Coastal Community Welfare Improvement through Optimization of Integrated Pond Farming Management in Indonesia

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Abstract: The lack of tenure and limited production factors causing coastal communities always be trapped on the circle of poverty, or far from prosperous. The research objective is to optimize the use of seaweed production factors that integrated with milkfish to improve the welfare of coastal communities in Indonesia. Data analysis employed Multiple Goal Programming methods. The results showed that the average of pond tenure by farmers covering 5,1 Ha with seaweed production 13,191 tons, and profits IDR76,347,700.0 per year (1USD equal to 13,000IDR). The maintenance costs of pond is the kind of production factor that limited availability, while production factors seeds, seedlings, fertilizers, and pesticides, are relatively available to farmers. Optimization results the integrated management of pond show the maximum revenue is achieved IDR1,089.89 million, labor employment 72 people, and target of seaweed production reached 188.65 tons. This means that the welfare of the farmers can be improved through the expansion of pond, and the addition of the production factor, especially capital and fertilizer.

Keywords: Coastal community welfare**;** optimalization; integrated pond

1. Introduction

It is important to note that from the regional economy perspective, the coast is an area inhabited by a society that is identical to the level of mastery and ownership of the factors of production (natural resources) are limited so that the level of income and education are low, minimum infrastructure and tends to be in the circle of poverty. The problem of poverty and underdevelopment that still dominates Indonesian coastal rural people's problems is higher quantity than urban communities. Statistics of Indonesia (BPS) show that in 2009 the number of poor people recorded 32.53 million, most of which are coastal people who are struggling in the activities of utilization of marine resources and fisheries. Arsyad *et al.* (2014) founded that 99.89 percent of households seaweed cultivators have a per capita income below the poverty line. Related to poverty reduction, since 2009 the Ministry of Maritime Affairs and Fisheries (KKP) has initiated a community empowerment program through the National Program for Community Empowerment Maritime Affairs and Fisheries (PNPM KP) under the coordination of the Coordinating Ministry for People's Welfare.

In line with the policy of the Ministry of Maritime Affairs and Fisheries who want Indonesia to become the largest producer of fishery products in 2015, the Directorate General of Aquaculture launched a program to increase production from 4.7 million tons in 2009 to 16.8 million tons in 2014, an increase of 353% for five years (KKP, 2014). Along with the mission of Marine and Fisheries who want the welfare of society, especially fish farmer, then in 2011 launched Rural Fisheries Enterprise Development (PUMP) of Aquaculture. This activity was conducted as background that socio-economic conditions are poor fish farmers. It is considerably important to note that poverty is a complex social phenomenon that cannot be seen by one view point meaning many factors associated with poverty itself, not only internal factor such as household human resource and production factors ownership, but also more importantly the impact of external factors such as access to social services and information availability in the community across developing countries (Arsyad and Kawamura, 2009) and Indonesia is no exception. Another crucial dimension associated with poverty in developing countries like Indonesia is both the role of agriculture and non-agricultural sectors in poverty reduction (Arsyad and Kawamura, 2010). This indicate sthat access to information can be crucial factor to reduce poverty.

One attempt was made to achieve the program increase the production through industrialization commodity pond aquaculture on land as a commodity seaweed (Gracilaria sp), shrimp and fish. The management of ponds in coastal areas of Indonesia is carried out both monoculture and polyculture with other fish species, shrimp or seaweed or commonly known as mariculture systems (integrated mariculture systems). FAO (2009), modern integrated mariculture systems must be developed in order to assist the sustainable expansion of the sector in coastal and marine ecosystems to increase of responding to the global demand for seafood but with a new paradigm of more efficient food production systems. Aquaculture systems are integrated and synergistic currently widely researched and studied because it can improve the quality of the water. Murachman *et al.* (2010) found that by integrating seaweed into polyculture farming black tiger shrimp and fish (three commodities) will improve quality of the pond water, which in turn will increase production and revenue of polyculture farming. Similarly, many different possible combinations of the species and the system can be directly beneficial to farmers either through additional valuable products, promoting the re-circulation (improving water quality), preventing diseases, habitat conservation, or increasing allowed production volumes through waste reduction (Troell, 2009) getting health environment in coastal area.

In Central Sulawesi of Indonesia, the utilization of the resource potential of coastal aquaculture in 2013 has resulted in fisheries production reached 1.23 million tons, an increase of 8.5 percent from 822,868.6 tons in 2010 (Statistics of Central Sulawesi Province, 2014). Commodity aquaculture accounted for the largest (of total fishery production) derived from seaweed of 1.16 million tons (94.50 percent). Based on the development roadmap seaweed Central Sulawesi Province, there are some districts that made the center of development and producer of seaweed is the largest order of the Banggai Islands Regency, Morowali, Parigi Moutong and North Morowali (DKP Central Sulawesi Province, 2012). Utilization of the coastal region of North Morowali Regency generally focused on commodities seaweed (Euchemma cottoni and Gracilaria sp) cultivated in coastal waters and pond areas. Management of seaweed cultivation in ponds is generally performed in polyculture with milkfish.

Integration of seaweed and milkfish cultivation can indirectly provide feed requirements for the growth of milkfish. Contrary, organic wastes excess fish can be parsed by seaweed (bioremediation) into oxygen by photosynthesis (Butterworth, 2010). Mariculture that integrated between fish (inorganic aquaculture) with seaweed (organic extractive aquaculture) can implications for the waste produced fish will be a factor of production (fertilizer) for seaweed (Chopin *et al*., 2001; Barrington, *et al*., 2009). Its means that the integrated mariculture can take place in ponds of coastal waters and can be highly intensified. The combinations of seabream culture, shellfish and seaweed farm can produce 25 tons of fish, 50 tons of bivalves and 30 tons of fresh weight of seaweeds annually per 1-ha (Neori *et al.,* 2004). However, in order to maximize profit cultivation farming, and increase employment and seaweed production required factors of production (input) such as seeds, fish seeds, fertilizers, herbicides and operating capital maintenance in optimal amounts (available) in order to get a land area of optimal to be pursued. Irmayani, Yusuf and Arsyad (2015) pointed out that capital is one of the factors of production used in the production process. Production can be increased by using tools or machines efficiently. In the production process there is no difference between equity and loan capital, which each act directly in the production process. Capital accumulation occurs when a portion of the income is saved and reinvested with the aim of enlarging the productivity and income.

Indications show that coastal communities in Indonesia, especially North Morowali District (the area of market access is limited) to manage ponds to semi commercial purpose, so that there is one of multi-trophic commodities managed intensively. As a result, utilization of resources (natural and human) are owned by farmers and the area has not been maximized to improve their welfare. Troell *et al*. (2003), it is necessary to analyze the role and function of integrated aquaculture practices for improved environmental, economic, and social acceptability within the broader perspective of integrated coastal management initiatives. Given this cuurent issue, the research objective is to optimize the use of production factors seaweed that is integrated with the milkfish in order to improve the coastal communities welfare in Indonesia.

2. Materials and Method

2.1 Research Site and Data Collection

The research was conducted in Bungintimbe village, East Petasia Sub District, North Morowali District of Central Sulawesi Province, Indonesia used a survey method. The site is the only village in the district of North Morowali which cultivate seaweed Gracilaria sp that integrated with milkfish in the pond. Given the research object is pond cultivator that number 20 people, the determination of sample using census method. This means that all members of the population pond cultivators used as a sample.

Types of data collected included primary data and secondary data. The primary data sourced from interviews with respondents seaweed cultivators integrated with fish. Components of this data include the type of data the initial investment costs (land value, the value of the equipment, building value and the value of ancillary equipment), operational costs seaweed farming and milkfish (seed seaweed and fish, fertilizers, herbicides, production, prices and seaweed and milkfish), maintenance costs, labor costs and other support costs. In addition to the primary data, also used supporting data (secondary data) within the scope of the village such as the total availability of seeds, fertilizers, herbicides, labor. Collecting data using the method of observation, interviews and literature studies which originate from various agencies.

2.2 Analysis Method

The research employed aquaculture enterprises benefit analysis and Multiple Goal Programming (MGP). Benefit analysis used as a basis in determining the coefficient of constraint functions of interest in the analysis of MGP. Jolly and Clonts (1993), aquaculture farm profit analysis using the formula: profit = TR-TC, where TR = total revenue (Quantity*price) and TC = Total Cost (Total Variable Cost + Total Fixed Cost). The results of profit analysis are used as a objective constraint coefficient of profit maximum in MGP method.

MGP analysis methods used to answer the research objectives of optimizing the use of integrated pond cultivation production factors (seaweed and milkfish) in order to achieve maximum profit, employment and increased production of seaweed. Use of factor (input) production show that the number of inputs used by aquaculture is integrated between the seaweed and milkfish in one production cycle (one year). The availability factor of production represents the total land resources, artificial and human resources (labor) owned by the farmers to conduct business activity. The value of all production inputs used per unit area of pond per year and the total availability of inputs by farmers serve as the data used in analyzing optimization seaweed farming is integrated with fish. Results obtained from these MGP analysis is an optimal solution based to establish the extent farms are managed so that the target of pond farm management achieved with current conditions. Specifically models of mathematical equations used in the analysis is the MGP (modified from Lee *et al.*, 1990):

1. Objective function: minimize deviation
   $Z = \sum_{i=1}^{3} DU_i \sum_{i=1}^{3} DU_i$

2. Constraint function:
   Objective constraint:
   $a_i X + DU_i - DO_i = A_i$
   Technical constraint:
   $b_j X \leq B_j$
   Non-negative constraint: $X \geq 0$

Where: DU_i = underachievement deviation; DO_i = overachievement deviation; a_i = coefficient of objective constraints; b_j = coefficient of technical constraints; A_i = target value of integrated pond management objectives; B_j = Value of resources (production factors) are available (Right Hand Side, RHS); X = area of pond land optimally managed cultivator; i = 3 objectives that minimized its deviations (maximum profit, employment and maximum production of dried seaweed); and j = 4 (number of production factors constraints: seaweed fronds, milkfish fingerlings, fertilizer, and maintenance costs.

3. Results and Discussion

3.1 Identify Production Factors

In general, the area of ponds in Indonesia is located far away from residential areas. This reality has led to control of the maintenance of ponds tend to be limited so that the impact on the productivity of the farm. Fishpond owners typically hire workers who manage the pond from planting, to harvesting and drying seaweed. To anticipate these problems, management of labor factors of production is needed to set the time of maintenance (regulation of water, pond cleaning, feeding, and harvesting). These conditions have implications on the organization of farming systems, where the workforce is given the right to fully manage the pond and work 24 hours, while the owners simply controlling and finance throughout the production process (procurement of production inputs). The results of the identification and use of production factors provided in a year are presented in Table 1.

Table 1. Use and availability of production inputs seaweed and milkfish cultivated integrated

No	Type of Production Factors	Value per hectar per year	Production Factor available
1.	Labor (HOK)	240,00	17400,00
2.	Seaweed Fronds (ton)	1,20	100,00
3.	Fingerlings of milkfish (unit)	196,08	14200,00
4.	Fertilizer (tons)	0,98	100,00
5.	Maintenance cost (Rp.000)	946,078	68.500,00

It is clearly depicted (Table 1) that each year the average employment per hectare per year 240 Day of Work (HOK), which means that the use of labor is relatively high compared to the results of research. Kasnir (2015) who argued that workers absorbed on seaweed cultivation as many as 169 types of Euchemma cottoni HOK. The high employment in aquaculture with a polyculture system in this area is because labor is used while the use of other inputs such as fertilizers and pesticides is still low, due to the high prices of these inputs. On the other hand, fertilizer is a material that contains a number of nutrients that are necessary for seaweed in sufficient quantities and balanced in order to achieve optimal production (Alam *et al*., 2009). Model farming polyculture of tiger shrimp, fish and seaweed consists of several related components namely: (1) the location and extent of pond polyculture of tiger shrimp fish and seaweed together with the environment of macro pond polyculture only pond bottom soil texture clay loam sandy with a composition of 45% sand, 28% dust and 27% clay, (2) pond preparation aimed at preparing the pond water for maintenance, given treatment includes giving saponins, scoop kerosene, dolomite, giving urea and TSP fertilizer, (3) stocking seaweed and milkfish, (4) Harvesting seaweed done at age 2 months, and then performed at each age 1.5 months. Harvest fish is done at the age of five months. Production of tiger shrimp and fish from aquaculture three commodities have the durability of life, obesity and a larger size than polyculture farming production of two commodities (Murochman *et al*., 2010; Suharyanto *et al*., 2010).

3.2 Production Value and Profits

Based on the production cycle, management of seaweed cultivation that are integrated with fish in coastal areas of North Morowali district of Central Sulawesi province of Indonesia generally lasts for 10 months per year. The frequency of harvesting seaweed for 10 months ranged from 5-6 times or the general range per one harvest 50-60 days. While the fish is done harvests an average of 5 months or 2 times a year. Given the potential of pond that is wide enough, then the ownership of land by farmers fairly large pond. The economic value of seaweed and milkfish cultivation integrated by the coastal communities are presented in Table 2.

Table 1 shows that there is significant variation in the pond land ownership by the farmers and therefore contributes to the production of seaweed and fish. Nevertheless tenure ponds in the study area is quite spacious, on average 5.1 hectares with an average production seaweed amounted to 13.191 kg or 2,587 kg per hectare per year. If the entire land area of aquaculture potential remedy used for seaweed cultivation, the production target of 187.98 tonnes could be achieved. This study does not include and analyze the production of fish due to data limitations harvest milkfish (harvest frecuency caused by irregular). The total cost of the initial investment reached IDR 453.08 million used for the purchase of land ponds, boats, buildings, and support equipment. The main benefit derived from the cultivation of integrated tamabk is the revenue from the sale of seaweed as the main business and sale of fish as a byproduct. Total gains from the sale of both commodities

Table 2. Economic Value (per year) of Integrated Seaweed and milkfish Cultivation

No	Economic Variabel	Average	Maximum	Minimum	Standard Deviation
1.	Pond area (ha)	5.1	20.0	2.0	4.8
2.	Production of Seaweed (Kg)	13,191	40,000	6,125	8,417.1
3.	Totaly Cost (IDR)	75,702,300	157,677,000	7.214,000	35,672,225.1
4.	Milkfish revenue (IDR)	20,137,500	48,000,000	7.200,000	12,874,299.9
5.	Dry seaweed revenue (IDR)	131,912,500	400,000,000	61.250,000	84,171,475.8
6.	Totaly Revenue (IDR)	52,050,000	448,000,000	70.250,000	95,380,262.5
7.	Profit (IDR/year)	76,347,700	290,323,000	33.036,000	62,782,065.9

amounted to IDR 76.35 million per 5.1 hectare or IDR 14,970,137 per hectare/year. On the other hand, the benefits of farmers is expected to reach the desired target by local governments to improve the income of fish farmers in the district of North Morowali at IDR1,083,000,000/year.

If examined in terms of the continuity of production, commodity excellence seaweed Gracilaria cultivated together with fish in the pond are available throughout the year, so that can be potentially good Gracilaria for raw materials processing industry and for exports. Glacilaria verrucosa seaweed production from ponds can reach at least one dry ton / ha / planting period (4-6 weeks). In the rainy season Gracilaria verrucosa seaweed growth is slow, so it can not produce optimally (Alamsyah *et al*., 2009). Ideally, if the production of fish to be achieved to the maximum, then the feed requirements as one of the basic requirements for the growth of such organisms must be met to the fullest. Referred to some literatures, a good nutrition is very important for the success and sustainability of the aquaculture industry as the economy, fish health, quality of products and efforts to minimize environmental pollution (Committe on Animal Nutrition, 1993; Handayani and Widodo, 2010).

The facts showed that the main target of cultivation commodities in ponds is seaweed, while milkfish culture is only subsistence farming. This is shown by the milkfish maintenance system do without artificial feeding, but only relying on natural feed in the pond, including the presence of seaweed. On the other hand, artificial feeding with seaweed raw material waste (15% of total feed ingredient) is able to increase the weight of milkfish of 5.9 g / day (Sulistiawati *et al*., 2013).

Research results by Suharyanto *et al*. (2010), the benefits of multi-trophic tiger shrimp farming, seaweed and fish reach IDR11,572,000 per hectare/3-month production period. High and low profits of farming depends on physical factors aquatic chemistry and biology (grass seed) which ultimately affects productivity. Physical factors pond water chemistry that can significantly increase the production of seaweed is the temperature, salinity, turbidity and brightness (Oliveira *et al.,* 2012). Maintenance seaweed polyculture with fish capable of improving the quality of the pond water through reduction of ammonia (Ryder *et al*., 2004). In addition, the benefits are also influenced by the quantity and input prices (cost of production). If production input is provided, the input prices tend to be stable so as to increase profits.

Results of other studies indicate that the financial benefits farmers polyculture three commodities higher and significantly different from the financial benefit of farmers polyculture two commodities. Seaweed in particular, allow the creation of flexible integrated sustainable mariculture operations. Benefits from a farming system in coastal area are: (i) efficient way to manage coastal; (ii) increase of profits; (iii) reduce the effects of eutrophication in large shallow coastal and (iv) the planting of macrophytes creates areas of vegetation, the which serve as refuges for young fish and spawning (Casalduero, 2001) implying sustainable management of coastal resources.

3.3 Optimization of Integrated Pond Farming Management

Optimizing the management of coastal resources for seaweed and milkfish integrated pond farming intended to (1) determine the extent of pond optimum run, (2) use of factor (input) available production, and (3) is aimed at the achievement of the management of coastal communities to improving the welfare of farmers through increased maximum profits, employment, and the target of increasing production. The results of the analysis using multiple objective programming methods are presented in Table 3.

Table 3. Optimization of Seaweed Cultivation Management Integrated with Milkfish

No.	Item	Optimal Solution	Iniatial Value/target
A.	Pond land area (Ha)	72.40	102.0
B.	Management goal achievement		
	1. Benefit (IDR Million)	1,083.89 [a]	1,083.00
	2. Employment (HOK)	17,377.00 [b]	17,400.00
	3. Seweed production (tons)	188.65 [a]	187.98
C.	Production input used		
	1. Seaweed fronds (tons)	86.86[d]	100.00
	2. Milkfish fingerlings (unit)	14,197.01 [d]	14,200.00
	3. Fertilizer(tons)	70.96 [d]	100.00
	4. Maintenance cost of pond	68,500.00[c]	68,500.00

Note: [a] = over-achievement; [b] = below-achievement; [c] = slack; [d] = surplus

Table 3 shows that the optimal pond land area cultivated in order to achieve the target of the management of ponds 72.40 hectares. This indicates that the recommended pond land area is narrower than the existing. Although the area of pond land that is recommended is lower, but almost all integrated aquaculture management targets can be achieved. This is demonstrated by the profit targets are achieved by IDR 1,083.89 Million, labor can be absorbed as much as 17,377.00 HOK (Working Day) or the equivalent of 724 workers, and seaweed production exceeding the planned target of 188.65 tons. To achieve these goals, almost all factors and production costs mainly used optimally pond maintenance costs, while the use of production factors such as fronds seaweed, fingerlings, and fertilizers has not been optimal. This is indicated by the slack value of the results of the MGP analysis, which means that a number of factors of production have not been used up.

The implications of findings are the profits of farmers accompanied by an increase in employment in coastal areas can be achieved through maximum utilization of all inputs used in the production process of seaweed that is integrated with the milfish. This means that in terms of economic, financial gains income of farmers through polyculture system is greater when compared with monocultures (one type of cultivation). This is because once the costs incurred in the production process is able to provide the benefits that come from two types of commodities that have high economic value. In addition, a combination of fisheries products for all production processes to minimize the risk of farm failure. Troell (2009) states that when there is a failure (decline in production and output prices) on one of the commodities polyculture, then another fishery commodities is expected to cover the losses caused, so that there is a strong economic resilience in the operation of the pond cultivation farming by coastal community. Research has found that the benefits obtained seaweed cultivation can also be improved by increasing the scale of business through the expansion of pond land areas. This strategy is one one of the efforts to reduce poverty in coastal areas of seaweed cultivators (Arsyad *et.al*, 2014). Management of seaweed farming in ponds is also able to reduce unemployment in the urban coastal areas.

The results also found that labor is used on its own or pond land leased to the maintenance of seaweed in ponds comes from one or more family members of the household by the number of 5-10 people consisting of a husband, wife and children. This shows that the contribution of workers coming from women (wives and other female family members) and other family members such as children is a key success factor cultivators of seaweed in coastal areas in order to improve their welfare (Cooke, 2004). Thus, Zamroni and Yamao (2011), the factors influencing the development of seaweed cultivation include the technical aspects of aquaculture such as the quality of aquatic environment, seeds, social, economic, marketing, managerial, and human resource capabilities. Integrated mariculture operations that successful must be consider all relevant stakeholders into its development plan government, industry, academia, the general public and non-governmental organisasi must work together and the role of integrated mariculture within integrated coastal zone management plans must be clearly defined (FAO, 2009). This means that integrated multi-trophic aquaculture systems (seaweed and milkfish) can improve the environmental balance of sustained (biomitigation), economic stability (product diversification and risk reduction) and social acceptability (better management practices). The development and application of technology multi-trophic aquaculture on a large scale in order to improve the welfare of society, and improvement of the coastal environment, require attention and political support from both the government and industry through policies and programs. It is associated with the provision of financing, factors of production (resources), and the implementation of research to carry out the development and monitoring program, and the empowerment of coastal communities through integrated multi-trophic aquaculture (IMTA) (Buschmann, *et al*., 2009) affecting poverty reduction both direct and indirectly.

4. Conclusion

Inputs (factors) production in pond cultivation that integrated (seaweed and milkfish) showing mainly been used in an optimal, especially capital utilization for maintenance of the pond, as well as the use of production factors seaweed fronds, milkfish fingerlings, and fertilizer. The use of factors of production will be able to optimize the utilization of the resource potential of 72 hectare of pond areas. The target of multi-trophic pond cultivation management for the welfare of coastal communities that can be achieved through the optimal utilization of land amounted IDR1,083.89 million for total income of farmers, workers absorbed 724 people and seaweed production exceeding the initial target be 188.65 tonnes. Target of integrated pond cultivation management can still be improved if the government and industry together with growers to optimize the application of technology mariculture, through policy development program (provider production input or factors: expansion of pond area, seaweed fronds, fingerlings of milkfish, fertilizer, and intensify the integrated cultivation of milkfish).

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