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Ecological-Economic Analysis of Floating Fish Cage-Aquaculture Business in Tondano Lake, Minahasa Regency, North Sulawesi Province

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Abstract: In this study, we analyzed the feasibility of the floating fish cage system-fish culture based on environmental and economic aspects. The environmental parameters included physico-chemical parameters, such as water temperature, pH, visibility, DO, nitrate and phosphate and the study used fish farmers and fishermen as respondents, while the economic analysis covered calculations of benefit cost ratio and net present value. Results showed that all coastal areas, but north Tondano Lake, are feasible for floating fish cage system-fish culture business.
Keywords: Tondano Lake, floating fish cage, business feasibilit

INTRODUCTION

Fisheries development implementation is focused on (a) increasing better fisheries production as the entity of food and nutrition need fulfilment, (b) increasing the productivity of the fisheries business as an additional value followed with increased income of the fish farmers and fishermen, (c) developing the working and business opportunities and the sustainable regional development, and (d) maintaining the fisheries resources conservation that gives positive impact on the living environment**.**

Lake utilization for fisheries activities is expected as a sustainable activity. There are several management approaches**:** (1) the ecological approach is based on the environmental allocation and management, particularly inter-component relationships in a physical and biological system. (2) Economic approach is based on the idea of natural resources rarity and environment, in which the resources and environment users are encouraged to take correct alternatives in utilizing the natural resources optimally [1-3]]. Social economic aspects are important in human life resulting in either negative or positive impacts. These aspects need to be studied whether the business will give economic or social benefit to various parties or not.

Tondano Lake, North Sulawesi, is one of the natural resources possessing multi-functions in supporting the development implementation. According to Minahasa Fisheries and Marine Services (2012), Tondano Lake has an area of 4,728 ha located at 600 M above sea level, gets water input from 41 big and small rivers, and three-fourth of which are those with rain holding area less than 250 ha. As one of the regional assets, it has got much attention from many stakeholders, since Tondano Lake is a strategic resource for human life and economic development in North Sulawesi Province, especially Minahasa Regency. It could be seen from the multiple benefits as nutritional food material source (fish and non fish), water source for industries, irrigation water for agriculture, energy source for hydroelectricity, drinking water, transportation medium and tourism. In the recent years, Tondano watershed has sufferred from environmental degradation and big changes causing lake silting. Water quality degradation also occurs from agricultural, duck farming, waste disposal, washing and fish culture activities around the lake[4].

Increased human activities around Tondano Lake which utilize the lake as Floating Fish Cage System-fish culture site, controlled floating fish cage unit development need to be done to avoid negative impact on the aquatic environment due to organic waste disposals (particularly N and P).[5]. It results from low attention given in technological principles of the floating fish cage system-fish culture, such as position, feeding and carrying capacity assessment. Nevertheless, main problem of the floating fish cage-fish culture farmers in Tondano lake is economic loss due to low productivity and water quality caused by increased

toxic gas production (ammonia, H2S, ect.) in early rainy season traditionally called *aer jaha* [6].

On the other hand, Tondano Lake is expected to be able to support the people economic development from the lake role and benefit. In fisheries sector, the lake is still expected could give positive contribution as economic growth source that could sustainably increase the prosperity of the fish farmers and people around the lake. Recent Tondano Lake condition needs an integrated and intensive management that the ecological and economic function of the resources could be maintained for future generations [7]. Hence, this study was aimed at analyzing the feasibility of the floating fish cage system-fish culture based on environmental and economic aspects.

MATERIAL AND METHODS

Floating fish cage farmer household sampling was done using randomized cluster and multi-stage household sampling following sampling strategy o as follows**:** First stage, from 25 districts, 4 areas around Tondano Lake, east part covers Eris district, south part covers Kakas and west Kakas, west part covers Remboken, South Tondano and West Tondano districts.

Second Stage: Using the purposive sampling technique, three districts were determined, (1) Eris, (2) Kakas, and (3) Remboken. Third Stage: all number of samples of these districts were selected the fish farmers (20%) as respondents representing the floating fish cage system-fish culture activities. (4). This respondent selection was done using snowball sampling.

Data Analysis.

To measure the water quality, temperature and visibility, thermometer and seichi disc were used for water temperature and visibility, respectively. For pH, DO, nitrate and phosphate, water samples were collected and analyzed in the Laboratory of Agricultural Standardization Research Board of North Sulawesi. Economic feasibility analysis of the floating fish cage business was done using the following equation:

Benefit Cost Ratio (R/C)

This analysis was used to know how far the floating fish cage business could give the profit as follows:

$$R/C = TR/TC$$

TR = Total gain of the business (IDR/ha/year)
TC = Total business cost (IDR/ha/year)

Decision making criteria are:
R/C > 1, profitable business
R/C = 1, break even point
R/C < 1, unprofitable business.

Site and Time

Water quality sampling determination was based on sampling points, which could provide carrying capacity information of Tondano Lake. Therefore, from the fact of lake utiliztion for aquaculture, number of the floating fish cage units were categorized as high, moderate, low and no utilization for floating fish cage. Those were as follows:

1. East Tondano Lake covers Eris village with the highest category of number units.
2. South Tondano Lake covers Toulimembet village with moderate category of number units.
3. West Tondano Lake covers Talikuran village with low category of number units.
4. North Tondano Lake covers Toulour village with no floating fish cage.

Moreover, floating fish cage business feasibility development was done using the gain value and the production cost calculated based upon the present value. The feasibility criteria were as follows:

$$NPV = \sum_{t=1}^{n} \frac{Bt - Ct}{(1+i)^t}$$

Notes:

B_t = annual gross benefit, in t year
Ct = annual gross cost, in t year
$1/(1+i)^t$ = Discount factor (DF)
i = bank discount rate
n = economic period of the business unit
r = discount rate
t = o, 1, 2, 3, …. year *n*

Decision making criteria were as follows:
NPV > 0; feasible
NPV = 0, break event point
NPV < 0; unfeasible

Internal Rate of Return (IRR)

This method was aimed to measure the discount rate as present value of Net Benefit that could be situated or same as the present value of capital expenditure. IRR indicates an average annual internal profit of the company running the investment and expressed in percent. IRR is a discount rate making the NPV of the business equal to zero. Mathematically, IRR can be formulated as follows:

$$IRR = i_1 + \frac{NPV_1}{NPV_1 - NPV_2}(i_1 - i_2)$$

i_1 = discount rate resulting in positive NPV
i_2 = discount rate resulting innegative NPV
NPV_1 = positive NPV
NPV_2 = negative NPV

RESULTS AND DISCUSSION

Ecological feasibility

East Tondano Lake:

a. **Tempeature**. Water temperature at the observation site ranged from 18^o to 19 ^{0}C, in

which it rose in the daytime and fell in the afternoon. Compared with the standard water quality for fish culture at the range of 26 – 29ºC, this area has water temperature condition below normal and it could rise in dry season**.**

b. **Visibility.** Water visibility is another important factor in floating fish cage-fish culture. In relation to standard water quality, water visibility for fish culture is ≥ 2m, so that recent aquatic condition is relatively good and suitable for fish culture development, 2.75 – 2.87 meter.

c. **pH.** Water pH ranged from 7.91 – 8.12, belonged to highly ideal range for aquatic biota, particularly cultured fish, in relation to Indonesian national standard water quality of 6 - 9. It reflects that the waters is fertile due to nutrient availability useful for aquatic biota so that it is very important for the fish farmer to obtain good fish production.

d. **Dissolved Oxygen (*DO*).** In east Tondano Lake, dissolved oxygen ranged from 8.8 – 9.9. It is above the minimum Indonesian national standard water quality of ≥ 4mg/l, so that this waters is good for floating fish cage system-fish culture development or suitable for better fish culture development and could be developed as a business capable of fulfiling the comsumer demand in the future.

e. **Nitrate.** Nitrate is a very important nutrient for growth. Field measurement showed that nitrate ranged from 0.00 - 0.14 ppm, while the Indonesian national standard water quality for nitrate is 10 mg/l. It means that east Tondano Lake waters has low nitrate content and it is still good forreflecting that agricultural activity around this area has not endangered the fish life yet in the floating fish cage system-fish culture.

f. **Phosphate (PO4).** Phosphate level in east lake waters ranged from 0.032 - 0.041 mg/l, while the Indonesian national standard water quality is 1mg/l. It reflects that east lake waters is still suitable for fish culture development or sustainable floating fish cage system-fish culture.

South Tondano Lake

a. **Temperature**. Water temperature ranged from 19 – 27.9^0 C, in which it rose in the daytime and fell in the afternoon. Compared with the Indonesian standard water quality for water temperature, 26 – 29 ^{0}C, water temperature of south Tondano Lake waters is still below normal, but could rise in dry season.

b. **Visibility.** In relation to the Indonesian national standard water quality of visibility for fish culture ≥ 2m, the recent water condition is relatively good and suitable for floating fish cage system-fish culture, 2.78-3.12 meter.

c. pH. pH ranged from 8.80 – 9.2, meaning that it is highly ideal for aquatic biota, particularly the cultured fish. Water pH could change and depend upon carbon-dioxide concentration. Measurements in south Tondano lake waters relatively approached the Indonesian standard water quality, 6 – 9. It means that the waters is fertile due to nutrient availability useful for aquatic biota so that this are very important for the fish farmer to obtain good fish production.

d. **Dissolved Oxygen (*DO*).** South Tondano lake waters has dissolved oxygen range of 8.12 – 8.20. It is good in association with Indonesian national standard water quality, Government Regulation numbered 82, 2001, ≥ 4mg/l, so that this waters is suitable for floating fish cage system-fish culture development or suitable for better fish culture development and could be developed as a business capable of fulfiling the comsumer demand in the future.

e. **Nitrate.** Nitrate is a very important nutrient for growth. Field measurement showed that nitrate ranged from 0.12 - 0.16 ppm, while the Indonesian national standard water quality for nitrate is 10 mg/l. It means that south Tondano Lake waters has low nitrate content reflecting that agricultural activity around this area has not endangered the fish life in the floating fish cage system-fish culture.

f. **Phosphate (PO4)** Phosphate level in south Tondano lake waters ranged from 0.012 - 0.015 mg/l, while the Indonesian national standard water quality is 1mg/l. It reflects that south lake waters is still suitable for fish culture development or sustainable floating fish cage system-fish culture.

West Tondano Lake :

a. **Temperature.** Water temperature ranged from 19 – 25^0 C, in which it rose in the daytime and fell in the afternoon. Compared with the Indonesian standard water quality for water temperature, 26 – 29 ^{0}C, water temperature of west Tondano Lake waters is still below normal, but could rise in dry season.

b. Visibility. Water visibility is important in floating fish cage system-fish culture. It is highly affected by organic and inorganic material suspension in the water, plankton and microscopic organism abundance (Pujiastuti, 2013). In relation to the Indonesian national standard water quality of visibility for fish culture ≥ 2m, the recent water condition is not good for floating fish cage system-fish culture, 1.6-1.7 meter.

c. **pH.** pH ranged from 7.91-8.2, meaning that it is highly ideal for aquatic biota, particularly the cultured fish. Measurements in west Tondano lake waters relatively approached the Indonesian standard water quality, 6 – 9. It

means that the waters is fertile due to nutrient availability useful for aquatic biota so that these are very important for the fish farmer to obtain good fish production.

d. Dissolved Oxygen (*DO*). West Tondano lake waters has dissolved oxygen range of 8.09 – 8.30. It is good in association with Indonesian national standard water quality, Government Regulation numbered 82, 2001, ≥ 4mg/l, so that this waters is suitable for floating fish cage system-fish culture development or suitable for better fish culture development and could be developed as a business capable of fulfiling the comsumer demand in the future.

e. Nitrate. Field measurement showed that nitrate ranged from 0.11 - 0.13 ppm, while the Indonesian national standard water quality for nitrate is 10 mg/l. It means that west Tondano Lake waters has low nitrate content reflecting that agricultural activity around this area has not endangered the fish life yet in the floating fish cage system-fish culture.

f. **Phosphate (PO4),** Phosphate level in west lake waters ranged from 0.032 - 0.041 mg/l, while the Indonesian nationa; standard water quality is 1mg/l. It reflects that west lake waters is still suitable for fish culture development or sustainable floating fish cage system-fish culture.

North Tondano Lake

a. **Temperature.** Based on Kusen water temperature in this area was 19ºC. Compared with the Indonesian standard water quality for fish culture, 26-29ºC, it is low or below noemal.

b. **Visibility**. In the present study, water visibility was 1.65m. This condition is not suitable for fish culture, and therefore, there is no floating fish cage –fish culture business in the area.

c. **pH.** Field measurement showed that pH was 8.13, and this reflects that water condition in this area is fertile due to nutrient availability usable by aquatic biota and benefits the fish farmers for better fish production.

d. **Dissolved Oxygen**. Water DO in this area was 7.81, and it is higher than the Indonesian standard water quality (≥ 4 mg/l) and Boyd (5 mg/l). Thus, this waters is suitable for fish culture.

e. **Nitrate.** Nitrate concentration was 0.20 mg/l, while the Indonesian standard water quality for nitrate is 10mg/l. It means that nitrate content in this area is still below the standard water quality, so that this concentration has not endangered the fish life.

f. **Phosphate**. This area had 0.77 mg/l, below the Indonesian standard water quality. It reflects that north Tondano lake waters is still suitable for sustainable fish culture.

Economic Feasibility of Floating Fish Cage System-Fish Cage.

East Tondano Lake. There are many floating fish cage system-fish culture business, so that the fish production is higher than that in south and west parts. This causes the fish price go down to average price of IDR 17.000/kg and it is different from that in the west part, IDR 25.000,-/kg. IRR of 1.21 and BCR of 1.36 mean that the business is feasible.

South Tondano Lake. For a floating fish cage system-fish culture with an investment of IDR 17,336,000,- could yield a profit of IDR 89,408,712,- per harvest with an IRR value of 1.22. This profit is obtained using 17 units of floating fish cages meaning that each unit could give a profit of IDR 5,259,300,- per harvest or IDR 1,314,800,- per month. However, feed cost is crucial problem component due to high feed price reaching 38.13% of the operational cost or variable cost. It means that feed price highly influences the production cost. Then, the production cost will determine the competitiveness of the country in export or domestic markets. As an implication, feed price control at the level of low price as simlar feed sort in the competitor country is very positive thing for aquaculture development.

West Tondano Lake. Fish price in west Tondano lake, IDR 25,000/kg, is more expensive than that in east and south parts since approximately 50% of women or more, fish farmer's wives, are those who leave the area selling the fish. They go to several nearby markets, such as Tomohon, Langowan, and Manado, or even to remote markets reached in about 3 hours from Remboken district to Kotamobagu, about 160 km.

The floating fish cage system-fish culture with an investment of IDR 17,336,000,- will give a profit of IDR 89,408,712,- per harsvest with an IRR value of 1.23 and BCR of 1.83, meaning that the fish culture business in this area is feasible.

CONCLUSION

The feasibility of floating net cage farming (KJA) was obtained by using 17 units with an investment of Rp. 17,336,000, - will give a gain of Rp.89.408.712, - per crop with a value of IRR of 1.22 which means that every unit of cages would give a profit of Rp. 5.2593 million, - in a single harvest or equivalent to Rp. 1.3148 million, - per month.

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