above were included in the previous study that had been finalized in May 2003. The subsequent steps have been started on November 2004 for four months. All rehabilitation processes were documented into CD-ROM.

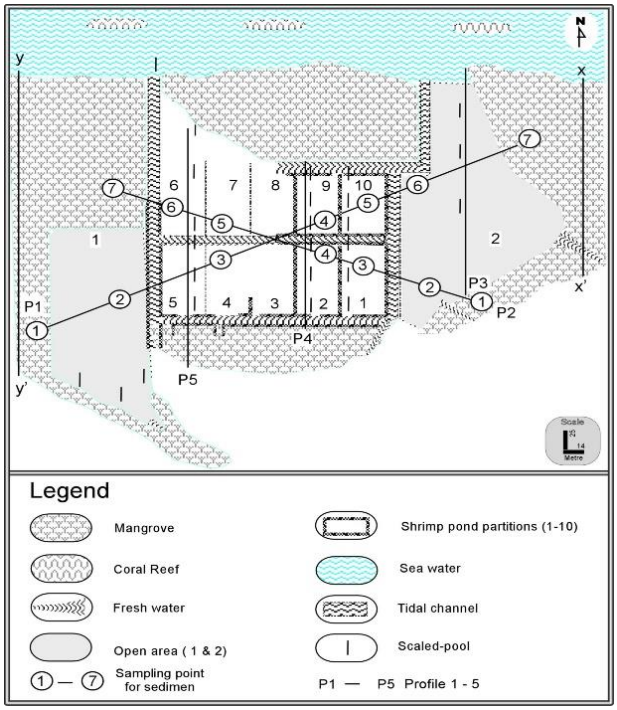

Figure 2. Map of the project site including sampling points for physical assessment

3.3 Team work

The following is the structure of the project's team work:

- Coordinator : DR. Rignolda Djamaluddin
- Supporting Team : KELOLA Staffs (6 people), Bunaken National Park Office (2 people); Students from Faculty of Fisheries and Marine Science-Unsrat (3 students), MPA-Zooxanthellae (5 people), the leader of Tiwoho Village
- Local workers/villagers: 32 people

4. Results and Discussion

4.1 Hydrological Change

Previous study indicated that the east tidal channel plays a significant role for the circulation of seawater during spring and ebb tides, and this is expected to be one of key factors that had changed the hydrological condition of the site. Physical work was conducted to close off this channel by blocking off two main parts of the channels as indicated in Figure 3a,b. It is predicted that in the following few months sediments come from the land behind will be deposited into deeper part of the channel which was not blocked. These sediments will then increase the bottom of the channel to certain level. It is very clear in the field that incoming seawater usually enters through the east channel is effectively blocked by the seaward barrier. The seawater is then distributed to the restoration site after the spring tide has reached the level at about the same as the present high of the channel. During the ebb tide, seawater is restrained by the barriers before leaving the restoration site. At the low tide, the area of restoration is inundated meanwhile the freshwater is still blocked in the deeper part of the channel and materials are deposited.

(a) (b)

Figure 3. Barriers at the east channel: (a) seaward location (b) middle location.

Before the site was rehabilitated, the freshwater came from upland continuously flowed through the landward channel that connected to the east channel. There was only limited number of freshwater entered the middle part of the site. This landward channel was blocked at three different points (Figure 4a,b,c) to make access for freshwater to enter the restoration site from behind. The intrusion of freshwater into the restoration site will then reduce the usually high soil salinity at high locations.

(a) (b) (c)

Figure 4. The closing of landward channel at three different points: (a) channel edge connects to the east channel, (b) middle part, (c) near the west channel

A little change was made to the west channel. The west wall of the channel was opened at two different points (Figure 5 a,b) to give access for tidal water to flow over the nearest artificial plantation area.

(a) (b)

Figure 5. Openings on the west channel at two points: (a) upper side and (b)

The remaining tidal channel that connected to the east channel, and separate the restoration site just in the middle was totally closed. The closing of this channel is to stop seawater entering and leaving the restoration site through the east channel. Then, accesses of seawater to flow from pond to pond in the middle part of the site was made by opening a number of dikes along the middle channel (Figure 6).

Figure 6. Opening at the two locations of the middle channel

The presence of high dikes had restricted the circulation of seawater. Physical changes had been made by levering dikes at certain points to give access for seawater to move from pond to pond (Figure 7). It was indicated in the field that the circulation of seawater during spring and ebb tides have changed significantly after the creation of inter-ponds canals. Ponds with about the same high are inundated at almost the same time, and no ponds were flooded when low tide.

Figure 7. Inter-ponds canals to give access for seawater to move from

4.2 Artificial Plantation

Field observation indicates that there are two locations (seaward side of plantation location and the location to the east of east channel) where natural mangrove seedlings are difficult to grow. The change in soil conditions (becoming harder and less organic compounds) have been expected to be the main factor of this secondary succession failure. In order to alter the present soil conditions, a little trick was made by growing up of 150 mangrove saplings of *Rhizophora apiculata* and 50 saplings of *Ceriops tagal* on these locations.

4.3 Secondary Succession within Eight Months

Three months after the rehabilitation a few number of mangrove seedlings of two species (*Avicennia marina* and *Sonneratia alba*) were found at certain points within the rehabilitation site. Seedlings of *A. marina* are growing near and around their parent trees on sandy substrate. At almost the same time seedlings of *S. alba* also established on the same growing points of *A. marina* and on relatively open areas with sandy substrate. Now, by the eighth months of the rehabilitation process there are more and more seedlings of both species establishing. The physical change made is expected to have supported natural establishment on the rehabilitated site that has initiated by *A. marina* and *S. alba,* although it may not be optimal. Other species (*Rhizophora apiculata*) seem to have a problem in their establishment, but this may correlate to the availability of mature propagules that are not available during observation time.

5. Recommendation

Physical rehabilitation of the site had been finalized. The successful of secondary succession of mangrove species on this site does not depend only on hydrological rehabilitation made. The presence of mangrove logs within the site can kill new established mangrove seedlings. The site has to be clear from mangrove logs. Human activities are others factors that may have an effect on the establishment of new mangrove species. In solving these problems, a village ordinance of "community-based mangrove management" at Tiwoho, which is now still in a draft form, has to be finalized. Within the restoration site there are five locations situated for monitoring and evaluation of mangrove species establishment. These locations have to be monitored and evaluated at three months intervals.

For further development, a program of mangrove education which is now integrated into local subject of course at preliminary schools has to be continued. At the university level, students can use this project site as a field laboratory of mangrove biology and taxonomy, and a demonstration site for mangrove rehabilitation focusing on hydrological alteration to support secondary succession of mangrove species. Eco-tourism is also potential to be developed, and this can be started with the construction of walk ways that connect the mangrove centre (*Daseng Lolaro*) and the mangrove forest including areas of artificial plantation and hydrological rehabilitation.