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ECOLOGICAL FOOTPRINT APPROACH IN DETERMINING THE MANGROVE FOREST AREA TO SUPPORT SUSTAINABILITY PRODUCTIVITY OF FISH POND FARMING OF LOCAL FISHERY IN THE COASTAL AREA OF SOUTH BANAWA DISTRICT DONGGALA CENTRAL SULAWESI PROVINCE

(PENDEKATAN JEJAK EKOLOGI DI KAWASAN HUTAN BAKAU UNTUK MENDUKONG PRODUKTIVITI KEMAMPANAN TERNAKAN IKAN KOLAM OLEH NELAYAN TEMPATAN DI PESISIRAN SELATAN BANAWA, DAERAH DONGGALA, PROVINSI SULAWESI TENGAH)

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Abstract

Semi-traditional pond farming operations by local fishermen along coastal areas are characterized by low input use, and low productivity. The existence of mangroves can increase productivity, so that the production of ponds depends on mangrove. This study aims to analyze the mangrove area that preserved to support productivity per hectare of ponds in a sustainable manner. The study was conducted in the coastal area of South Banawa District from June to August 2017. A sample of 30 local fishermen who tried to intercropping shrimp and milkfish intercropping semi-managed traditionally. Sample is chosen by purposive method because the character of population is heterogeneous. Qualitative analysis is used to explain the problems of pond management, while quantitative analysis based on the ecological footprint model to determine the area of mangrove forest is maintained to support the productivity of ponds in a sustainable manner. The results of this study indicate that the ratio of mangrove forest to pond business per hectare is 0.29: 1 hectare. The total ecological mangrove maintained in the South Banawa area is 343.1 hectare, consisting of 308.3 hectre to support the fish pond, and 34.8 hectare to support local consumption cultivation.

Keywords: Pond business, local fisherman, coastal area, ecological footprint

Abstrak

Operasi perladangan kolam semi-tradisional oleh nelayan setempat di sepanjang kawasan pesisir dicirikan oleh penggunaan input yang rendah, dan produktiviti yang rendah. Kewujudan bakau boleh meningkatkan produktiviti, supaya pengeluaran kolam bergantung kepada bakau. Kajian ini bertujuan untuk menganalisis kawasan bakau yang dipelihara untuk menyokong produktiviti setiap hektar kolam dengan cara yang mampan. Kajian ini dijalankan di kawasan pesisir Daerah Banawa Selatan dari Jun hingga Ogos 2017. Sampel 30 nelayan tempatan yang cuba menceburi ternakan udang dan ikan susu secara separa tradisional. Sampel dipilih dengan kaedah purposive kerana sifat populasi adalah heterogen. Analisis kualitatif digunakan untuk menjelaskan masalah pengurusan kolam, manakala analisis kuantitatif berdasarkan model jejak ekologi untuk menentukan kawasan hutan bakau dikekalkan untuk menyokong produktiviti kolam secara mampan. Hasil kajian ini menunjukkan bahawa nisbah hutan bakau untuk perniagaan kolam sehektar adalah 0.29: 1 hektar. Jumlah bakau ekologi yang dikekalkan di kawasan Banawa Selatan adalah 343.1 hektar, yang terdiri daripada 308.3 hektar untuk ternakan ikan kolam dan 34.8 hektar untuk aktiviti penanaman bagi kegunaan tempatan.

Kata Kunci: Perniagaan kolam, nelayan tempatan, kawasan pesisir, jejak ekologi

INTRODUCTION

The coastal area is a resource that nourishes many local people. Utilization of resources can provide economic opportunities and welfare. Continuous improvement in economic and welfare capabilities is achieved when production increases are accompanied by sustainable environmental friendliness. Therefore, the management of these resources should be based on the principle of sustainability.

Indonesia as an archipelagic State has the second longest beach in the world after Canada, which is 81.791 km (Wa Alimuna 2009). About 75% covering 257 districts of Indonesia are coastal areas covered by Mangrove Forest of 3.5 million hectare, or 23% of the world's 15 million mangrove forests, making coastal areas an important ecosystem for marine and terrestrial biota (Ministry Environment and Forestry RI 2017).

As an ecosystem, mangroves have ecological functions that are not economically valuable (Dwi Setyawan et al. 2002). Even ecological functions also describe potential economic functions as a source of livelihood for the population, industrial raw materials, and foreign exchange (Suryono 2013). Mangrove management and conservation is inseparable from the development of pond farming (Dahuri et al. 1996) as a source of local community's economy because, both types of resources viewed from the ecological aspect have asymbiotic relationship of mutualism and from the economic aspect has a complementary. However, from the spatial aspect is substitution. According to the perception of fishermen, the substitution capacity of mangrove ponds on mangrove is higher than mangrove substitution capacity of ponds because, the economic value of mangrove when made in pond is bigger than preserving it. However, from the environmental aspect, mangrove has an important role because its function such as: (1) continuous and consistent supply of energy; (2) maintaining the consistency of mud (not solid); (3) neutralizing water pollution; (4) neutralizing CO_2emissions from various sources, and (5) Carbon sources. (Lear and Turner, 1977).

The development of ponds under huge conditions of mangrove, the productivity can reach between 500 - 800 kg /hectare/year(Bur Bridge, at al, 1988 and Abu Dardak et al. 1988), at the same price, the business can provide more profit compared to conditions without mangrove forests. Therefore, the mangrove population owned by Indonesia (23%) must be preserved, because its role is not replaced with other resources (Novianty Riny et al. 2012). However, lately the population continues to decline (Pramudji 2002), because it converted function to various needs, especially ponds (Yunidar et al. 2015). One of them is mangrove population in South Banawa region declined from 1,118.00 hectare to 54.94 hectare (4.51%).

According to Abu Dardak et al. (1988) any loss of 1 hectare of mangrove will lead to a decrease in shrimp production of about 480 kg/hectare. This is reinforced by Bur Bridge et al. (1988) that, pond productivity in thin areas of mangrove forest populations is only about 410 kg / hectare / year. Consequently, the profits from the pond business are getting smaller and not feasible. This shows that the productivity of pond business depends on the sustainability of mangrove.Some concepts related to the principle of sustainable development that has been used are: (1) agroforestry, (2) selvovishery, (3) daily *Banjar* and (4) licensing, but in reality the application has not run well yet.

Deforestation of mangroves, originated from conflicts of interest and views among stakeholders on the economic and ecological value of mangroves. Based on the perspective of local communities, mangrove is a resource of high economic value if converted to ponds (fishery and marine sub-sector), while the ecological perspective, pond business high economic value if the carrying capacity of mangrove is maintained (forestry sub-sector).

Carrying capacity is the largest population that can be supported by habitat. Natural carrying capacity such as mangroves has certain limits in supporting environmental balance. It Mean the carrying capacity of a mangrove forest to a population can be increased if it always uses sustainable principles in its utilization (Wackernagel and Rees, 1995). The principle of sustainable development besides managing also protects natural resources and is oriented towards changes in technology and institutions in order to ensure the sustainability of generation needs. Sustainable development; protecting soil, water, genetic resources of plants and animals, not ecologically destructive, technically applicable, economically and socially acceptable (Agenda 21 Indonesia, 1994). Based on this definition, mangrove resources can provide the greatest socio-economic benefits to the community if the utilization is also considering conservation actions. According to Paembonan (1987), sustainability is defined as a change that increases over time. Development which is a conscious effort of human being is environmental change, that is reducing environmental risk or enlarge environmental benefits (Soemarwoto 1992).

According to Wackernagel and Rees (1995) if excess resource consumption, it will exceed the carrying capacity called "over shoot". This phenomenon causes a "crash" in nature called "big bang". Therefore, the consumption of sustainable resources is to save and adjust to the carrying capacity so that the utilization is still sustainable. Therefore it is necessary to establish the ratio of mangrove forests to the needs of local communities for the consumption of mangrove forests remain at the carrying capacity. One of the planning models based on sustainable and applicable development principles is Ecological Footprint (EF) (Wackernagel, 2002). EF is an analytical tool for determining the ratio of mangrove forests with ponds per hectare so that existing conflictsof interest can be resolved in the coastal region of South Banawa Central Sulawesi Province.

RESEARCH METHODS

Selection of Research Village

The research was conducted in seven villages in South Banawa area: Surumana, Lalombi, Tanamea, Tolongano, Tosale, Lumbudolo, and Salubambu with the consideration that this area has unique ecosystem which is characterized by lake and surrounded by mangrove, has been transformed into shrimp pond in intercropping with local milkfish. The study was conducted for three months from June to August 2017. Activities undertaken during the first month were completing licensing, selecting respondents and conducting surveys. Furthermore, taking secondary data in various related agencies, the last is tabulation, data analysis and writing research report.

Sampling

The sample of research is determined by 30 local farmers with purposive sampling method with consideration of heterogeneous population livelihood (Jogiyanto, 2010) in 7 villages in South Banawa region. The sample of 30 is expected to represent the character of the population measured, so as to provide representative data.

Data Collection

a) Primary data, is data obtained directly from the respondents through interviews using a questionnaire. The data can be qualitative and quantitative, including data on the ownership of ponds, the number of shrimp and milkfish products consumed by farmers per harvestand data from key figures in the region.

b) Secondary data, is sourced from documents, annual reports, references, and journals. Covering area, population, mangrove forest area, pond area, shrimp/fish/hectare pond population, pond productivity, weather, climate and data other than primary data related to this research.

Data Analysis Technique

The approach technique used to determine the area of Mangrove Forest needed / maintained to support the productivity of the pond business in a sustainable manner is the ecological footprint approach (EF), mathematically can be formulated as follows (Wackernagel and Rees, 1995):

$$EF = N\,(ef), \text{ where } ef = \sum_{i=1-n}^{n} aa_i$$

Application of the analysis, carried out through the following stages:

1) To estimate the average consumption (kg / individual / year) by the formula:

$$ConsumptionAverage = \frac{\sum Cnsumption / year}{\sum population}$$

2) Determine the average productivity of land per hectare (p) with units (kg/hectare /year)

3) Estimate land area suitable for producing every major consumer goods / raw materials (i) per individual (aa_i) hectare/individual, carried out by formula.

$$aa_i = \frac{c_i}{p_i}$$

Where: C_i = average consumption per year, p_i = average productivity per year
t = month, aa_i = land to produce primary consumption needs per individual

Its application, ecological footprint (EF) is taken through the following stages:

(1) Estimates the average annual consumption of individuals using aggregate consumption data, divided by total population consumption or estimated consumption every individual/family by direct measurement. Most of the data required in the analysis is nationally available in tables, statistics, such as tables of energy needs, food / feed, or products derived from forests as well as consumption needs tables for some categories or taken directly in the field.

(2) Estimate the area of forest provided per individual (aai) to produce the main needs goods (food) (i). That is, by dividing the average consumption at a given time (month / year) of the consumer goods (c) above, in kg / individual / t, with average productivity at a given time (t) or yield per time particular (P), in kg/hectare, aai = ci / pi.

To calculate the total EF per person (ef), it is necessary to assume that all existing ecosystem areas (aai) are capable of producing / providing consumption goods for fish / shrimp in ponds and local people. There are 5 main categories of consumption: (1) food, (2) housing, (3) transportation,

(4) non-food goods, and (5) services. By obtaining the total EF of individual per-capita, the total EF of the population we study (N). To assess the EF of a land, the existing land / forest is distinguished over the main land and is categorized as its use. The main land is divided into 4 kinds and 8 categories of its use (Wackernagel and Rees, 1995).

(3) Determining mangrove area for various needs in South Banawa region is done by following stages: minimum mangrove forest area to support sustainable pond productivity based on existing pond area (Lp) in thearea.

$$L_P = R_1.\sum L_t \text{ .....(1)} \qquad R_1 = \frac{\Delta E}{\lambda} \text{ ...... (2)} \qquad \Delta E = \frac{\sum (E_k - 2E_S)}{\varepsilon} \text{ ...... (3)}$$

Where: R1 = the area of mangrove forest that supports each hectare of pond area (hectare)
ΣLt = total number of ponds available (1,063,1hectare)
ΔE = lack of energy / hectare of ponds that must be supplied from mangrove forests
λ = 100 GJ / hectare, ε = 0.239 x 106, P = production (kg), and ΣD = population (people)

b) mangrove area for local consumption pond location (Lb) for local population.

$$L_b = \frac{\sum C_U}{P_t}.\sum D \text{ , ...(4);} \qquad P_t = \frac{\sum P}{\sum L_t} \text{ ; ......(5);} \qquad L_e = L_P + L_b \text{ , ... (6)}$$

Where: Σ Cu = Total consumption of shrimp (kg / individual), Pt = productivity of pond (kg /hectare)

c) determine the total amount of mangrove area maintained to achieve equilibrium (Le).

d) the area of mangrove forest to be planted (Lo) to reach the area above (Le) in the area:

$$L_e = \sum L_i \text{ , ... (7);} \qquad L_o = L_e - L_S \text{ , ...(8);} \qquad L_S = 54.94ha \text{ , ...(9)}$$

(4) Determining the economic benefits of pond cultivation in the South Banawa area, the fish farming analysis is used: Net B / C-ratio (Choliq, 1993).

RESULTS AND DISCUSSION

Characteristics of Aquaculture

The characteristics of ponds in 7 villages in the South Banawa area during the years (2005 - 2016) can be grouped over four production periods. Each period consists of 5 years and 2 years i.e. the period of 2005, the period of 2014 period of 2009 and the period of 2016. This grouping is based on the consideration period of data validation/updating by the local government, so the data more accurate. The characteristics of the pond cover the area, changes in area, production, production changes in each period.

1. Pond Area

The area of ponds in South Banawahectares increased every period. The highest increase in 2014, i.e. from 726.96 hectare and peak in 2016 reach to 1,063.1 hectare. This increased, occurs in each village.

Table 1. Pond Area Each Period, Year 2017

Village	Area (hectare)			
	2005	2009	2014	2016
Surumana	32,25	105,00	190,50	293,50
Lalombi	30,00	132,00	162,60	294,60
Tanamea	17,00	54,00	96,10	150,10
Tolongano	16,50	41,55	268,38	309,93
Tosale	1.30	2.80	3.13	5.93
Lumbudolo	0.25	0.75	2.75	3.50
Salubambu	0.50	2.00	3.50	5.50
Total	98.05	338.10	726.96	1.063.10

The table shows the increase of pond area in each village. In 2005 the largest was Surumana Village 32.25 hectare (32.98%), and the most narrow was Lumbudolo Village 0.25 hectare (0.26%). The largest pond area in 2009 is Lalombi Village 132 hectare (39.04%) and the most narrow is Lumbudolo Village 0.75 hectare (0.22%). In 2014 the largest pond is Tolongano Village 268.38 hectare (36.92%), and the smallest is Lumbudolo Village 2.75 hectare (0.38%) and the largest pond in 2016 is Tolongano Village 309.93 hectare (29.15), and the most narrow is Lumbudolo Village 3.50 hectare (0.33%)

The increase of pond area occurred because in that period the shrimp price jumped. The price of shrimp in the previous year's market is only Rp 30.000 /kg increased to Rp 150,000 / kg by the end of 2013 until the end of 2015. Therefore, the expansion of the aquaculture area is caused by the market pressure. Efforts to increase production continue to pursue price incentives through intensification with pond farm fertility measurements compared to intensification with technological measures. This causes the farmers to expand to a more fertile place. Such 30 respondents only 10% are intensifying existing ponds and 90% are expanding into new areas. Of the 90% of the expansive population, 66.7% are pond owners and 33.3% of pond workers. Therefore the expansionary push factor is caused by the management of ponds that do not think about the sustainability of the mangrove carrying capacity that supplies natural energy to the ponds.

2. Natural Ponds

Natural ponds, forming like lakes use as ponds, not made by humans, but formed by nature. Its depth is about 11 m, surrounded by mangrove trees where water is a mixture of fresh water with sea water entering when the tide. There are fish that enter themselves at the time of the tide and settle in the lake and harvested by the community at certain times in mutual assistance under the control of the village head.

The function of this lake is used as a comparison in this study, especially related to the contribution of ecological mangrove forest to the sustainability of productivity of pond business in the region. There is no introduction of any cultivation technology, such as supplementary feeding, maintenance and others. The productivity of natural pond also decreased with the decreasing of mangrove forest population from year to year.

Table 2. The productivity of Natural Ponds in the South Banawa District of Donggala Regency

No	Years	Products (kg)	Productivities (kg/hectare)
1	2016	417.50	9.94
2	2014	622.20	14.31
3	2009	1.014.42	24.15
4	2005	1.267.30	30.17

Table 2 shows that, the productivity of natural ponds in 2009 decreased compared to productivity in 2005, and the productivity of 2014 was lower than in 2009, and the productivity of 2016 was lower than in 2014. The decline was related to the depletion of mangrove forest populations.

In contrast to the natural ponds, artificial ponds for both shrimp and milkfish production, although the increase in absolute but relatively not significant increase, because the natural food of shrimp / fish available is less due to declining mangrove forest populations. In the period of 2005-2009 and 2009-2014 the production is quite high, but the increase is decreasing. The lowest increase occurred in the period 2014-2016 from 4.20% to 1.66% for shrimp, while the milkfish from 3.56% to 1.88%. In the case of the previous period of 2005-2009 reached 7.56% for shrimp and 39.12% for milkfish.

Table 3. Increasing Productivity of Pond Cultures in South Banawa Years Period (2005-2016)

		Productivities (kg/hectare)		Decline Percentage of Productivities (%)	
No	Years	Shrimp	Milkfish	Shrimp	Milkfish
1	2016	288,37	189,04	1.66	1.88
2	2014	283,57	185,48	4.20	3.56
3	2009	271,67	179,25	7.56	39.12
4	2005	250,05	109,13		

The largest decrease in pond productivity occurred in the period 2005-2009,ie 7.56% for shrimp and 39.12% for milkfish. Furthermore, the increase from the period of 2009 to the year 2014 increasing decreased and the smallest occurred in the period 2014 to 2016 that is 1.66 for Shrimps and 1.88 for milkfish. The decrease in productivity of aquaculture ponds is periodically related to the decrease of Mangrove Forest, ie from 1.71% in the period 2005-2009. The largest decrease in the period 2014 to 2016 amounted to 6.79%. When the increase in pond productivity increases with decreasing mangrove population, the character is in conflict with each other. The productivity of the pond increased steadily from 7.56% to 4.20% and lowest at 1.66% for shrimp and from 39.12% to 3.56% and at the lowest productivity increase at 1.88% point for milkfish. If the increase in pond productivity decreases, than the decrease of mangrove population decrease, increasingly larger (Table 4). The decrease of 1.71% in the period of 2005-2009 to 2.14% in the period of 2009 -2014, and to 6.79% in the period 2014-2016.

Table 4. Decreased Area of Mangrove in South BanawaYears Period (1987-1999)

		Productivities (kg/hectare)		Decline Percentage of Productivities (%)	
No	Years	Shrimp	Milkfish	Shrimp	Milkfish
1	2016	288,37	189,04	1.66	1.88
2	2014	283,57	185,48	4.20	3.56
3	2009	271,67	179,25	7.56	39.12
4	2005	250,05	109,13		

The greater decline in mangrove forest populations is caused by massive mangrove logging since these years and peaked in 2005 along with the higher price of shrimp and milkfish. The declining mangrove forest population hectares an impact on the decrease of natural food production for the surrounding biota. However, this impact does not occur instantly so it is not directly felt by farmers. The turmoil is reflected in the decrease in productivity of natural ponds in 2009-2016. In the present condition, fish weight is lighter than the previous year. Formerly 6-7 fish/kg, now become 10-15 fish/kg. Shrimp ponds/fish farms are also small and light, but are supplied with feed and artificial fertilizers so that their physical productivity increases, and can be maintained by increasing the feed dosage. Every year 100% of respondents increase the feed dosage from 200 kg/hectare in 2014 to 250 kg/hectare in 2016. With the depreciation of the rupiah against the current US dollar, the factor price of production also increases, so it will affect the profitability of farmers. The advantages obtained by farmers in the present day is lower than the previous one. However, with the increase in the price of shrimp/fish, the fishpond business is still profitable, causing degradation of mangrove forest and the remaining 54.94 hectare.

The results of the analysis show that, mangrove forests should be maintained to support the existing population of 339.48 hectare. Consisting of 304.80 hectare to support pond productivity and 34,80hectare for shrimp and milkfish locality for local consumption with assumption that mangrove forest productivity is about 2.3 m3 / hectare / year and 100 GJ / hectare (energy). To reach that amount, mangrove is planted (339.48 – 54.94 hectare) = 284.54 hectare.

3. Growth of Pond Area and Advantage of Fisherman

The highest growth of Shrimp Pond/Milkfish in the period of 2005/2009 were Lalombi Village 77.27%, 75.00% Salubomba, 69.04% Surumana, Tanamea 68.52%, and Lumbudolo Village 66.66%. The lowest growths were respectively Tosale Village 38.89%, and Tolongano 59.08%. The price of shrimp in 1987 was Rp 5,000 / kg, and milkfish of Rp 1,500 / kg. the price is quite high, because the exchangerate of the Dollar is (Rp 1,664/1 USD).

In the period of 2009/2014, the highest growth of Shrimp Pond/Milkfish was Tolongano Village 84.49%, Lumbudolo 72.72%, Surumana 44.88%, Tanamea 43.81% and SalubambuVillage 42.85% while the lowest was TosaleVillage 10.54%.

The price of shrimp in 1992 rose to Rp 18,000/kg, as well as milkfish rose to Rp 2,000/kg. In the period of 2014/2016, the highest growth of ponds was Tosale Village 47.22%, Lalombi 44.81%, Salubambu 36.36%, Tanamea 35.97% and Surumana 35.09%. The growth of the lowest pond area in Tolongano village is 13.41%, and Lumbudolo 21.43%. The price of shrimp in 2016 rose Rp 64,333 / kg, and milkfish Rp 5,000 / kg, with the exchange rate USD 7,100/1 USD.

At the price of shrimp farmers (gate price) Rp 18,000 / kg, and milkfish Rp 2,000 / kg, in 2009, farmers profit Rp 12,164,217.10/hectare, net B/CR> 1 (6.02). At gate price Rp 25,000 / kg, and milkfish Rp 2,500 / kg in 2014, farmer profit Rp 23,240,631.50 with net B / CR> 1, (6.88). At gate price of shrimp Rp 64,333 / kg, and milkfish Rp 5,000 / kg in 1999 farmer profit Rp 72,599,714.00/hectare with net B/CR> 1 (10.22). This is supported by the results of Ginting's (2014) research on three types of fish (Tilapia, milkfish and shrimp) in Nelayan Indah Village which concluded that, economically, all types of branches are profitable and financially viable (Lamusa, 2013 and Mahmud, et al. 2007).

4. Footprint Productivity Pond

Shrimp and Fish Energy Requirement

Shrimp/ fish milk requires energy for activity and growth. Energy must be met at all times whether sourced from feed or from natural. Natural food of shrimp /fish is generally supplied from its environment through food chain mechanism. Food chain mechanism in the aquaculture areas are mangrove leaves (Learand Turner, 1977). Therefore, without mangrove forest (source) the mechanism food chain is difficult to take achieve and will inhibit the supply of energy to the existing biota (sink), including to the shrimp/fish cultivation. In addition to the inhibited supply of energy from source to sink also leads to a decrease in the quality of the environment in general, especially the aquatic environment where shrimp/fish are cultivated. Feed (artificial) in the long term can condense the mud in the pond. So in the concept of sustainable development, feed is an additional energy, not the main food. Fish during growth (from release until harvest = 120 days) requires energy between 4,000-6,000 kcal or an average of 5,000 kcal every one kilogram of rough product.

Shrimp Energy Requirement

The demand for shrimp and milkfish energy can be determined from the large dosage of feed supplied, and the duration of maintenance and the content of each feed given per kilo of calories i.e. 250 kg/hectare coconut cake (BK), 600 kg/hectare bran (DD), 120 days (4 month) maintenance period, 2,212 kcal energy BK and 1,630 kcal energy DD (Juju Wahyu, 1990). Based on these data, the requirement of Energy Shrimp (KEU) is 1,531.00 kcal.

Energy Requirement for Increase Body Weight of Shrimp (KEPBBU)

The amount of energy per day supplied by the farmer is the total energy provided during the maintenance period divided by the length of maintenance, So KEPBBU is 12,758.3kcal/day. So the amount of packing given per day to produce 12,758.3 kcal of energy is 850 kg divided by maintenance (120 days) equal to 7.1 kg/day (daily consumption). From 7.1 kg/day this is resulted 12,758,3 kcal of energy for requirement of body weight gain (KEPBB).

Added Shrimp Body Weight/Milkfish (PBBU).

The number of larvae (*nener*) stocked 29,614 fish/hectare, with 25% mortality rate, the number living up to harvest: 0.25 x 29,614 = 7404 individu, 29,614 - 7404 = 22,212 individu, the average harvest weight = 27 (17- 36 individu)/kg, so productivity = 4,424.3 divided by 27 individu = 163.9 kg/hectare. Based on initial body weight (BBA) = 1 kg/5205 larvae, the weight of shrimp body/milkfish (PBBU) is 7.05kg /day. So the UN shrimp for 120 days with feed concentration of 250 kg BK and 600 kg DD (850 kg)/hectare is 7.05 k /day (of the total).

Productivity of ponds = 847.1 kg/hectare

Shrimp energy requirement/hectare: 5000 kcal/individu x 2 x 847.1 = 8.471.000 kcal, so the energy shortage per hectare of pond: 8.471.000 kkal - 1,531,000 kkal = 6.940.000 kkal or 29.037657 kkal (ΔE) . Assumption; natural energy needs derived from mangrove forests. So the energy needs per shrimp/shrimp ponds = 0.289 GJ/hectare.

Needs Mangrove Forest

Lack of energy from feeding and supplied from outside of mangrove into = 29.03 GJ/hectare. While the productivity of mangrove energy = 100 GJ/hectare, then the mangrove area needed to support productivity per hectare ponds = 0.29 hectare or 1: 0.29. So the area of mangrove that can support the productivity of pond is 1.603 hectare = 308,3 hectare (27.58%).

5. Footprint of Local Consumption Cultivation

The mangrove area needed to support the sustainability of the cultivation of pond for local consumption is 34.80 hectare (3.11%) so that the shrimp need for local community of 2.02 kg/ person/year can be fulfilled. Footprints for firewood public consumption are not counted, because they do not qualify (Wackernagel and Ress, 1995), because firewood they use is not coming from logging but mangrove branches or dead logs.

6. Total Footprint

Based on the calculation for the above mangrove forest requirement, the total footprint of South Banawa area is 343,10 hectare or 30.70% from the area of original mangrove forest and equilibrium point between carrying capacity with mangrove consumption is 288,20 hectare or 25.78% from area of mangroves required.

CONCLUSION

The ratio between pond area and mangrove forest is 1: 0.29. This means the footprint of each hectare of 0.29 hectare pond to support the productivity of ponds and environmental sustainability in a sustainable manner. The total mangrove that is maintained in the South Banawa Region is at least 343.1 hectare (30.7%) of the total initial mangrove forest, which is 308.30 hectare to support the productivity of the 1.063 hectare pond, and 34.8 hectare to support shrimp/fish farming for local consumption including natural ponds. So the equilibrium point between the carrying capacity and the level of mangrove forest consumption in South Banawa region will be achieved on the minimum mangrove area of 343.10 hectares or 30.70%. To reach the area, it must be mangrove area of 288,20 hectare (25.78%) for local consumption including natural ponds. So the equilibrium point between the carrying capacity and the level of mangrove forest consumption in South Banawa region will be achieved on the minimum mangrove area of 343.10 hectares or 30.70%. Physically, the productivity of the pond decreases as the mangrove population diminishes, but economically the pond business is still profitable. The high price of shrimp, the economic value of the pond. Therefore, the added value of mangroves when converted to pond is higher than that of preserved mangrove, so mangroves tend to be converted to ponds.

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