Intervention Strategy against Abrasion within the Framework of Coastal Management in Paojepe, Wajo, South Sulawesi

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ABSTRACT

The study conducted in 1999 2001 has aimed to solve the abrasion problem at Paojepe coast, Wajo, South Sulawesi. This study has elucidated some research findings. Firstly, the damage of the coastal environment in Paojepe has reached such a critical stage that it urgently calls for measures to address and overcome the problems. The undeniable fact under discussion here includes depletion of the mangrove forest, rapid coastal abrasion, and decrease in the coastal biodiversity. Secondly, the critical condition of the coast still be solved through three main approaches : (1) biological approach : *Rhizophora* spp., and mangrove species replantation ; (2) physical approach : adaptative strategy using wave breaker and log-blocker construction ; and (3) effort to increase the roles of the community. Partial approach to the handling of abrasion (for example, by only focusing on biological or physical aspect) is unlikely to lead to success or produce satisfactory results. A few cases of abrasion handling through mangrove planting without taking into account the physical aspects (oceanography) and socio-cultural conditions of the local people have ended in complete failure. Careful development and thorough examination of an approach, coupled with interdisciplinary methodology embracing various aspects (socio-cultural, biological, physical, ecological, etc), will lead to positive results and success. Each aspect has its own mutually exclusive and mutually supportive a role. The *Rhizophora* planting activities on the coast of Paojepe have run well without significant technical problem. Growth and development of the *Rhizophora* have been satisfactory, with more than 90 % seedlings surviving. At three years old, the *Rhizophora* has been 2.5 to 3 meters high and start producing several fruit even a few. At about three and a half years old, they will have developed strong roots, but still need some time before they can withstand the harsh waves. A study under LIPI concludes that under normal circumstances, mangroves will be strong enough against abrasion at the age of 5 years. However, it also depends on the physical aspects of the coast (i.e. structure and texture of the soil), and on oceanographical aspects. The other strateges against abrasion will be discussed completely in this article.

Key words : Coastal management, abrasion problem, Paojepe, Wajo, South Sulawesi

INTRODUCTION

Mangrove forest conversion on the coast of Paojepe has brought the disappearance of the mangrove ecosystem and, consequently, has increased its vulnerability from frontal waves sweeping the coastline--hence the biological, physical and chemical degradation. From biology view point, with diverse in the mangrove forest flora and fauna has been deprived of its biodiversity. Meanwhile, physically, as direct consequence of the biological destruction, the forest eventually ceased to exist. This has led to coastal abrasion capable of eroding inshore platform by 10 to 50 meters annually, depending on the physical condition of the coast. Moreover, the mangrove ecosystem changes to be pond area have also triggered chemical changes. Pesticide application on pond locations has had its share in troubling the chemical condition, which in turn afflicted its biological condition, particularly in the form of drastic biodiversity shrinkage. The example of this condition is the observation conducted to compare plankton species in the coastal areas and pond areas has concluded significant differences (*See the report from Phase-II*). The same holds true for the mangroves. Only 28 species are left scattered in different locations nowadays, compared to over 50 species commonly found in mangrove forests. Fauna diversity has also diminished in the species of fish, mollusks, reptiles, etc. The change of ecosystem has had its share for the shrinkage.

The process of mangrove ecosystem devastation in Paojepe has exacerbated with coral reef mining which is still in progress even until today. The fact that the reef clusters along 1.5 km from the coastline would normally function as a natural wave breaker; it could withstand and absorb impending waves as they reached the shore, particularly during the eastern and western seasons. Another aggravating factor has been the fishing activity using explosives or chemical substance (cyanide) which has killed and destroyed the reefs. The destruction of coral reef colony on Paojepe has been caused not only by mining and fishing, but also by huge water mass that usually accompanies coastal abrasion and erosion on upstream sites. Its excessive volume could have been absorbed by the mangroves; but with the disappearance of the forest, the water influx carried with it sedimentary deposits over the coral reefs along the coast.

After some trial and error efforts to identify Paojepe ecosystem condition and based on over three years' research activities as well as studies encompassing biological, physical, chemical and socio-cultural aspects with a view to solving the abrasion phenomenon, a strategy to restore the ecosystem in the area has been formulated.

STRATEGY AGAINST ABRASION

1. Adaptive Strategy of the Community

The conversion of the mangrove forest ecosystem into that of ponds has caused various ecological problems. From a biological perspective, the local biodiversity has been decreased. From a physical viewpoint, it has been signed by abrasion. The abrasion has caused many social, biological and physical problems. The abrasion has altered the community's adaptive strategy in the framework of managing natural resources in the coastal area. Their adaptive strategy to mitigate abrasion consists of two types:

a. The first strategy is usually opted by a group of community members who are unable to face the altered environment (due to the abrasion). They abandon and thus let abrasion take control. Generally these non-owners, or farmers managed rented ponds. Following the destruction of their ponds, they will return to their hometown or go elsewhere for new locations. As most of them are poor, some will have to change their occupation as wood sellers, laborers, etc. Those who can afford it will try farming by renting or buying safer land, which is usually near in-land paddy fields, and they convert into ponds;

b. The second type is opted by the other group who persist within their might to protect their ponds. Traditionally, owners of inshore ponds have persisted to fight abrasion by entrenching inshore embankments. Some of these farmers have done by implanting bamboo along the embankments in their attempt to make them strong enough to withstand the waves. Some have done it by piling up stacks of reefs onto the outer layers of the embankments, and by making bigger and stronger embankments. Average outcome so far has not been satisfactory, especially due to the structure and texture of the coastal soil and the enormous force of the waves during eastern and western seasons that will often cause the destruction of embankments.

As may be perceived from the above community-developed strategies against abrasion, the indigenous seem to have natural instinct and inherent awareness to prevent abrasion, albeit constrained by such factors as lack of knowledge, economic problem, and domination of certain economic interests. Nevertheless, within their efforts to manage abrasion, these have initiated problem of another type. The use of coral reefs for embankments along the coast can be used as a case this point. Reefs have been natural devices for breaking waves and blocking sea currents. It is exactly on the account of their exploitation of reefs that abrasion has accelerated.

Having learned from these adaptive strategies for managing abrasion, the biology team has developed a model for abrasion intervention based on scientific approaches, both biological and physical. Biological research was developed by identifying species of mangroves that serve as a natural wave absorber. Meanwhile, physical research was conducted through an oceanographical study to better understand the various aspects related to coastal conditions, such as direction and velocity of the sea currents, characteristics of the waves and other information that may support in-depth comprehension. Besides that, efforts were done to improve local knowledge on the importance of mangrove forest and practical yet effective measures to cope with and solve the problem of abrasion. Furthermore, no less important in managing abrasion concerns an aspect of collaboration, an enabling environment related to a sense of belonging among the stakeholders in the coastal management. This has been realized through good co-operation among the government, research institutes and universities, NGOs and the community.

2. Proposed Strategy and Implementation

It is imperative that the dismal state of the coast in Paojepe be managed and intervened as soon as possible before the area turns expands to a pitiable land of peat. Not only should any such effort involve all stakeholders, it should also be well planned and effective strategy which are based on the identification of the coastal characteristics, and *well received* by the local community. Therefore, to handle the abrasion problem, the following prerequisites should be met:

- **Beneficial** : The strategy or manner or method opted must be beneficial, meaning that it should be beneficial to the community and appropriate by ecological principles. Modern and sophisticated strategy that does not yield benefits to the community is meaningless and generally doomed to fail. On the contrary, a simple but beneficial to the community at large is believed to have greater likelihood for success. The higher the utility values to the community, the better the people's participation.
- **Sustainable :** Rather than be short-term, it must be beneficial to the community in a sustainable manner. To conserve the coastal environment, the effort should also enable the community to maintain their own livelihood, and: maintain environmental equilibrium in the area so that economic motives behind any land utilization will neither jeopardize nor ignore ecological principles. Moreover, such state of balance could be a supporting factor for success in sustainable area management.
- **Integrated** : The strategy should be implemented and integrated with other development programs in the area. For example, the coastal abrasion management should support the development of fishery business and improve its ecological capability. Besides, the strategy formulation would include various aspects (fields) related to the coastal abrasion. Measures against abrasion offered by research institutes and universities with absent support nor active participation from the community, local government, entrepreneurs and NGOs, would not attain maximum results. Research institutes and universities could provide data and analysis necessary for problem solving. The government ought to support, particularly in matters pertaining to legalities and regulations on natural resources management and environmental conservation. Businesspersons should opt for and promote environmentally friendly modes of business, while NGOs could play a facilitation role to the community in facing the environmental change through adaptive efforts that lead to protection of natural resources. By employing an integrated and inclusive effort in the management of coastal environmental should be made a model not only for local but also for regional and national purposes.
- **Equitable :** In formulating a strategy to manage the area, the coastal community should be granted an equitable concerning the direction to produce the policies. As such, they will not be mere object to the strategy or program but a partner in the processes of planning, implementing and evaluation of the intervention. It is through involvement and participation of the community, the comprehensive understanding can be achieved as regards the importance of abrasion intervention and coastal conservation for their own live. Such comprehensive understanding will instill and nurture awareness of the community to be responsible in the coastal protection.
- **Collaborative :** Implementation of the strategy should prioritize on co-operation with stakeholders. In the field of biology, for example, the replanting of mangrove seedlings could collaborate the research institute, universities, local or central government, NGOs and local community provide the technology, while the local or central government helps with provision of the seedlings. NGOs while volunteering in the

action could facilitate the community who provide pond locations in taking care of the young plants. Through such collaboration, the effort to address abrasion would be easier and more likely than otherwise. Active participation of all stakeholders is the main key to conserve the area.

Based upon a 2-year multidisciplinary study encompassing biological, oceanographical, and socio-cultural aspects, mode of the strategy for managing Paojepe abrasion has undergone the following stages:

Trial and Error

Besides the above-mentioned interdisciplinary study, a few trial and error activities to prevent and to cope abrasion were also conducted include :

- *Planting of Rhizophora seedlings* : The planting is done in two ways. First, direct planting of *Rhizophora* seedlings on the shore or abrasion-hit ponds; and secondly, cultivation of the seedlings in 15 x 20 cm polybag. This trial and error planting had been based on experience of the local people as well as results from observation of the physical, biological, as well as socio-cultural characteristics and conditions of those communities. In fact, the activity had also been designed for getting to know each other, raising awareness of the local people of the importance of mangrove forests, and improving their participation in the management of coastal area. Due to lacks of important information and data, however, the success rate of the first stage was low. Only few numbers of mangroves has survived, not because *Rhizophora* is a difficult species to cultivate but because of strong tidal waves and winds, particularly during the eastern and western seasons, which would uproot and wash away the young plants. Moreover, planting mangroves on inshore sites would end up with a higher rate of failure than that done on embankment-protected ponds offshore.
- *Repair and entrenchment* of inshore embankments that border the coastline using bamboo device. The local people have done this on self-reliance basis by using bamboo and reefs, mostly as soon as the eastern season is over. While the effort has been labor intensive, the entrenched embankments were still not strong enough against abrasion. During the trial and error, repair and entrenchment works were done by combining the construction of wave breakers in front of the shore. The aim wave breakers construction would slow down the wave and protect embankments from drifting logs or debris, when the huge wave arises.
- Devising a model for preventing abrasion. In the study to respond and to develop community's participation in the field works, a model for wave breaker installation and construction was made, also based on trial and error as well as analysis on the actual condition during the study. The model included mangrove-planting activities on pond locations, entrenchment of embankments on the shore, and construction of a wave breaking protection. However, due to the limited funds for abrasion management turned out to be a major constraint, in its realization, the model only accommodated mangrove planting on pond locations at the permission of pond owners. Construction

of the wave-breaking device ended up with rudimentary device installed 20-50 meters from the embankments from of the shore.

In-depth reviews over the trial and error activities in the framework of stopping the abrasion on the coast of Paojepe have elaborated the two types of methods as follows:

a. Biological Intervention

The biological intervention on Paojepe has been initiated. Firstly, identification of all species left of mangroves plant in the area and field observation on the species that can withstand strong tidal waves. Two particular mangrove species with such character, namely *Rhizophora apiculata* and *Rhizophora mucronata*, were found in the area. Next, efforts were made to plant the two types of seedlings on pond sites and on the shore. Secondly, planting of *Rhizophora* spp., and developing mixed planting system of various mangrove plant species to speed-up the regeneration process of mangrove forest.

a.1. *Rhizophora* planting

The planting has started since 1999/2000 as one of trial and error effort towards the community's trust in our plan to against abrasion. The first-phase action research in 1999/2000 realized the planting of as many as 100,000 seedlings, of which 90,000 were planted directly on inshore ponds and 10,000 cultivated in 15 x 20 cm polybags.

The cultivation in polybags aimed to study the growth rate of *Rhizophora* spp. seedling, enhance its survivability, and select the strongest seedlings to the waves. Result of the observation showed that the viability of seedlings in polybags improved their survival rate by 10 % more than those directly planted on pond sites. While the percentage of viability of seedlings planted on polybags could survive by 90 to 95 %, the ones planted directly could only reach 80 to 85 %.

The planting activity was continued in the 2000/2001 period, and 150,000 seedlings had been planted in Paojepe coast for as long as 4 kilometers by using the same method directly on pond sites. The 2001/2002 period, the number of mangroves planted in the period was 30,000 seedlings. The period of the study (2002/2003), 100,000 seedlings have been planted. The following table elaborates on relevant information, including seedling quantity, the dispersal allocation and location, as well as estimates of live and missing *Rhizophora*.

Table 1. Realization and Location of *Rhizophora* planting

No	Time	Seedling quantity	Area size	Location	Name of the owners
1	26/07/1999	25,000	2,5 ha	By estuaries of the Masiae, Baruga, and Kujung-Kujunge	Diko, Dondang, Sumang/Dullah/Makka, Amir, aba/Uci
2	16/08/1999	25,000	2,5 ha	Around Baruga, near	Uci, Amir,

				estuaries of the Kujung-Kujunge and Masiae	Baho/Tahang, Benga, Nurdin and Dondang
3	3/10.1999	> 45,000	4,5 ha	By estuaries of the Kujung-Kujunge, Baruga and Masiae	H. Mursyidin, Baho/Tahang, Benga,Alimudin/Manga, Sanu, Uci, Dullah /Makka, Amir, Dondang
4	7/08/2000	7,500	0,75 ha	By estuaries of the Masiae and Baruga	Dullah, Amir; also for seedling
5	26/08/2000	10,000	1 ha	Around Baruga	Syamsul and Amir
6	2/09/2000	11,500	0,75 ha	By estuaries of the Kujung-Kujunge and around Baruga	Syamsul Alam, Amir
7	1/10/2000	10,000	1 ha	Around Lauku	Sape
8	8/10/2000	11,000	1,1 ha	Around Baruga	Sumang/Dullah/Amir
9	13/10/2000	10,500	1,050 ha	By estuaries of the Baruga, Masiae, and Kujung-Kujunge	Dullah, Dondang, Amir and Syamsul Alam
10	26/10/2000	11,500	1,1 ha	Around Baruga	Sumang/Dullah and Amir
11	5/11/2000	11,500	1,1 ha	By the Kujung-Kujunge's estuary	Syamsul Alam
12	29/11/2000	20,500	1,35 ha	By estuaries of the Masiae and Baruga	Uci, Dondang
13	20/04/2001	10,000	0,75 ha	By estuaries of the Masiae and Kujung-Kujunge	Diko, Alam, Dondang
14	July-Sept 2001	30,000	3 ha	Around Baruga and by estuary of the sungai Kujung-Kujunge	Baho and Benga, Syamsul Alam, Uci and Amir
15	27/04/2002	10,000	1 ha	Around Lauku	Sape, H. Mursidin, H. Mudasir, and Daeng Sau
16	22/05/2002	10,000	1 ha	Around Baruga	Dullah, Romma, Uci and Alam, Amir
17	Juni 2002	4,000	-	Around Baruga	Uci and Amir
18	4/09/2002	11,000	1,1 ha	Around Baruga and by estuary of the Kujung-Kujunge	Uci, Baho (Romma, Sanu and Syukur)
19	11/09/2002	20,000	2 ha	Around Lauku	Sape, Daeng Sau, Pattola and Mudasir
20	14/09/2002	7,000	0,5	By estuary of the Masiae	Dondang
21	End of Sept 2002	30,000	2,5 ha	Around Baruga, Masiae and Kujung-Kujunge	Dullah,. Mursyidin
	Total	331,000	30,55		

Within the 3.5 years 331,000 seedlings have been planted in various locations 4 kilometers along the coasts of Paojepe and Lauku.

An evaluation in September 2002 reported that the approximate number of live seedlings was 216,356 (± 65 %) and the 50,000 of the newly planted in that same month. Overall, 80% of the total seedlings planted survived. Meanwhile, 35 % of the total seedlings disappeared due to the mistake when they were planted so they had been washed away by the abrasion.

The seedlings could have had a higher viability, 90 to 100 %. However, as the area was susceptible to abrasion attacks, most of the young plants got carried away or washed ashore by sea waves. Meanwhile, mortality by other causes, such as clams, crabs and germination problem, was less than 10% of the total seedlings.

Details related to live *Rhizophora* on Paojepe coast are presented on the following table:

Table 2. Location and Number of Live *Rhizophora*

No	Location	Number of live *Rhizophora*
1	P. Diko's pond	4,963
2	P. Dondang's pond	3,982
3	P. Sumang/Dullah's pond	31,874
4	P. Amir's pond	32,542
5	P. Baba/Uci's pond	20,161
6	P. Syamsul Alam's pond	33,250
7	P. Baho's pond	25,435
8	P. Romma + P. H. Mursidin's pond	9,982
9	P. H. Mursyidin's pond	19,700
10	P. Nurdin and P. Sanu's pond	9,467
11	Lauku	> 25,000
12	Sub-total	216,356
13	Planting in September 2002	50,000
14	Total	266,356

a.1.1. Growth and Development of the *Rhizophora* Seedlings

The growth and development of *Rhizophora* seedlings planted on abandoned ponds have been quite satisfactory. A brief account on these growth and development is illustrated as follows:

Finding of an observation shows that the seedlings planted during the phase-1 period of 1999/2000 have grown 3 meters high. Figure 1 below shows the growth and development process from seedlings to 3,5 years old trees. At around 2,5 to 3 years, the *Rhizophora* produce their *primordia* flower buds, but some more time is needed before they become fruit. After 3 years the *Rhizophora* will start producing fruit, although usually 3 to 10 only.

a.1.2. The Regeneration Process

The *Rhizophora* seedlings were planted in monoculture, which means, only one species was involved, the *Rhizophora*. It used a method that had based itself on field research and comparative studies in several regions in South Sulawesi, i.e. Tongke-Tongke village in Sinjai district and Bonepute village in Bone. All these studies conclude that only the *Rhizophora* spp can adapt well under punishing waves and currents. The species is also known to grow faster and has stronger roots than others. One drawback to being monocultured, however, is that their root system could impede the growth of other species of cohabiting mangroves. If the *Rhizophora* are planted densely, the other mangrove species, such as the *Avicenia, Sonneratia, Hibiscus*, as well as other trees will almost certainly be outgrown to the point of starvation and death.

On certain locations where sediments were found, it has been noticed that besides the planted species, other species of mangroves were also found (such as *Avicenia spp., Hisbiscus tiliaceus, Acrostichum aureum, Xylocarpus moluccensis, Acanthus ilicifolius, Ipomoea pes-capre, Sesuvium portulacastrum, Spinifex littoreus, Stachytarpheta jamaicencis)* among a few species of beach grasses. This condition is favorable to the process of reforestation on Paojepe, particularly on locations where the sediments have hardened enough to endure the waves during the harsh eastern and western seasons.

a.2. Enrichment of the Mangrove Species

Since only few species can live among with the *Rhizophora*, attempts have been made to enrich the planted mangroves and speed up the very process of reforestation itself. One way has been through diversification, by which *Avicenia* seedlings were inserted among existing *Rhizophora*. However, satisfactory results remain to be seen. Compared to the *Rhizophora* species, other species of mangrove grow more slowly and cannot be cultivated easily, hence the difficulty in finding the seedlings.

For similar purpose, planting of nipa palms (*Nypa frutican*) was also tried, although without success. Again, there was a problem with seedling provision.

Actually, before the conversion into pond locations, a variety of nipa palms used to inhabit the area, mostly nearby the estuaries. Now they are practically absent after the mangrove area was converted to be ponds. A small group of nipa palms can still be found on the upper part of the water duct near the settlement area, but the number is too small to use as source for cultivation, either by a vegetative or generative method.

Collecting nipa fruit from this region has also been a difficult business since as the local people usually consume the ripened fruit for additional diet. There has been an effort to collect the fruit from other regions, e.g. Barru, for germination purpose. Still, the result was unsatisfactory, inasmuch as low viability of the seedlings (less than 10%) and tardy growth.

The process of flora diversification and enrichment on Paojepe has not been confined to species of mangroves, but also involved other species of edible plant or plants with economic values, such as coconuts, vegetables, and other cultivated plant. The coconut the team offered for cultivation on embankments was *kelapa genjah* or the *Cocos nucifera* riping fast, which would normally yield fruit in 3 years or so. In addition, a small group of farmers, whose ponds are located offshore near paddy fields, have been seen to cultivate legume (*Vigna unguiculata*) and corn (*zea mays*) on their embankments.

However, most pond farmers lacked enthusiasm in the enrichment effort and were unappreciative to this idea, such as coconut planting. Part of the delimiting factors came from within the ponds themselves: the size of most embankments was perceived to be too narrow for growing coconuts on, so some farmers feared that the root system would break embankments. Such this fear was unjustified, as some of the local people there had successfully planted coconuts on their embankments. Basically, a more likely reason behind such reluctance was that a few of them were not owners; some were only pond renters. They might have been disheartened at a thought of long-term economic gain, if they would enjoy it at all.

b. Physical Intervention

1. Construction of the Wave Breaker/Debris Evader

As described earlier, a combination of measures has been taken to block and tackle abrasion on Paojepe. Firstly, under the biological method, it was done through the planting of *Rhizophora* and other species of mangroves. Secondly, it was through the constructing of a simple wave breaker made of bamboo and entrenching outer embankments of ponds that border the shores. Materials for constructing the breaker had been provided through aid from the Research Team of University of Indonesia, while the bamboo had been procured from outside of Paojepe. The actual work was carried out on self-reliant efforts made by the farmers' community.

Profile of the Device

The device for breaking waves and evading logs and debris (that occasionally drift in from the north) consists of a few bamboos implanted as far as about 1.5 kilometers along the coastline. The bamboo would be cut to a length of 2-3 meters each and implanted at a distance of 30 to 50 cm away from one another.

Besides being used as the wave breaker, the bamboo canes were used also for the strengthening of embankments. To this end, they would be cut to about 1 meter long and implanted along both the inner and outer sides of the pond embankments opposite the shore. Effectiveness of the combination of these two simple measures against abrasion have proved significant, by which young *Rhizophora* planted on such ponds were hedged from the harsh waves and drifting wooden debris (see the illustration).

Unhedged ponds located inshore will be likely to be eroded; abrasion has sheer capability to turn them into part of the coastline. Should this happen without intervention, the next ponds ahead will be targeted. The likelihood for abrasion to erode by 50 meters each year is high. Most ponds are shallow, their average depth equal to that of the shore surface. Thus if the embankments are crushed, the coastline will invariably extend inwards.

Actually, the key success factors in Paojepe abrasion management have been the determination and high concern of the farmers towards their ponds. As long as these farmers are willing and determine to maintain embankments properly and repair them each time abrasion hits them, then the abrasion can be reduced. Entrenched embankments will protect *Rhizophora* seedlings so they can grow bigger and function well against the waves. In fact, it is not too demanding to maintain embankments, because normally the planted *Rhizophora* will grow strong enough against the waves after about 5 years. Until this happens, repair work is only required only 4 times a week. Yet to many farmers, it is still too much or economically "unproductive" work. Therefore, awareness raising towards coastal conservation and long-term benefit is also a key factor for success in the management of abrasion on Paojepe.

Durability of the Device

One disadvantage of using bamboo for constructing wave breakers is a low durability of about 3-4 years only. Nevertheless, because it is relatively affordable and easy to obtain, bamboo has remained a first choice for the purpose. As long as they can still function well against the waves, the planted seedlings could can expected to grow, developing stronger roots for stronger grips. By the time the breaker reaches the time to decay, the seedlings will have been strong erect trees and the area will have been sedimented. When the trees reach 5 years old, they will be the coastal protector against the tormenting waves during the eastern or western season. In the final analysis, bamboo wave-breakers are basically adequate preventive measures against abrasion.

Problems : To most farmers, the actual constructing of a wave breaker was hardly ever a problem, as they shared the burden in groups and would often took along relatives, neighbors or siblings. The problem was more with the provision of raw materials, for which farmers would have to find from another region. Most have found this to be too costly, but the construction cost relatively low. The family and their neighbors would joint and collaborate to establish the bamboo weave breaker. Moreover, the success of abrasion handling also depended on how they maintained the bamboo canes--usually by "weaving" them together--against sea currents that might drift them away, as well as against other fellow farmers, who would occasionally sail the water for hunting crabs or *nener* (the young milkfish).

2. Maintenance of Embankments of Inshore Ponds

Maintenance of pond embankments by the coastline was done on self-reliance basis. The farmers would repair embankments as soon as the eastern season was over. At this time of year, many embankments would be destroyed and needed repair particularly the embankments front of coast line. The farmers would rebuild them by piling up the earth and entrench both the inner and outer sides with bamboo (see the picture). Some of them would pile up corral reef instead, but usually the practice would only worsen the situation, because the sea wave could easily throw the reefs into ponds.

As briefly mentioned above, for pond maintenance a farmer would invite other fellow farmers or neighbors to a self-reliant effort. This traditional collaboration was also useful when implanting bamboo canes as a wave-breaker. In exchange of this favor, the pond owner usually would serve meals, drinks and cigarettes, but never money.

It is worth reiterating here that well maintained embankments of inshore ponds have had direct effects in blocking abrasion and protecting the young mangroves. However, there was difficulty in making it a sustainable practice, considering that some farmers were working on rented ponds. At first, they had felt that maintenance work was just a waste of time and energy, void of short-term economic values. For this reason, special assistance was provided, by which provision of food was given too them and coordination with leaders of their community was sought. Only after that would they participate in self-reliant efforts to maintain embankments. Indeed, with a lot of complexities being involved (i.e. status of pond ownership, pond utilization permit from owners who lived in different regions, etc.), the actual process was more painstaking as it would seem.

EFFECTS OF MANGROVE PLANTING ON BIODIVERSITY AND PHYSICAL ASPECTS OF THE COAST

The Biology Team has observed and studied both the biological and physical effects of the mangrove planting activities in the past three and a half years on Paojepe coast. Employed as parameters here are findings from observation activities conducted before and after the planting processes.

A. Effects on Biodiversity

1. Floristic Diversity

Generally, the effect on the diversity of mangroves has not yet been significant. In the first observation 28 species of mangroves were found scattered in the area. Anyone observing the location today will come up with a similar finding. However, a closer observation at the planting sites will witness appearances of the following mangrove species : the *Avicenia spp., Hisbiscus tiliaceus, Acrostichum aureum, Xylocarpus moluccensis, Acanthus ilicifolius, Ipomoea pes-capre, Sesuvium portulacastrum, Spinifex littoreus*, and *Stachytarpheta jamaicencis*. These mangroves cohabit among the *Rhizophora* not only on the sites but also on sedimented locations. They are not foreign to the area, having been found to live on riverbanks, water ducts, and embankment of offshore ponds by riverside.

2. Fauna Diversity

a. Ichtyofauna :

The final result of the observation to compare fauna diversities *ex-ante(before the Rhizophora planting)* and *ex-post (after the Rhizophora planting)* the *Rhizophora* planting on Paojepe coast are fully presented on the table below:

Table 2. Fishes Species Found during observation

NO	Family	Species	Observation		Potential used	Habitat
			Ex ante	Ex post		
1	Caesionidae	*Pterocaesio chrysozona*	+	+	C	CR
2	Carangidae	*Chironomus tala*		+	C	CW
3	Centropomidae	*Lates calcalifer*		+	C	CW,FW
4	Chandidae	*Ambassis interrupta*		+	C-O	E,MT,R
5	Chanidae	*Chanos chanos*	+	+	C	CW,CR
6	Cichlidae	*Oreochromis mossambica*	+	+	C (?)	MT
7	Clupeidae	*Spratelloides gracilis*		+	C	CW,E
8	Drepanidae	*Drepane longimana*			O	CR
9	Echeneidae	*Echeneis sp.*	+	+	UI	MT,OS,IS
10	Eleotrididae	*Ophiocara cf. porocephala*	+	+	UI	MT
11		*Eleotris cf melanosoma*	+	+	UI	MT
12		*Eleotris sp.1*	+	+	UI	MT
13		*Eleotris sp.2*	+		UI	MT
14	Elopsidae	*Megalops cyprinoides*	+	+	C	CW,MT
15		*Megalops sp.*	+		C	CW,MT
16	Engraulidae	*Stolephorus indicus*	+	+	C	CW
17	Gerridae	*Gerres filamentosus*		+	C	CW,E
18		*Gerres macracanthus*		+	C	CW,E
19		*Gerres sp.*		+	C	CW,E
20	Gobiidae	*Glossogobius sp.*	+		UI	E,MT
21		*Periopthalmus cf argentimaculatus*	+	+	UI	E,MT,FW
22	Holocentridae	*Ostichthys kaianus*	+	+	C	OS
23		*Sargocentrum sp.*	+	+	C	CR
24	Labridae	*Cheilinus digramus* (*		+	C	CR
25	Leiognathidae	*Gazza sp.*	+	+	C	CW-CR
26		*Leiognathus equlus*		+	C	CW-E
27		*Leiognathus dussumieri*	+	+	C	CW-E
28		*Leiognathus sp.*	+	+	C	CW-E
29		*Secutor indicus*	+	+	C	CW-E-FW
30	Lobotidae	*Lobotes surinamenis*		+	C	CW

31	Lutjanidae	*Lutjanus rivulatus*		+	C	IS,CR
32		*Lutjanus russelli*		+	C-O	IS,CR
33		*Lutjanus decussatus*	+	+	C-O	IS,CR
34		*Lutjanus lutjanus*	+	+	C	OS,CR,CW
35	Menidae	*Mene sp.*	+	+	C	CW,E
36	Mugillidae	*Mugil cephalus*		+	C	CW-E,FW
37		*Liza subviridis*	+		C	CW-E
38	Mullidae	*Upeneus vittatus*	+	+	C-O	SW
39		*Upeneus sulphureus*	+	+	C-O	SW
40	Nemipteridae	*Nemipterus isacanthus*		+	C	CW
41		*Pentapodus nagasakiensis*		+	C	CW
42	Poecillidae	*Oryzias cf celebensis*		+	UI	MT
43	Polynemidae	*Eleutheronema tetradactylus*		+	C	CW
44	Pomacentridae	*Abudefduf sexatili-vaigiensis*		+	O	IS,MT
45		*Amblygyphidodon curacao*		+	O	IS,CW
46	Priacanthidae	*Priacanthus taeinus*		+	C	CR
47	Scaridae	*Scarus sp.1*		+	C	CR,OS
48	Scombridae	*Auxis sp.1*	+	+	C	CW
49		*Auxis sp.2*	+		C	CW
50	Serranidae	*Epinephelus areolatus*	+		C-O	IS
51		*Epinephelus tauvina*	+	+	C-O	CR
52	Siganidae	*Siganus sp.1*			O-C	SW
53		*Siganus canaliculatus*	+		O-C	SW
54	Sillaginidae	*Sillago analis*		+	C	SW
55		*Sillago sp.*		+	C	SW
56	Sphyraenidae	*Sphyraena baracuda*	+	+	C	CW,OS
57		*Sphyraena flavicuda*	+		C	CW
58		*Sphyraena sp.*	+		C	CW
59	Syngnathidae	*Microphis sp.1*		+	O	MT
60		*Microphis sp.2*		+	O	MT
70	Terapontidae	*Terapon jarbua*		+	C-O	CW,E,FW
71		*Terapon theraps*	+		C-O	CW,E,FW
72		*Pelates quadrilineatus*	+		C-O	CW,E
73	Toxotidae	*Toxotes jaculatrix*		+	O	MT,E
74	Triacanthidae	*Triacanthus biaculatus*		+	O	CW

Notes: *CR: Coral reef, CW: coastal water, IS: inshore, OS: offshore, E: estuarin, FW: freshwater, MT: mangrove and pond, SW: sand and mud, UI: Unidentified, C: Consumption, O: Ornamental, C-O/O-C: Both Consumption and Ornamental, +: Found.*

Findings of the observation on the fauna diversity inshore have shown that the number of fish species before the *Rhizophora* planting (36 species) was significantly different from that *ex post* (52). Similarly, the difference in the numbers of individual fishes was also significant. However, the *Rhizophora* could not have caused any of the differences, because when the observation was taking place, the pond-planted trees were still too young to effect such changes on the coastal area. A later field study offered several possibilities: 1) since the observation had taken place at two different points in time, it might have affected the result of the fishing; 2) the observation might have involved different area coverage's; and 3) the observation had been conducted by different individuals using different equipment.

As far as it concerned a few pond farmers who would occasionally go hunting *nener*, they admitted having been able to catch more young milkfish on pond sites where *Rhizophora* planting today than before the planting. Not with standing, the very activity of *nener* hunting around the population of young *Rhizophora* could actually destroy them. It could also violate the wave breaker construction and shun away success in the effort against abrasion.

Results from an analysis on indexes of diversity, indexes of similarity, indexes of equitability and indexes of species richness of the fauna are presented on the following table:

Table 3. Analysis on indexes of diversity (H), index of similarity (Is), index of equitability (E), and index of species richness (D), ex ante and ex post the *Rhizophora* planting

Index	*Ex ante* finding	*Ex post* finding
Index of diversity (H)	3,024	3,650
Index of equitability(E)	0,865	0,876
Index of species richness (d)	6,617	8,930

Source: Field Research Data, the Biology Team, 2002

Results of the analysis shows that the *ex post* fish diversity is higher than the *ex ante*. The increase in number might have been due to several factors: temporal (e.g. depending on what time of day the observations was carried; how long the collection activity last respectively, etc.), spatial (whether or not the two observations covered the same area) and instrumental (whether a same set of equipment had been used under the same or different method). As mentioned above, the existence of the young trees cannot be said to have affected the fish diversity and affluence, as the trees were grown on pond sites, not on the tidal coast area.

Another indication nullifying the notion that differences in *ex ante* and *ex post* diversity and species richness of fish had not been caused by the young *Rhizophora* is the fact that most of the fishes found on sites belong to the species of coral-reef dwellers, such as members of the families of Acanthuridae, Balistidae, Chaetodontidae, and Labridae. While the first three families have decorative bodies (both in their forms and colors), the Labridae has beautiful colors. Their conspicuous presence in the reef habitat often attracting sea divers, the location is very near from the research site. For that reason, the dominant fishes found, were species presence in the reef habitat (see the table above).

Meanwhile, the species found around the mangrove forest and pond sites are members of the families of Eleotrididae, Gobiidae, Hemirhampidae, and Syngnathidae.

Observation shows that there were only very few fish found as permanent dwellers of the mangrove area, and the majority fish observed is mudfish (*Periopthalmus* sp.). On the contrary, a species of fishes were found on pond sites, including those belonging to genera of *Eleotris, Ophiocara, Butis, Sicyopterus, Terapon, Chanos, Oreochromis, Anabas*, from the Mugillidae family. Meanwhile, *mujair* (*Oreochromis mossambica*), *belanak* (*Mugil* sp., *Liza* sp., *Pseudomugil* sp.), and milkfish (*Chanos chanos*) were all found in abundance. Most of the fishes, except the *mujair* (*Oreochromis mossambica*), had entered the ponds when the tide rose through exhaust channels nearby the ponds. Interestingly, the *mujair*, while quick in propagation hence the abundance, has little economic value as it is considered as a pest or predator. It would be better if the Fishery Office authorities in Wajo District, in cooperation with investors, could promote conversion of such wasted abundance into commodities with added value, i.e. pellet products, fish flour, so that they could become a source for extra income.

b. Diversity of Other Aquatic Fauna (Non-fish)

The number of other species of aquatic fauna identified during the *ex post* observation was similar to that prior to the mangrove planting, among others 25 species of mollusks belonging to 19 genera and 14 families (*see Table*). One of the reasons behind the few number of mollusk species was because the collection activity had been carried out around the sites where *Rhizophora* had been planted. The result would have been bigger if the collection had covered from wider areas. The same holds true for the ex ante result. The number of species in each family stood at a range of 1 to 3 species. The families found with 3 species were, among others the Cerithidae, Potamididae, and Strombidae.

Observation on reptiles has not shown significant differences either. The ex post number of snakes found was 3 species : *Enhydris cf matanenesis*, *Ahaetulla prasina*, and *Enhydris enhydris* (*see Table*), which commonly found in mangrove forest and pond sites. Differences in their individual quantities, however, were more notable if before the *Rhizophora* planting there was only 1 individual, more individuals were found after the planting, mostly of *Ahaetulla prasina* and *Enhydris enhydris*, with 2 individuals respectively.

Another reptilian observed was the monitor lizards (*Varanus salvator*). Their high population was found mainly on pond sites. Pond farmers see them as pests, as they often eat the cultivated milkfish and shrimps. According to some farmers working on inshore ponds, there were more monitor lizards today than before.

Observation on non-fish crustaceans shows that their ex ante and ex post quantities remained about the same. Four species of prawns were found, namely *Penaeus monodon*, *P. merguienensis*, *P. indicus*, and *Metapenaeus* sp. The *Penaeus monodon* is also known locally as *udang windu*, *udang harimau* or '*tiger prawn*'. Its economic value is quite high, and it is a favorite export commodity to most pond farmers. This explains why most farmers cultivate this prawn on their ponds, traditionally, semi-intensively, or intensively. The other three species above are known locally as *udang putih*, or white prawns. Although considered as pests, they are also considered as additional income of the pond. Elsewhere they are caught for sale at local markets, hence a source of additional income. Observation findings show that fewer white prawns were found ex post than it had been ex ante. The reason is because the *ex post* observation took place in September, a peak month during the dry season, when their big population is found only rarely.

Other crustaceans included the crab and the *mantis* (*Lysioquila* sp.) of the Squillidae family. *Ex ante* observation records 10 species of crabs of 4 families, while *ex post* observation (after 3,5 years planted) shows 9 species of the same number of families (*see Table*). While *ex ante* observation recorded one species of starfish, namely the *Astropecten polyacanthus* of the *Astropectinidae* family, none was found during the *ex post.*

Table 4. Diversity of other Aquatic Fauna

Class	Group	Family	Species	*Ex ante* observation		*Ex post* observation	
				Found	Nb of individu	Found	Nb of individu
Mollusk		Arcidae	*Onadara antiquata*	x	++	x	++
		Cerithiidae	*Clava vertagus*	x	+	x	-
			Clypomorus moniliferum	x	++	x	++
			Clypomorus breviculum	x	++	x	++
		Conidae	*Conus litteratus*	x	+++	x	+++
			Conus striatus	x	+++	x	+++
		Littoriidae	*Littorina scabra*	x	+++	x	++
		Melongiidae	*Melongena pugilina*	x	+	x	++
			Melongena paradisiaca	x	++	x	++
		Muricidae	*Chicoreus adustus*	x	+	x	+
			Chicoreus capucinus	x	+	x	+
		Nassariidae	*Alectrion picta*	x	+++	x	++
			Nassa olivacea	x	+++	x	+++
		Naticidae	*Polynices mamilla*	x	+	x	++
		Ostreidae	*Crassostrea cuculata*	x	++	x	+++
		Potamidida e	*Telescopium telescopium*	x	+++	x	+++
			Terebralia sulcata	x	++	x	+++
			Cerithidea cingulata	x	+	x	++
		Strombidae	*Strombus urceus*	x	+++	x	+++
			Strombus canarium	x	+++	x	+++
			Strombus luhuanus	x	+++	x	+++
		Turbinidae	*Turbo porphryites*	x	+	x	++
		Veneriidae	*Gafrarium gibbia*	x	+	x	+
			Tapes verginia	x	+	x	+
		Volutidae	*Voluta vespertilio*	x	++	x	+
Reptile	Snake		*Enhydris cf matanensis*	x	+	x	+
			Ahaetulla prasina	x	+	x	+
			Enhydris enhydris	x	+	x	+
	Monitor Lizard		*Varanus salvator*	x	++	x	+++

Crustacea							
	a. Prawn	Penaidae	*Penaeus monodon*	x	++	x	+++
			Penaeus merguinensis	x	+++	x	+++
			Penaeus indicus	x	+++	x	+++
			Metapenaeus sp.	x	++	x	++
	b. Crab	Portunidae	*Portunus pelagicus*	x	+++	x	++
			Chorydis sp.	x	++	x	++
			Scylla serrata	x	+++	x	++
		Ocypodidae	*Ocypoda sp.*	x	++	x	+++
			Uca sp.1	x	+++	x	+++
			Uca sp.2	x	+++	x	++
			Sesarma sp.	x	+	x	++
		Grapsidae	*Plagusia dentipes*	x	++	x	+++
			Grapsus albulineatus	x	+	x	+
		Xanthidae	*Pseudolomera speciosa*	x	++	x	+++
	c. *Mantis*	Squillidae	*Lysiosquila sp.*	x	++	x	+++
Starfish		Astropectin idae	*Astropecten polyacanthus*	x	+	x	–

Notes: + = Rare (<5 individuals/observation point); ++ = moderate (5 - 10 observation points) ; +++ = abundant (> 10 observation points).

Results of a more detailed analysis on the distribution of a diversity of predominant fauna on the mangrove area presented on the figure below:

Balistidae	========================
Carangidae	===
Chaetodontidae	=======================
Eleotrididae	==============
Gobiidae	==================
Leiognathidae	==
Labridae	=================
Lutjanidae	===
Mullidae	===
Mugillidae	===========================
Serranidae	===========================
	FW | E-TM | CW-SW | IS | CR | OS

Notes: FW: freshwater, E-TM: Estuarin, pond and mangrove, CW-SW: coastal water-sand and mud, IS: inshore, CR: coral reef, OS: offshore : Source: Result of Field Research, the Biology Team, 2002

Figure 2. Distribution Pattern of predominant groups of fauna on the coastal mangrove area (research site)

Figure 2 shows that fish habitats vary enormously, namely CR *(coral reef)*, *CW (coastal water)*, *IS (inshore)*, *OS (offshore)*, E *(estuarin)*, *FW (freshwater)*, *MT (mangrove and pond)*, *SW (sand weed)*, and *SM (sand mud)*. However, this is not a rigid classification, since a few same species were found in few habitats *(see Figure)*. The fact must have related to their life cycle, tidal flows, sea currents, and other physical-chemical factors that call for periodic assessment.

3. Plankton Diversity

Observation on the plankton diversity included the phytoplankton and zooplankton. Findings suggest that the population of the former species on Paojepe after the *Rhizophora* planting is approximately the same as before the activity, which comprise 4 groups of phytoplankton: the Cyanophyta, Chlophyta, Crhysophyta and Dinophyta. The difference lied in the number of phytoplankton species, as described on the following table.

Table 5. Number of phytoplankton varieties identified after mangrove planting

No	Group	Number of species	
		Ex ante	*Ex post*
1	Cyanophyta	18	16
2	Chlophyta	13	12
3	Crhysophyta	29	19
4	Dinophyta	1	1

Source: Field Research Data, the Biology Team, 2002

The table on results of phytoplankton identification on Paojepe shows a decrease of quantity. This was cause the phytoplankton observation was carried out during the dry season *ex-post* the *Rhizophora* planting, which might have affected its species. For example, during dry season, most ponds were intentionally made to dry for ridding it from pestilence, poisonous residue, et cetera. The ponds dried, pond farmers would do groundwork preparation and repair embankments.

Table 6. Plankton Diversity on Paojepe coastal waters

Species	Number of individual species	
	Ex-ante	Ex-post
Cyanophyta :		
1. Anabaena sp.	25	20
2. Aphanocapsa sp.	5	10
3. Chamaesiphon curvatus	5	15
4. Chamaesiphon incrustans	15	10
5. Chroococcus dispersus	5	7

6. Dactylococcopsis sp.	5	3
7. Lyngbya sp.	5	5
8. Microchaeta sp.	10	5
9. Microcystis aeruginosa	910	615
10. Microcystis sp.	45	55
11. Oscillatoria amoena	5	5
12. Oscillatoria lacustris	30	15
13. Oscillatoria limnetica	120	105
14. Oscillatoria princeps	15	15
15. Oscillatoria sancta	225	155
16. Oscillatoria sp.	25	50
17. Phormidium sp.	5	5
18. Volvox xp.	30	5
Chlorophyta :		
1. Botriococcus sp.	20	15
2. Chlorella elipsoides	5	5
3. Chlorella sp.	10	5
4. Chlorella vulgaris	65	15
5. Closterium juncidum	10	5
6. Closterium rostratum	10	15
7. Closterium sp.	5	5
8. Euglena minuta	20	15
9. Microspora sp.	5	5
10. Plerosigma sp.	25	15
11. Trachelomonas acanthostoma	15	7
12. Ulothrix sp.	5	5
13. Ulothrix tenuissima	5	5
Chrysophyta :		
1. Achnanthes sp.	10	5
2. Asterionella sp.	35	15
3. Bidulphia obtusa	10	15
4. Chaetoceros almorei	25	27
5. Chaetoceros gracile	5	5
6. Chaetoceros sp.	70	55
7. Cocconeis sp.	15	10
8. Coscinodiscus kutzingi	5	5
9. Coscinodiscus lacustris	35	25
10. Cymbella gracilles	5	5
11. Denticulla sp.	5	15
12. Diploneis sp.	15	10
13. Genicularia sp.	5	6
14. Ghomponema gracile	5	7
15. Gyrosigma sp.	10	15
16. Navicula anglica	10	5
17. Navicula lanceolata	170	155

18. Nitzschia longissima	20	12
19. Nitzschia sigma	50	45
20. Pleorosigma sp.	25	20
21. Rhizosolenia delicatula	5	5
22. Rhizosolenia habelata	10	5
23. Rhizosolenia setigera	15	5
24. Rhizosolenia sp.	5	5
25. Stauroneis sp.	10	5
26. Surirella biseriata	10	12
27. Synedra ulna	40	20
28. Thalassiosira sp.	10	5
Dinophyta :		
1. Peridinium sp.	10	7
Copepoda :		
1. Calanus sinicus	60	50
2. Calanus sp.	5	10
3. Larva copepods	105	85
4. Paracyclopina sp.	10	5
Protozoa :		
1. Branchionus plicatilis	5	5
2. Branchionus sp.	5	10
3. Globorotaalia sp.	85	70
4. Rotifera sp.	25	35
Total idividuals	1893	
Total varieties	176	

Source: Result of Field Research, the Biology Team, 2002

A comparison of results of the phytoplankton identification on Paojepe coastal waters ex-ante and ex-post the planting suggests that the area has a relatively high plankton diversity. However, if we count the number of individual phytoplankton by a certain volume, the number is relatively small, within a range of 15 to 395 individuals per liter, excepting the *Microcystis aeruginosa*, which totals to 910 individuals (*ex-ante*) and 610 (*ex-post*) respectively.

As was the case prior to the planting of *Rhizophora*, the zooplankton observation focused on the Copepoda group, due to its important role for both marine and coastal fisheries. Besides an important source of food for a few species of fishes and commercial shrimps, the group also plays a role as a biological indicator of seawater organisms. Among zooplanktons in the sea, the Calanoid Copepod is the most important group, constituting more than 70 % of zooplankton species. Another important role of the group is in linking the lowest to higher levels within the entire food chain.

Observation findings on the copepoda on Paojepe, both ex-ante and ex-post the mangrove planting, recorded 35 species of Copepoda. The most dominant ones were the *Labidocera pavo, Acartia erythraea, Centropages furcatus,* and *Pontellopsis sp.* Before the *Rhizophora* planting, 6 species of Copepoda had been found, namely *Acartia erythraea, A. pacifica,* *Centropages furcatus, Pontellopsis inflatodigitata, Pseudomacrochiron parvum* and *Labidocera pavo*; the ex-post result was a mere 3 species : *Acartia pacifica, Centropages furcatus,* and *Pseudomacrochiron parvum.* Reduction in the quantity was due to the fact that the observation (*ex-post*) took place when most ponds on the area were under the drying process. The three species were also found in pond channels.

The Copepoda species most dominantly found belong to the group that has low tolerance towards salinity changes due to the fact that the supply of pure water into Paojepe coast was very little, hence the high salinity (25-35 %). This also explains why the plankton diversity in pond water is different from that on the coast. Coastal water is actually also rich in planktons. However, as soon as the water enters into ponds at the flow of tides, its richness drastically plunges with time. It is not because of consumption by fish, but because most planktons cannot survive long in the pond water, due to a lack of nutrition. A case like this is often on peaty ponds, which are known to have low pH, due to the physical and chemical contents as well as a lack of nutrition.

c. Effects of Mangrove Planting on Physical Condition of the Coast

Detailed observation using a quantitative method to measure effects the of mangrove planting activity towards changes in the physical condition of the coast has not been carried out because the *Rhizophora* are still too young, three and a half years old. At this age, *Rhizophora* are not strong enough against sea abrasion. Consequently, efforts against abrasion so far have laid emphasis on the planting more *Rhizophora* and maintenance work. As such, the direct effects could not be quantified. Nevertheless, indications of reduced abrasion has been found thanks to the wave breaking as well as longs/debris evading constructions made of bamboo. In addition, indirect effects on the coastal condition have been due to the maintenance including entrenchment of embankments of ponds that border the shore. Among these indirect effects was indication of reduced abrasion on such pond areas, especially in compared in areas where pond embankments were not entrenched. The maintenance efforts were helpful in protecting the mangroves that lived there.

During the 3.5-year period, no effort was ever taken to measure the process of sedimentation that took place on site. Neither were other quantitative tests on the reduction of abrasion nor the water quantity (both physically and chemically). The reason was that tangible physical appearances of direct effects from the planting have not seen clearly. Provided that further field research under The MacArthur Foundation continues to see these *Rhizophora* enter their fifth year, they can be expected to be able to withstand the harsh waves, and thus close observation on the physical effect from the planting can be carried out.

EVALUATION AND DISCUSSION

Research implementation on the biological and oceanographical aspects in support of the characterization of the coastal area has run smoothly without significant constraints. Funding, however, has been a major problem, because oceanographical and biological research activities generally require considerable funds, mainly for laboratory analyses and renting of oceanographical equipment which is quite expensive. This is the reason why the second phase research had exempted such oceanographical work, a consequence of which was the absence of related oceanographical data during the eastern season, despite the fact that they actually were among the most vital information for the formulation of strategy for managing the coast of Paojepe. Therefore, further research will prioritize on detailed analysis of the oceanographical aspects. Indeed, more elaborated and comprehensive planning, better coordination, and more detailed funding allocation are essential so that each group of researchers can function at their best. In trying to meet those requirements, the biology team will as much as possible combine its current data with that from a maritime research project under LIPI (Indonesian Institute of Sciences), a national institute that has undertaken a lot of research activities on South Sulawesi coasts. Given that coordinator of the biology team also comes from this institution, the team expects itself to capitalize on the good relationship. In fact, in analyzing the progress made after 3.5 years of *Rhizophora* planting the biology team has benefited from data acquired from related studies conducted previously by researchers of Research Center for Biology, LIPI-Bogor.

Similarly, application of result of the research within the framework of abrasion fighting on Paojepe has taken place well. On field implementation front, *Rhizophora* planting activities on pond sites inshore were successful, thanks to the enthusiasm and support of the local community in taming the abrasion. A few of them were even willing to let their ponds be planted with seedlings and to volunteer in cultivating the seedlings provided. Many of them have realized the importance of *Rhizophora* planting as an alternative for facing the looming danger of abrasion. However, their awareness could still be raised to a point of self-reliance, when they can be expected to become self-motivated in abrasion prevention under self-effort basis, e.g. in the provision of seedlings and bamboo canes. As regards self-provision of seedlings, there has been an interplay of factors (some may be classical) behind their reluctance or inability. Price was one of these factors. Procurement was also a problem, as they would have to travel for some distance. While they have had the capacity to provide seedlings on self-reliance basis, most of them found it difficult to set aside some money for other purposes than production. Actually, the additional cost needed for abrasion prevention could be lower than an abrasion-destroyed pond.

The growth and development of the planted mangroves have shown encouraging results. For example, the *Rhizophora* of about 3.5 years old generally reach a height of 3 meters with a diameter range of 2 to 5 cm. Some trees even have produced fruit even 5 to 15 fruits only. These positive results have been attributed to the relatively good and conducive coastal condition, both physically and chemically. It should be noted, that the area used to be a natural habitat for *Rhizophora*. From a physical perspective, its muddy soil is suitable for *Rhizophora*. Failure in previous *Rhizophora* planting attempts was mainly caused by a lack of protection of the mangroves, so that the waves could wash the trees away, especially those planted inshore. Situation like that would peak during the eastern and western seasons (*musim timur dan musim barat*). In overcoming such situation, the planting was done rearward at a certain distance away from the coastline. The next planting program focused on pond sites. The latter activities have taken place especially well with the support of cooperative pond farmers.

As far as the biological aspects are concerned, no substantial problem has occurred in the process of abrasion handling in Paojepe. Among the conducive factors have been the good physical characteristics of the coast and absence of harmful pestilence. From a physical viewpoint, the muddy type of soil, good as it may be for mangroves, actually has triggered abrasion. Another physical hindrance has been due to coral reef mining and destruction, which is still in progress even today. Actually, the local government has tried to ban such practices, but under weak supervision the mining continues to be committed, even in higher frequency and bigger quantity. Another contributing factor to the acceleration of abrasion has been the fishing activity using explosives and poisonous substances, which are as lethal to big or small fish alike as damaging to reefs. Destruction of the reefs, as natural protectors from strong waves, has amplified abrasion power. As a result, the intensity of erosion has increased and abrasion has been far more damaging a threat. Unless the coastal *Rhizophora* planting is supported by other preventive measures, e.g. coral mining prohibition, the effort is likely to fail. Abrasion can be tackled only in an integrated fashion encompassing biological, physical, socio-cultural, security and economic aspects. With thorough consideration and maximum implementation, the likelihood will be great for such a program to succeed. On the contrary, no matter how many extra seedlings are added for further planting on Paojepe, if it is run without support from other aspects, the likelihood will not be as great. Coordination of all stakeholders is important, as is determination to restore the coastal condition as quickly as possible.

The most important aspect in addressing the problem of abrasion on the area today has been active participation of the local government, which has extended generous supports in the forms of materials and clear, conducive regulations. The local community has gained understanding and started being aware of the importance of mangrove forest for coastal conservation. Such awareness and understanding must meet with concrete activities to combat abrasion.

While the local people have been aware of and understood the importance of mangrove forest for the sustainability of their fishing venture, efforts to assist and facilitate them are still necessary and, therefore, should be continued. Actual assistance may vary in forms, i.e. through capacity building for maintaining mangroves through "weaving", separating, and enrichment techniques, etc.

Implementation of the wave breaker and logs evader constructing program has yet to meet any of the two models previously designed. Prepared to shield the coast against sea currents or waves, these models come in model A and model B (see 2nd Year Report), based on earlier field research findings and practical experiences of pond farmers. These models have not been well realized due financial limitation in the procurement of raw materials (bamboo canes) lack of human resources, and time constraint. These problems could have been solved had we given financial compensation to the workers, but one important purpose of the construction work is to develop active participation of the community in abrasion handling effort. To develop a sense of ownership, it was considered crucial that the pond farmers themselves implement the constructing; otherwise, they would not bother to take care of it. Moreover, funding the local people (through provision of raw materials) was not meant as charity work, but stimulus for better participation in caring the environment

Simple as it is, the wave breaker has indicated the concern and participation of the local people. Rather than being passive recipient of ready-made wave breakers, they have been actively involved since the design period, while the study team served only as provider of the raw materials. Actually the development concept of the model for addressing abrasion as we offered it has incorporated a similar mechanism, whereby we would serve as providers of raw materials and the local community as implementers. Yet, due to limitation of funds, time and human resources, its actual implementation was constrained. It is expected that through the right approach and concrete evidence in the form of successful planting, the local community of pond farmers could be motivated to pay attention to efforts to prevent abrasion for the sake of environmental conservation.

The bamboo construction functioning as a simple wave-breaker and logs/debris evader can last for about three years before it needs repair or replacement. To include such maintenance purposes, at least five years will be needed by an integrated program designed in the framework of coastal management.

CONCLUSIONS

Listed below are lessons learned during the three and a half years spent for field research and applications of its findings as regards Paojepe coast.

1. The efforts taken to solve the problem of abrasion on Paojepe coast based on interdisciplinary analyses on socio-cultural, physical, biological and ecological aspects have resulted in a fresh approach to the problem, entailing specific methodology that demands the following faculties:
   a. it should involve participation of the community and provide both economic and ecological benefits to the local people;
   b. it should take into account longer-term utilities as well as sustainable benefits;
   c. it should be integrated with other programs while avoiding duplication, redundancy and contradiction;
   d. it should prioritize on partnership with stakeholders or other parties of like interests and responsibilities.
2. Partial approach to the handling of abrasion (for example, by only focusing on biological or physical aspect) is unlikely to lead to success or produce satisfactory results. A few cases of abrasion handling through mangrove planting without taking into account the physical aspects (oceanography) and socio-cultural conditions of the local people have ended in complete failure. Careful development and thorough examination of an approach, coupled with interdisciplinary methodology embracing various aspects (socio-cultural, biological, physical, ecological, etc), will lead to positive results and success. Each aspect has its own mutually exclusive and mutually supportive a role.

3. The *Rhizophora* planting activities on the coast of Paojepe has run well without significant technical problem. Growth and development of the *Rhizophora* has been satisfactory, with more than 90 % seedlings surviving. At three years old, the *Rhizophora* has been 2.5 to 3 meters high and start producing several fruit even a few. At about three and a half years old, they will have developed strong roots, but still need some time before they can withstand the harsh waves. A study under LIPI concludes that under normal circumstances, mangroves will be strong enough against abrasion at the age of 5 years. However, it also depends on the physical aspects of the coast (i.e. structure and texture of the soil), and on oceanographical aspects.
4. Failure in the *Rhizophora* planting efforts on Paojepe has not been so much caused by the physical nor biological aspects of the area, but more by the technical aspects during the planting work itself. For example, planting the seedlings during the eastern or western season will unfailingly cause the seedlings to be washed away. To mitigate such loss, the *Rhizophora* could be planted on ponds that are still protected by embankments. In this case, the planting should be done in such a way that keeps the *Rhizophora* farther and farther away from the coastline, to anticipate the unstoppable abrasion. The Team hope that by the time the wave reaches the pond, the mangroves will have been strong enough to endure it.
5. Based on a field observation, the bamboo canes that are used as raw materials for the construction of wave breakers can only last for about 3 years, before they need repair or replacement.
6. Even if an abrasion handling effort is taken by combining the various interdisciplinary aspects above, maximum effectiveness will not be achieved without supports from the local government. The local government, in supporting such efforts, could take a leading role in managing off-shore coral reef mining practices, taking measures against fishing activities that use of explosives or dangerous chemical substances.

REFERENCES

Boedhihartono, J.E. Prioharyono, Y. Purwanto and E.M. Choesin (eds). 2001. *Management of Mangrove Forest: Conversion and Reforestration of Mangrove on the Coast of Paojepe, South Sulawesi.* Department of Anthropology, Faculty of Social and Political Sciences, University of Indonesia and The John and Catherine D. Mac Arthur Foundation. 2001. 177 p.

Haryono and Y. Purwanto. 2001. *Keanekaragaman Jenis Ikan dan Kaitannya dengan Sistem Pengelolaan Kawasan Pesisir Teluk Bone.* Proceedings from a Seminar on Fish Biodiversity, Bogor 6 June 2000. Pusat Studi Ilmu Hayat IPB, JICA, and Puslit Biologi-LIPI. 2001 : 99-108 p.

Purwanto, Y. 1999. *Kajian ekosistem kawasan pantai guna menunjang pengelolalan tambak dan rehabilitasi pantai di Paojepe, Siwa, Kabupaten Wajo, Sulawesi Selatan.* Interdisciplinary Workshop: Penanaman Bakau dan Pemisahan Terumbu Karang di Teluk Bone, Sulawesi Selatan. Antropologi, FISIP-UI, MacArthur Foundation, Pemda Tk II Wajo dan YTMI. Sengkang, 15 November 1999.

Purwanto, Y. 2000. *Pengelolaan Lokal Kawasan Pesisir : Studi Kasus Desa Tongke-Tongke, Bonepute dan Paojepe, Teluk Bone, Sulawesi Selatan.* International Symposium and Workshop: Mengawali Abad ke 21: Menyongsong Otonomi Daerah, Mengenali Budaya Lokal, Membangun Integrasi Bangsa. Research Center. UNHAS, Makasar, 1-5 August 2000 : 19 p.

Purwanto, Y. 2001. Pendekatan Etnoekologi dalam pengelolaan kawasan pesisir di paojepe, Kabupaten Wajo, South Sulawesi. Proceedings from Seminar and Workshop on Environmental Management. Universitas Kristen Satya Wacana, Salatiga, 13-14 July 2001. *Seri Penelitian Fakultas Biologi UKSW. (4)2* : December 2001 : 242-258 p.

Purwanto, Y. 2002. *Studies on conservation and management of coastal resources through the integration of social, physical and biological approaches: A Case Study in Paojepe, Wajo, South Sulawesi, Indonesia.* The International Symposium on Land Management and Biodiversity in Southeast Asia. Hokkaido University and Research Center for Biology-LIPI, Kuta, Bali 17-20 September 2002. 14 p.

Winarto, Y.T., H. Arifin, Y. Purwanto, J.E.M. Prioharyono, A. Qosim, B. Gala, and M. Lampe. 1999. *Abrasion : Mangrove conservation, coral reef degradation, Cases from the Coasts in South Sulawesi and the offshore of Pulau-Pulau Sembilan.* Department of Anthropology FISIP-UI and UNESCO, Jakarta. 1999. 86 p.