Evaluation of mangrove management through community-based silvofishery in North Sumatra, Indonesia

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Abstract. Aquaculture expansion has been reported as the primary driver of mangrove loss and a significant cause of mangrove deforestation in North Sumatra, Indonesia. Development of silvofishery based on creating balance condition between conserving mangrove forest and offering better livelihood for local communities surrounding mangrove. The present study evaluates of mangrove management through community-based silvofishery in three villages, namely Paluh Manan, Paluh Kurau, and Lama, Hamparan Perak of Deli Serdang Regency, North Sumatra, Indonesia. Three communities used the same ecological type-silvofishery, characterized by planted mangrove surrounded aquaculture. Results showed that in the Paluh Manan village, planted mangrove and aquaculture in the ratio of 75:25 with planting distance of mangrove 50x50 cm, containing 2,500 trees/ha, resulted in US$ 36.2/month/ha of fish and shrimp farming. In the Paluh Kurau village, a mixture mangrove and aquaculture in an 84:16 ratio, planting distance of 1x1 m, consists of 1,600 trees/ha, US$ 23.8 of generating revenue from crab farming. Furthermore, in the third village, Lama village, consists of mangrove and aquaculture in the proportions 90:10, with planting spacing 2x2 m, composing 1,000 trees/ha, led to US$ 45.8/month/ha from fish, shrimp and crab farming. The present study suggested the mangrove management through community-based mangrove-friendly aquaculture.

1. Introduction

Mangrove forests in North Sumatera, Indonesia covered approximately 50,369.8 ha in 2015 and existed in the eastern coast of Sumatra Island and commonly distributed in Asahan, Langkat, Deli Serdang, Batubara, Tapanuli, Nias, Labuhanbatu until Serdang Bedagai [1]. The significant ecology, economy, and environment of mangroves have been well documented; however, mangroves are currently the most threatened ecosystems due to indirect and direct deforestation and degradation [2]. Aquaculture expansion has been reported as leading driver of mangrove forest cover loss in Indonesia. Furthermore, conversion to shrimp aquaculture, oil palm plantation, and urban development has been the primary cause of mangrove deforestation in North Sumatra, Indonesia [1-4].

The livelihood of many people living in and adjacent to mangrove areas is strongly dependent on forestry and fisheries resources provided by the mangrove ecosystems. Mangrove ecosystems serve as vital spawning, nursery, and feeding grounds for aquatic animals such as shrimp, crabs, and fish, and provide habitats for resident and migratory birds and habitats for other animals [5]. Mangrove conservations as well as sustainable mangrove management, therefore, are needed to maintain the presence of mangrove forest and increased reforestation programs.

Development of silvofishery based on balance condition between conserving mangrove forest and fishery by offering better livelihood for local communities surrounding mangrove forest. Primavera

[6] has suggested that mangroves and aquaculture are not necessarily unharmonious. Such mangrove-friendly aquaculture is amenable to small-scale, family-based operation and may be adopted in mangrove conservation site [6]. The present study, therefore, aimed to evaluate on mangrove management through community-based silvofishery in three villages, namely Paluh Manan, Paluh Kurau, and Lama, Hamparan Perak of Deli Serdang Regency, North Sumatra, Indonesia.

2. Materials and Method

2.1. Study area

The study was performed in three villages, namely Paluh Manan, Paluh Kurau, and Lama, belong to Hamparan Perak District, Deli Serdang Regency, North Sumatra, Indonesia. Three communities used the same ecological type-silvofishery, characterized by planted mangrove surrounded aquaculture. Some sample respondent in this study was 52 respondents from three villagers, which belongs farmer group, respectively as described previously [7]. One farmer group in Paluh Manan has 25 members, in Paluh Kurau Village has 14 members, and Lama Village has 13 members.

2.2. Data collection

Figure 1 depicts the procedure for evaluation of silvofishery including the data collection as previously described [8]. Two scientific activities were done to obtain the data, performing research in the silvofishery ground and literature search to support this experiment. Interview, questioner, and observation were carried out in the silvofishery site to get primary data on the silvofishery system and its application. Furthermore, from literature search resulted in secondary data. Both data were combined through performing research and literature search.Secondary data was obtained from Mangrove Forest Management Agency (BPHM) North Sumatra and Forest Area Conservation Agency (BPKH) North Sumatra regarding with information of site and supporting data.

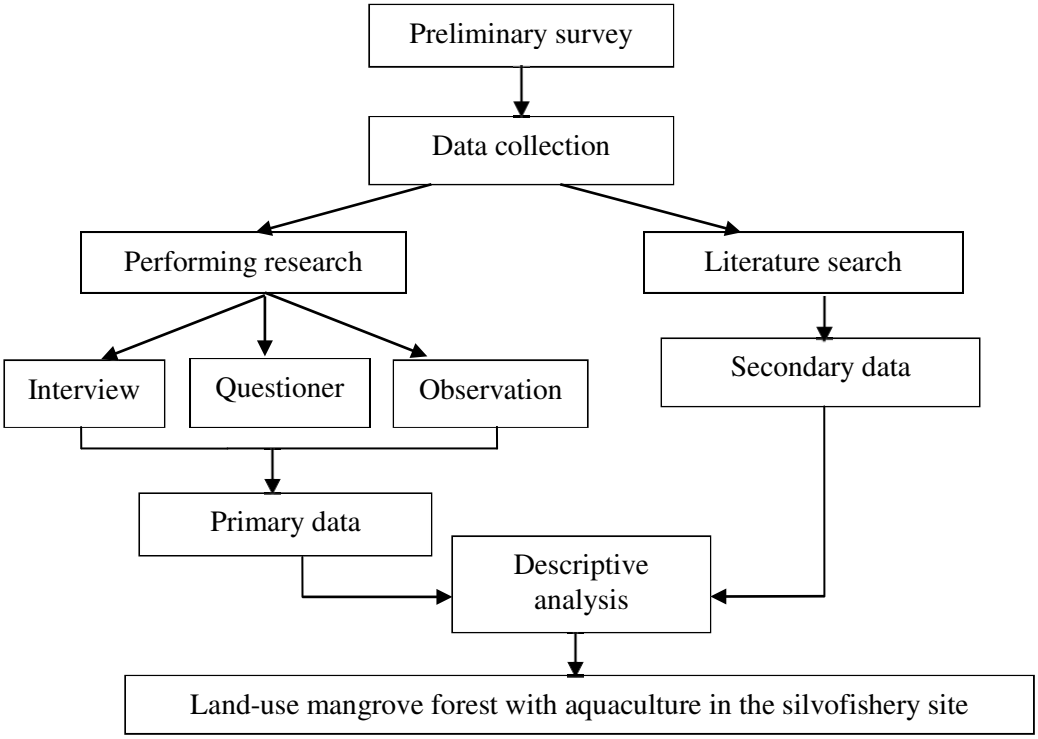

Figure 1. Research procedure including data collection.

3. Results and Discussion

3.1. Silvofishery in Paluh Manan Village

The pond area is influenced by tidal sea process; therefore the community group managed the aquaculture by planting mangrove around the aquaculture. This activity was to strengthen the soil structure of beds as not to be crushed by the tides. The mangrove planted in the pond area is intended to restore fertility and give space to the fish or shrimp seeds that have been spread by farmers and neutralize toxins that exist in the previous fish farming [8].

Maintenance of ponds in the Paluh Manan village concerning water management for the production process is well organized as shown in Figure 2. Figure 2 also illustrates that water coming from the stream enters the pond through a pipe made for the opening of brackish water and regularly drains water. The planted mangroves species were *Rhizophora mucronata*, *R. apiculata* and *R. stylosa* along with intentionally oil palm plantations. Planted mangrove and aquaculture was in the ratio of 75%:25% with planting distance of mangrove 50x50 cm, containing 2,500 trees/ha (Figure 2).

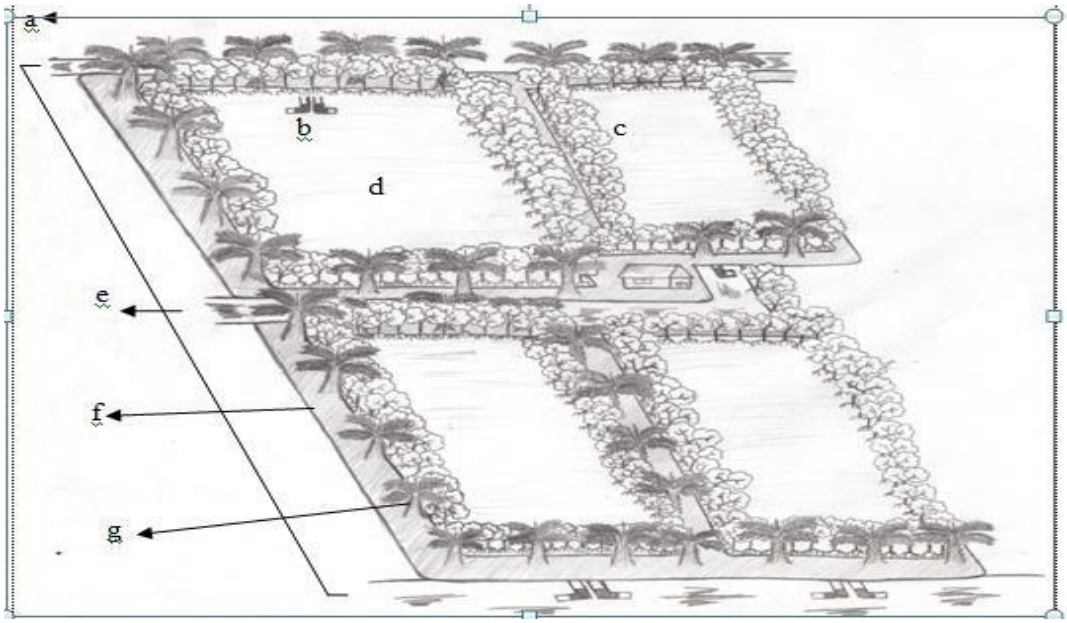

Figure 2. Silvofishery model in Paluh Manan Village. a. Primary road, b. Silvofishery gate for freshwater to brackish water, c. Mangrove species (*R. mucronata* and *R. stylosa*), d. Pond, e. Stream, f. Beds, g. Oil palm plantation

Mangrove planted with ponds in the silvofishery system of Paluh Manan Village consists of, *Rhizophora mucronata, R. apiculata*, and *R. stylosa*. These mangroves are planted on the edge of the ponds because they have an important role in triggering high phytoplankton growth. The type of pond dominated by *R. mucronata* is more suitable for plankton growth and was able to provide higher nutrient than other types of mangrove stands [9]. *Rhizophora* roots do not hamper the pond production process. *R. mucronata* and *R. stylosa* leaves can be used for animal feed such as cow and goat and provide shade for living creatures that exist around the pond [10].

Table 1 shows the cultivated species in the aquaculture are Nile tilapia and tiger shrimp but not the crab species. Crabs had a hole-like risk in the beds that increased the cost of land management. Silvofishery operational cost for six months US$ 186.5 (Table 1). Silvofishery production for one pond within six months is displayed in Table 2. This activity resulted in US$ 36.2/month/ha of fish and shrimp farming.

Table 1. Silvofishery operational in Paluh Manan Village for six months

No	Activity	Cost (US$)
1	Pond activity	38.5
2	Feed	23.1
3	Nursery for Nile tilapia @ 1250	19.2
4	Nursery for shrimp @ 2000	9.6
5	Land rental	38.5
6	Employment	57.7
Total		186.5

1 US $: IDR 13,000

Table 2. Silvofishery production in one pond within six months

No	Type	Price (US$)	Amount (Kg)	Cost (US$)
1	Nile Tilapia	1.15	150	173.0
2	Shrimp	4.6	50	230.8
Total				403.8

1 US $: IDR 13,000

3.2. Silvofishery in Paluh Kurau Village

Silvofishery in Paluh Kurau was initially mangrove production forest. Species composition between mangrove and fish pond in Paluh Kurau Village were *R. mucronata, R. apiculata, R. stylosa* and *Avicennia marina*. Species of *R. mucronata, R. apiculata, R. stylosa* were planted in ponds while *A. marina* planted in front of the sea because this species is expected to protect other species of waves from the sea and appropriate zoning as well [11].

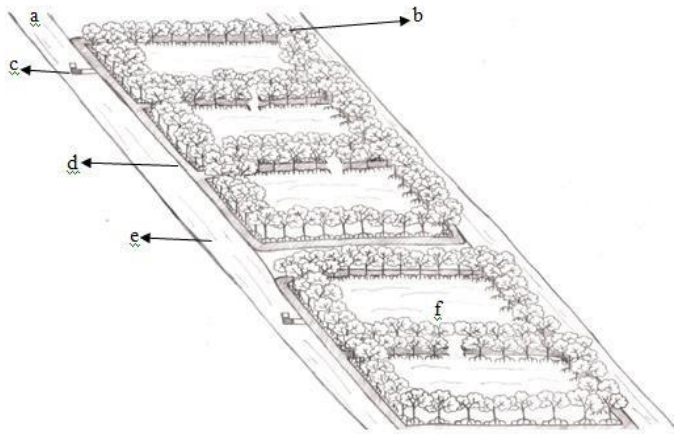

Figure 3. Silvofishery model in Paluh Kurau Village. a. Silvofishery gate for freshwater to brackish water b. Mangrove species (*R. apiculata, R. mucronata,* and *R. stylosa*), c. Pipe, d. Beds, e. Stream, f. Ponds

Community group planted 1,600 mangrove species in the pond area with a spacing of 1m x 1m in 1 ha. The composition of mangrove with ponds is 84%:16%. The silvofishery is believed to be able to combine the interests of mangrove conservation with improving the welfare of the surrounding community. The relationship is expected to form an ecological balance. Ponds that are ecologically lacking producer elements can be supplied through feeding, by the existence of producer subsidies (marine biota) from mangrove forests [9].

Table 3. Silvofishery operational in Paluh Kurau Village for six month

No	Activity	Cost (US$)
1	Pond activity	46.1
2	Feed	30.7
3	Crab seeds @4000	153.8
4	Land rental	26.9
5	Employment	61.5
	Total	319.0

1 US $: IDR 13,000

The profit of silvofishery pond crab cultivation in Paluh Kurau Village was US$ 461.5/6 months. This activity resulted in US$ 23.8 of generating revenue from shellfish farming (Tables 3-4). Crab is a species that can only be cultivated in ponds because crabs live in salt water while shrimp and tilapia are not suitable grown using salt water but brackish water [12].

Table 4. Silvofishery production in one pond within four months

No	Type	Price (US$)	Amount (Kg)	Cost (US$)
1	Crab	2.3	200	461.5

1 US $: IDR 13,000

3.3. Silvofishery in Lama Village

In 2005 community group in Lama Village used intensive pond technology system without mangrove plants. Water did not depend entirely with the ups and downs of inclusion and discharge. This pond resulted from high production results in one-two years, but after three years later the production decreased dramatically.

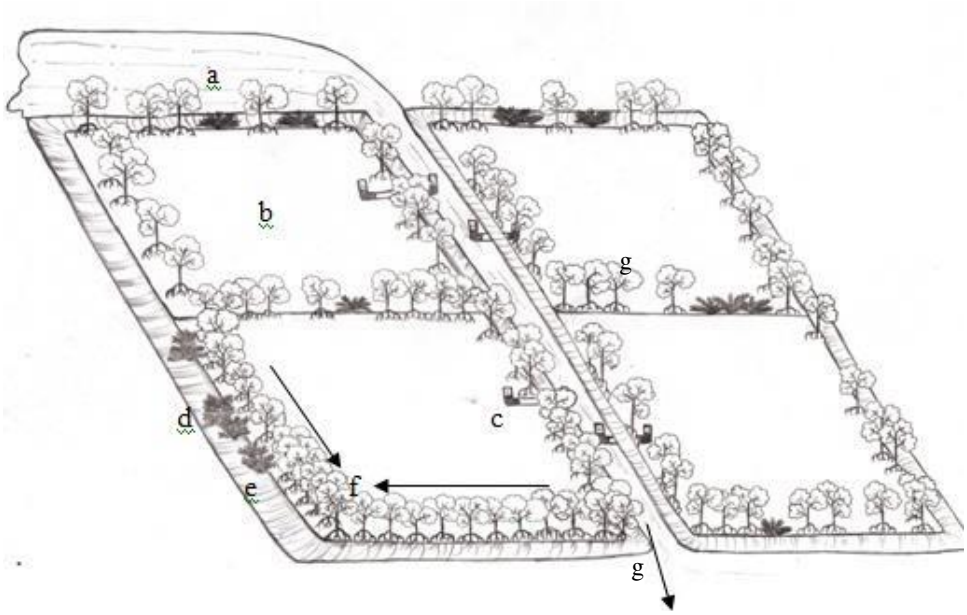

Figure 4. Silvofishery model in Lama Village. a. Reservoir, b. Pond, c. Pipe, d. *Acrostichum aureum*, e. Beds, f. Mangrove species, g. Stream

This aquaculture was destroyed because the results of ponds cultivated such as tilapia, shrimp, and crabs suffered many diseases consequently failed the production. In 2010 they planted in ponds with mangrove species such as *R. mucronata* and *R. stylosa* with total of 1,200 seedlings. In 2013, the

existing mangrove added with *A. marina* and *A. aureum* around the pond area that unintentionally grown. Some crops are intentionally planted in the embankment of ponds like cassava.

As depicted in Figure 4 that the mangroves were planted on the underside or the edges of the ridges, such as *R. mucronata* and *R. stylosa* with a spacing of 2m x 2m with the 1,000 mangrove plants. The composition of mangrove (density) with pond per ha is 90%:10%, led to US$ 45.8/month/ha from fish, shrimp and crab farming (Tables 5-6).

Table 5. Silvofishery operational in Lama village for six months

No	Activity	Cost (US$)
1	Pond activity	38.5
2	Feed and fertilizer	38.5
3	Nursery for Nile tilapia @ 1250	46.2
4	Nursery for shrimp @ 2000	5.7
5	Crab seeds @ 48	8.1
6	Land rental	38.5
7	Employment	57.7
	Total	233.2

1 US $: IDR 13,000

Table 6. Silvofishery production in one pond within six months

No	Type	Price (US$)	Amount (Kg)	Cost (US$)
1	Nile Tilapia	1.15	325	375.0
2	Shrimp	3.8	23	88.5
3	Crab	3.3	19.2	44.3
Total				507.8

1 US $: IDR 13,000

In the mangrove-friendly aquaculture such as silvofishery, this site was planted with mangroves to provide firewood, fertilizers, and protection from the wave. The mixed mangrove-aquaculture system has various benefits such as low capital provision, livelihood diversification through the provision of regular income, and the recognition of an organic farming practice [3]. Thus, at present social induced-rapid developmental changes stipulate a better understanding of the dynamic of mangrove forest [13].

4. Conclusions

Conversion to aquaculture is responsible for deforestation in Indonesia, including in North Sumatran mangrove. This study confirmed that mangrove forest and fishery is compatible by developing silvofishery. The present study suggested the mangrove management through community-based mangrove-friendly aquaculture. Silvofishery benefited from feeding cows, chickens, and goats. Thus, the activity that originated from mangroves can be profitable in all aspects for others.

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