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Technical and Economic Efficiency of Fish Net Cagesystem-Based Fish Culture in Tondano Lake, Remboken District, Minahasa Regency, North Sulawesi, Indonesia

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Abstract:
This study was aimed at knowing the technical and economic efficiency of fish culture in cage system for fish farmers in running the business to be able to increase their income. It was carried out in two phases; in which the first step yields the technical efficiency for the fish cage famers in Tondano Lake, Remboken district, Minahasa regency. The technical and economic efficiency was obtained through direct observations, interviews, and used Data Envelopment Analysis (DEA) method and business feasibility analysis. Data Envelope Analysis (DEA) Solver showed that only one of 15 fish farmers under fish net cage (FNC) culture system reached the best technical efficiency.
The FNC business with an investment of IDR 17, 336,000 will give a revenue of IDR 225,000,000/yr with net profit of IDR 135,786,000/yr, IRR of 783.26%, and BCR of 2.14. Feasibility analysis using a discount factor of 12% and time period of 10 years found NVP>0, BCR>1, and IRR>discount factors, meaning that the FNC business is feasible to run.

Keywords: *Fish farmer, fish net cage, technical, economic efficiency*

1. Introduction

In NorthSulawesi, one of the natural resources possessing multi-functions in the development is Tondano Lake in Minahasa regency. It is the biggest lake in North Sulawesi, according to Fisheries and Marine Services of Minahasa (2012), with a total area of 4,728 ha, and located about 600m above sea level. Based on the watershed morphology, Tondano lake receives water from 41 large and small rivers and ¾ part isriver with rain catchment area less than 250 ha.

Tondano lake, as one of North Sulawesi regional assets, get a lot of attention and concerns from various level of communities, such as environmental masyarakat pemerhati lingkungan, government, and scientists. In recent years, these attention and concerns come from the fact that Tondano lake is a strategic resource for economic development in North Sulawesi Province, particularly Minahasa regency.It can be seen from the multi-benefits as source of nutritive food material (fish and non-fish), water source for industries, irrigation, water-powered electricity power, drinking water, transportation medium, and tourisms(Rondo and Soeroto, 1990).

According to Korah (2000), total number of FNCs in Tondano lake in 1995 were 4,122 units, and these numbers drastically declined by 1997 as a result of monetary crisis.Feed price increased about 100 – 200%, andother facilities became quite expensive. According to Fisheries Services of Minahasa (2012), number of FNCs operated up to November 1998 were 2,408 units and rose to 9,279 units of production nets and 2,899 units of seedling nets.

Human activities in Tondano lake that benefit the surrounding waters of Tondano lake as fish culture location using fish net cage system also increase from year to year. It has been encouraged by economic stimulation through fish culture, in which optimal culture operation will, of course, increase the fish production and then the income of the local fish farmers.

Remboken is one of districts located near Tondano lake where fish culture business is run under the FNC system.Fish culture development always expects high profit gain since the activity is oriented to achieve maximum production without taking into account the intensive treatments, such as appropriate feeding technique and other expenditures that highly influence the technical and economic analyseson the financial study of the business.

2. Method

The study focused on businessmen and fishnet cage farmers with their family members who actively run the fish culture in Tondano lake. Subject determination used purposive sampling. Sampling was intended that data had the characteristics/categories that represented the information needed. Respondents were selected purposively, i.e. not based on village origin, but the characteristics of people around Tondano lake in Remboken district. Sampling also use the principle of non-probability sampling (Kerlinger, 1986), applying purposive dan snow-ball sampling techniques.

Data required to analyze the feasibility of the fish net cage business in this district consisted of primary and secondary data. The former covered investment, i.e. cage frame, monitoring house, fish spawners, net, and etc. There were also operational costs, such as wages, fish feed, drugs, and etc. Depreciation cost is estimated 33.3%. Carrying capacity data were culture area or the size of fish net cage. The latter is related with research reports, annual report, laporan tahunan, statistics of Tondano in numbers, living environmental conditions, and data of Fisheries and Marine Services office.

Fish net cage (FNC) business feasibility data analysis was done as follows:

2.1. Data Envelopment Analysis (DEA)

Technical efficiency analysis on the input dan the output of the FNC fish culture in Tondano used Data Envelopment Analysis (DEA) output and input-oriented approach following the model developed by Fare *et. al*. (2000); Lindebo *et. al*. (2002) dan Kirkley *et. al*. (2003).

2.1.1. Technical Efficiency Measurement

2.1.1.1. Input-Oriented Technical Efficiency

Efficiency measurement can be done based on input and output approach.

DEA model for input-oriented technical efficiency is:

Min λ

λ,z

$$u_{jm} \le \sum_{J=1}^{J} z_j u_{jm}, m = 1,2,...,M$$

$$\sum_{j=1}^{J} z_j x_{jn} \le \lambda x_{jn}, n = 1,2,...,N$$

$$z_j \ge 0, j = 1,2,...,J$$

where:

λ = efficiency measured for each DMU j
u_{jm} = number of m outputsproduced by each DMUj
x_{jn} = number of n inputs used by DMU j
z_j = intensity variable for DMU j

Valueof λ = 1.0 means that a business unit is efficient andλ< 1.0 means it is not efficient. For instance, if λ = 0.8 means that the business can reduce 20% inputs in order to produce the same output level (Walden & Kirkley 2000)

2.1.1.2. Output-Oriented Technical Efficiency

DEA model for Output-Oriented Technical Efficiency is

Max θ

θ,z

With constraints:

$$\theta u_{jm} \le \sum_{j=1}^{J} z_j u_{jm}, m = 1,2,...,M$$

$$\sum_{j=1}^{J} z_j x_{jn} \le x_{jn}, n = 1,2,...,N$$

$$z_j \ge 0, j - 1,2,...,J$$

where:

θ = output TE measure
u_{jm} = number of m outputs produced by DMU j
x_{jn} = number of inputs used by DMU j
z_j = variable intensity for DMU $_j$

Ifθ = 1.0, the DMU is efficient, θ>1.0, it is not efficient. For instance, θ = 1.25 means that the DMU still needs to increase 25% output under the same input level (Walden & Kirkley 2000).

2.2. Benefit Cost Ratio (B/C)

B/C = TR/TC

Furthermore, the feasibility of FNC fish culture business development was conducted through estimation of the amount of revenue and the operational cost based on present value.The feasibility criteria used were Net Present Value (NPV), Internal Rate of Return (IRR), and B/C ratio.

2.2.1. Net Present Value (NPV)

NPV is a present value of net profit gained in the future by estimating the difference between present benefit and cost as follows:

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

z

where:

B_t = annual gross benefit for t year
Ct = annual gross costs for t year
$1/(1+i)^t$ = Discount factor (DF)
i = interest rate of bank
n = economic age of business unit
r = discount rate
t = 0, 1, 2, 3, ... n year

2.3. Internal Rate of Return (IRR)

To measure the interest rate that will make the present value of the net benefit be able to be adjusted or equal to the present value of the investment spent, the following formula was employed:

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

where:

i_1 = interest rate that yields positive NPV
i_2 = interest rate that yields negative NPV
NPV_1 = positive NPV
NPV_2 = negative NPV

2.4. Net Benefit Cost Ratio (Net B/C Ratio)

Additional benefit at each unit of cost added was analyzed as follows:

$$Net\ B/C = \sum_{t=1}^{n} \frac{Bt}{(1+i)^t} / \sum_{t=1}^{n} \frac{Ct}{(1+i)^t}$$

where:

Bt = benefit at year t
Ct = cost at year t
1/(1+i) = discount factor
n = business age

3. Results and Discussion

3.1. Production Factors of Fish Culture in Fish Net Cage

3.1.1. General Condition of Fish Net Cage

Fish culture under FNC system in Remboken district was conducted in Tondano lake. Results showed thatthe fish farmers set the FNC about 50 m distant from the lake bank. This distance selection could result from that the coastal area of the lake is grown with aquatic plants, such as Eichornia crassipes, and even in certain sites, the plants are not easily cleaned because their population is very high. This condition has influenced the coastal area of the lake since where *E.* crassipes grow, the area becomes shallow water and difficult to place the fish net cage.

The fish net cage was 4 m long x 3 m wide x 1m deep. The fish farmers had 5 to 23 units of FNCs (Table 1).

No	Total Units	Number (Person)	Percent (%)
1.	1 – 10	6	40
2.	11 – 20	6	40
3.	21 – 30	3	20
Total		15	100

Table 1: Number of Fish Net Cage in Remboken District
Source: Processed Primary Data, 2018

Results found that 40% farmers had only 1 to 10 unitsandthese were the highest number of FNC owners. It could result from that if they want to add more FNCs, the fish farmers will need more operational costs. Only 23.00% fish farmers had higher number of FNCs since they could prepare more working capital.

Interviews indicated that the fish farmers could not add more units of FNCs because the income gained from the fish culture is mostly used to buy feed and sometimesjust to meet the daily primary needs of the family members, so that the fish farmers are difficult to prepare extra money for addition of FNCs.Table 1 demonstrates the FNC placement area used as study site. As a whole, the FNC area in Tondano lake was 20 x 20 m^2, rectangular shaped, and does not have either serial or parallel culture media design.

3.1.2. Fish Seed

Fish stocked in Remboken district were taken from Tumaluntung and Tatelu villages, North Minahasa regency, but some from local farmer's hatchery. Based on the interviews with the fish farmers, the fish seeds are mostly taken from the hatchery in order to focus on the rearing than fish seed handling. A rearing cycle in Remboken district is done for 3 – 4 months from fish stocking to the harvest. The lowest stocking was 1,000 individuals and the highest was 3,000 individuals. The fish size ranges from 8 – 10 cm long. One-kilogram of fish contains 100 individuals with an individual price of IDR. 150, so that the fish farmers must spend IDR. 150,000 to IDR. 450,000 to stock 1,000 to 3,000 fish.

The present finding showed that most fish farmers, 46.15%, stocked 10 – 15 kg/cycle, and the rest, 23.08% and 30.77% stoked 30 – 40 kg and 20 – 30 kg fish, respectively, in the FNCs. Fish stocking variations in Remboken district are dependent upon production rate expected by the fish farmers, FNC size, and number of FNCs owned.

With FNC of 4m x 3m x 1m, the fish of 8 – 10 cm long are stocked only 1,000 fish/FNC. However, water mass upwelling often occurs, locally called as "aerjaha", since 2013 the fish farmers have stopped stocking 1,000 to 3,000 fish divided into a vailable FNCs.

3.1.3. Fish Feed

Nile tilapia stocked in FNCs to increase fish production highly require feed to stimulate the fish growth that expected production could be achieved. Food and feeding play very important role to support growth and therefore, need to be highly considered. Production will be low if food and feeding do not take into account of fish size and amount of feed given. Feed employed by the fish farmers in Remboken was CP and Confeed-trademark pellet, but they, in general, preferred to use Confeed feed under a price of IDR. 465,000/bag (50 kg/bag).

Interviews with 13 fish farmers showed that 6 of them often bought the retailed feed of IDR12,000/kg in the local shop. It makes them spend more money than purchasing a bag of 50 kg. They had to do it because the fish farmers do not have sufficient amount of money to provide food for the cultured fish. This study found that feeding was done 3 times a day, at 08.00 – 09.00 am, 12.00 – 13.00 pm, 16.00 – 17.00 pm. Since 2012,feed price has been increasing, so that feeding frequency is changed from 3 times a day to twice a day, at 08.00 – 09.00 am and 14.00 – 15.00, and even the fish farmers do not often give pellet, but replace it with rice, vegetables, corn meal, and milled corn.

3.1.4. Fish Production in Fish Net Cage (FNC) System

Fish production in FNC system includes all fish taken from the fish cultivation activities. Nile tilapia production under FNC system in Remboken district varied depending upon number of FNC units run by each fish farmers in Tondano lake. Fish production under this rearing system is presented in Table 2.

No	No. Production	No. farmers	Percent(%)
1.	50 – 99	4	30.77
2.	100 – 149	7	53.85
3.	150 – 200	1	7.69
4.	>201	1	7.69
Total		13	100

Table 2: Nile Tilapia Fish Production under Fish Net Cage in Remboken District (Kg/Cycle)
Source: Processed Primary Data, 2018

The present study indicated that fish production ranged from 50 to 149 kg based on 84.62% of total fish farmers surveyed. The production success is affected by several factors, such as stocking density,distribution, and feed amount provided with age and rearing technique.

3.2. Technical Efficiency Analysis of Fishnet Cage System-Based Fish Culture in Remboken District

Remboken district is located in the western part of Tondano Lake and has appropriate position of the lake. This area has relatively deeper waters than other parts of the lake, so that the fish farmers are highly encouraged to run the fish cultivation. Based on Data Envelope Analysis (DEA) Solver, the output is fish production, and the input is number of FNCs and feed used. Table 3 demonstrates how many fish culture business executors of FNCs are in the best efficiency rate.

No	Technical Efficiency	No. fish farmers	Percent (%)
1.	<0.1	-	0.00
2.	0.1 – 0.19	-	0.00
3.	0.2 – 0.29	-	0.00
4.	0.3 – 0.39	4	26.67
5.	0.4 – 0.49	-	0.00
6.	0.5 – 0.59	3	23.08
7.	0.6 – 0.69	5	33.33
8.	0.7 – 0.79	-	0.00
9.	0.8 – 0.89	2	13.33
10.	0.9 – 0.99	-	0.00
11.	1	1	7.69
Total		15	100

Table 3: Technical Efficiency of FNC Input Approach in Remboken District
Source: Processed Data, 2018

Technical efficiency analysis showed that only one of 15 FNC business executor had technical efficiency value of 1 (Table 3). It means that those fish farmers have the best technical efficiency.It reveals that about 53% of fish farmers in Remboken district have run the fish culture for 11–20 years, and this activity was donewithout paying attention on operational costs spent for fish culture in Tondano lake. They also did not economically take into account of time and energy actually used that would influence other costs as business property cost calculation.Rearing time was sometimes not taken into consideration as well. The activity was not well managed, in which the fish farmers were not seriously responsible for the culture activities and only do as they would.

The technical efficiency reflects that the fish cultivation in Remboken district is merely carried out for individual enjoyment and part of their hobby. The fish are used for themselves in family gatherings, such as Christmas party, Easter, wedding, birthday, and death**.** These fish culture activities are eventually done to meet such necessities.

3.3. Relationship between Input Andoutput in Technical Efficiency in Remboken District

Remboken district, western part of Tondano lake, has sufficient number of villages, and 7 of them are located along the lake bank, i.e. Leleko, Paslaten, Talikuran, Timu, Sendangan, Kaima, and Sinaulan.At input technical efficiency, there was correlation between number FNCs of DMU and business profit, in which 7 fish farmers (49.75%) were at the efficiency below 60%. It showed that the technical efficiency with the same outputs could be achieved if the input is 35.94%, andwith the same input, 60% output will be obtained.

In the input technical efficiency was obtained the correlation between FNC unit of each DMU and business profit as shown in Figure 1.

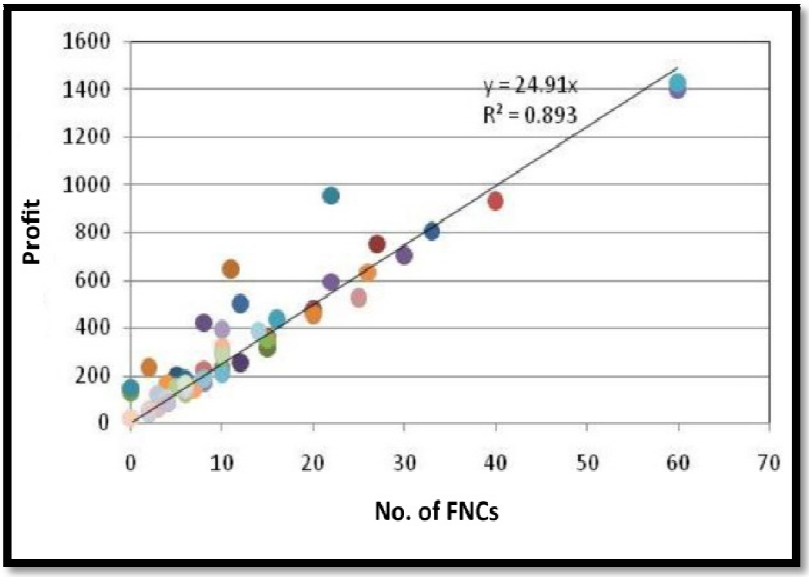

Figure 1: Relationship between Number of Fish Net Cage and Profit

This correlation is linear asProfit = 24.91 FNC (R^2 = 0.893), meaning that each FNC unit can make profit of IDR.24.91 million/yr.It exhibits that each FNC unit could yield income higher than IDR. 2,000,000,-/mo.

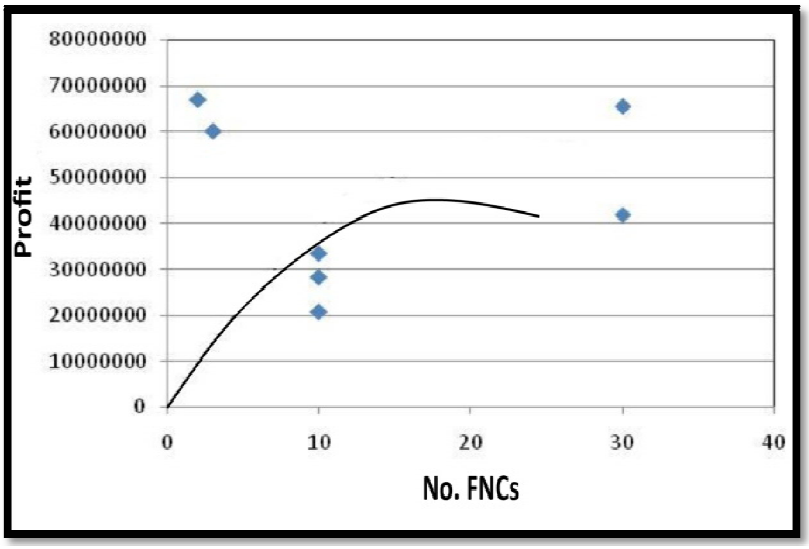

Figure 2: Relationship between FNC Unit and Profit

From Figure 2, it appears that seventeen FNC units yield net profit, IDR.135,786,720, -with the following equation:
$Y = -14473\ x^2 + 5000000\ x$ (R^2=0.37)
where: Y = profit and X = FNC unit

Number of FNCs that gave optimum profit was 17 units, with a profit of IDR 135,786,720, -so that number of FNCs should not be more than 17 units. The development of 17 units of FNCcan be accomodated by one piece of netto make 17 units of FNCs with a dimension of 6 x 4 x 4 m (suitable for the size of FNC in Tondano). To develop 18 units of FNCs, the fish farmers have two units of net, there will be many unused net left, and it means that there is an extra cost spent with no gain or profit.Similarly, if only 16 units of FNCs are made, there will be some nets wasted, it causes some loss for the fish farmers.It indicates that in FNC preparation, the fish farmers have to consider producing the multiples of units in order to save the use of net material, and thus, there will no additional cost and profit decline.This management strategy is also supported by Pangemanan (2014) to be able them to obtain maximum output and profit under an affordable costs.

The economic feasibility of fish net cage (FNC) in Remboken district was IDR 25.000,-.Such a price is more expensive than that in other districts near the lake bank, since the fish price established in other districts near the lake bank ranges from IDR 17,500,- to IDR 22,500,-. This higher fish price in Remboken district could result from that most fish harvested are directly purchased by intermediate fish sellers and sold outside the district.

The fish net cage business with an investment of IDR. 17.336.000,- will give profit of IDR.135,786,720,-/harvest with a NPV of IDR.767,230,000,- and IRR of 78.26%, and BCR of 2.14 will yield profit of IDR. 7,012,588.24,-/harvestor equivalent to IDR.1.114.800,-/mo.

The economic feasibility analysis using a discount factor of12% per yearfound that FNC business in Remboken district had the NPV of50, BCR Ratio >1, and IRR of20%. Hence, the FNC business in in Remboken could be categorized as feasible to run.The cost structural components have become business constraints among the fish farmers, since feed price reaches 38.13% of the operational costs. It means that feed price will greatly determine the amount of production costs.

Feed is one of the determining factors of the business in relation with the extent of the expected fish production. It is also related with food and feeding efficiency.According to Korah (2000), Food Conversion Ratio (FCR), in fact, ranges from 2.44 to 3.67 kgof feed, meaning that each usage of 2.44 to 3.67 kg of feed will give fish body mass increment of 1 kg. If the fish culture yields food efficiency of 100%, the use of 1 kg feed will yield 1 kg of fish, meaning that the food efficency is low. This inefficiency occurs from different feed water content. The feed water content is< 10%, while the fish containsapproximately 67% water. These numbers indicate that this fish culture business under food efficiency of 100% still produces more wastes that fish production.

To increase the efficiency,the wastes of the intensive fish culture should be utilized to yield low trophic level-fish, such as omnovores, herbivoresor detritus feeder. To make the food efficiency through integration of the intensive fish culture in "low level-tropic aquaculture", the production costs could be significantly reduced, and therefore, the product competitability could be highly increased.

4. Conclusion

- The feasibility of FNC culture business was obtained in 17 units of FNCs with investment of IDR. 17,336,000,- and would give profit of IDR. 135,786,720, -/cycleand IRR of78.26%meaning that each FNC unit would give profit of IDR. 7,012,588.24, -/cycleor equivalent to IDR. 1,114,800,-/mo.
- In relation with input technical efficiency, each DMU (business executor) will get profit of IDR. 24.91 million/FNC/yr.

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