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Financial benefits of the environmentally friendly aquaponic media system

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Financial benefits of the environmentally friendly aquaponic media system

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Abstract. Fish cultivation is one of the ways to increase the productivity of fishery technology development. Technology innovation of fishery in Indonesia has existed since long ago, especially in Lampung province. The technological development of trout cultivation makes the fishery business more effective, efficient, economical, highly competitive, and environmentally friendly. This research aimed to identify the plus value of fish cultivation that has economic value. The aquaponics system's principle was aimed to make trout cultivation to become environmentally friendly. This research was conducted in Lampung province at South Lampung regency and Central Lampung regency. The research had been done from May to August 20th, 2020. The data used in this research were the kind of primary data and secondary data. Primary data was obtained from the community of fish cultivation at Central Lampung supported by a related agency. The method of research was aimed to analyze the worthiness of the business. Based on the result of research, it can be concluded that the trout cultivation of catfish and mustard greens with aquaponics technology was worth and profitable as economical. The principal of aquaponics technology was utilizing nutrient, food waste, and fish metabolism in case of symbiotic mutualism among fish, plants, and bacteria. Aquaponics technology of closed recirculation produced fish optimally by saving water use and could exploit the waste of fish cultivation so that the aquaponics system could become the system of fish cultivation that is environmentally friendly.

1. Introduction

The success of fish cultivation depends on a system's effectiveness in handling or produce cultivation waste [1]. Technology innovation is needed to anticipate the reduction of aquaculture production caused by the reduction of water quality. Technology innovation is expected could reduce waste [2],[3], having economic value, and cultivation media. The Aquaponics system is one of the systems that could solve the waste problem of fish cultivation.

Aquaponics system is one of the technologies which integrated to fish cultivation that sealed (recirculating aquaculture). Aquaponics is a bio-integration that connects the recirculating aquaculture to plant/hydroponic vegetables [4]. Cultivation of an aquaponics system requires a plant that could function as a biological filter in the water ecosystem [4]. Kind of water plant that often uses in aquaponics system such as water spinach (Ipomea aquatica), lettuce (Lactuca satica), pokchai/mustard greens (Brassica chinensis), and tomato (Lycopersicon esculantum), meanwhile the kind of fish that could be used in aquaponics system are the consumption fish and decorative fish [5].

The province of Lampung has a big potential to be developed as the biggest fish producer in Indonesia both in fresh water fishery, brackish water (shrimp and milkfish) and sea fishery [6], [7]. Lampung province has massive potential in sea cultivation fishery that is gained more than 10.600 hectare (ha). Besides, there is also a potential of brackish fishery, both for enlargement and hatchery of fish/shrimp that gained 61.200 hectare. One of the ways to increase the productivity is to develop the cultivation technology of freshwater fishery. Technology innovation of fishery sector is not a new thing in Indonesia, especially in Lampung. The development technology cultivation of freshwater fishery aims to make the bussiness of fishery to become more effective [8], efficient, economical, highly compete, and environmental friendly based on the local culture. The local fishes are very potential to be developed to become commodity cultivation as biologically, economy, social and culture [9], [10].

The use of technology cultivation fishery in this era is expected could give impact both in increasing the productivity and increasing the well-being of life by adding the income from grazier/cultivator of freshwater fish [11], [12], so that the people in Lampung could be successful. The study of dissemination cultivation freshwater fish technology that has economical value in Lampung is expected could give recommendation to the development of freshwater fish, in case of increasing well-being life of grazier/cultivator, and the local fish cultivation is also expected could maintain the sustainability of fish cultivation and move the economic matters in Lampung.

The objective of research was to identify the advantage value of freshwater fish cultivation which has economy value and principal of aquaponics as a system of fish cultivation that environmental friendly.

2. Method of Research

This research was conducted in the province of Lampung, specifically at Toto Katon Village, Punggur, Central Lampung regency. The research had been done on May until August 2020. The data collecting technique used in this research was the Study of Dissemination Technology of Freshwater Fish which has economy value in Lampung, namely:

1. Literature study/Library study, from scientific books, scientific journal, result of research and some books that were published by competent agencies.
2. RAA method (*Rapid Rural Appraisal),* it was a participative approach which was aimed to get the data/information and measurement (assessment) that generally conducting at the field and taking in short time.
3. Early survey/field orientation at *Pilot Plant* location.
4. *Focus Group Discussion* (FGD) was done in each *Pilot Plant* location.

Kind of data that was used in this research were primary and secondary. Primary data had been taken from the community of freshwater fish in Central Lampung supported by related agency.

2.1. Analysis of plus value

The analysis of plus value was done due to answer the purpose of number six that was to identify how big the plus value of product preparation in the process of production so that it could be worth to be developed. The plus value was counted by using Hayani's method, it can be seen on Table 1 as follows:

Table 1. The plus value calculation procedure based on Haryani's Method

No	Variable	Value
1.	Output (kg/day)	A
2.	Raw Material (kg/day)	B
3.	Labor (HOK/day)	C
4.	Conversion Factor	D = A/B
5.	Coefficient of Labor (HOK/kg)	E = C/B

6.	Output Price (Rp/pack)	F
7.	Average wage of Labor (Rp/HOK)	G
Income and Benefit		
8.	Raw Material Price (Rp/kg)	H
9.	Contribution from another input (Rp/kg)	I
10.	Output value (Rp/kg)	J = D x F
11.	a. Plus value (Rp/kg)	K = J – I – H
	b. Plus value Ratio (%)	L = (K/J) x 100%
12.	a. Labor reward (Rp/kg)	M = E x G
	b. Labor part (%)	N = (M/K) x 100%
13.	a. Benefit (Rp/kg)	O = K – M
	b. Benefit Level (%)	P = (O/K) x 100%
Fringe benefits for production factor		
14.	Benefit Margin (Rp/kg)	Q = J – H
	a. Benefit (%)	R = O/Q x 100%
	b. Labor (%)	S = M/Q x 100%
	c. Another Input (%)	T = I/Q x 100%

Notes:
A = *Output* or the result total production.
B = *Input* or raw material that was used for production.
C = The labor to process the production counted by HOK in one analysis period.
F = Product price that valid in one analysis period only.
G = Average of wage received by labor in each period of production counted based on HOK.
H = *Input* price of main raw material of soy /kg in analysis period.
I = Contribution or another *input* cost that consisted of supporting raw material cost and shrinkage cost

Criteria of Plus Value (NT) were as follows:
a. If NT > 0, it means that the product development gives plus value (positive).
b. If NT < 0, it means that the product development is not give plus value (negative) [13].

2.2. Worthiness financial analysis
The method that was used in conducting the financial analysis on a project or bussiness was investation assessment criteria. This method was aimed to examine whether or not a project or bussiness worth to run financially. The method were consisted of *Net Present Value (NPV), Internal Rate of Return (IRR), Net Benefit per Cost (Net B/C),* and *Payback Period (PP)* [14, 15] also sensitivity analysis. Worthiness aspect financial analysis was done due to test some superior products in agro tour area.

2.2.1. Net Present Value. Net Present Value (NPV). NPV is a deviation between PV net cash with PV investation along to the time of investation [16]. The formula to count NPV is as follows:

$$\mathrm{NPV} = \sum_{t=0}^{n} \frac{\mathrm{B_t} - \mathrm{C_t}}{(1+\mathrm{i})^{\mathrm{t}}}$$

Notes:
Bt = benefit that obtained each year
Ct = cost that taken out each year
n = bussiness year
i = degree/level DR (%) Source: (Barus, 2001)
Worthiness measurement of investation based on NPV value are as follows:

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1). If NPV = 0, it means that the bussiness is not profitable neither loss (benefit received can only cover up the taken out cost), so the decision that must be taken based on the measurement from the decision maker.
2). If NPV > 0, it means that the bussiness is worth to run.
3). If NPV < 0, it means that the bussiness has loss and not worth to run.

2.2.2. Net Benefit Cost Ratio (Net B/C). Net Benefit Cost Ratio is a ratio activity from net benefit that has positive value with the net benefit that has negative value. The formula that uses to count Net B/C are as follows:

$$\text{Net B/C} = \frac{\sum_{t=0}^{n} \frac{B_t - C_t}{(1+i)^t}}{\sum_{t=0}^{n} \frac{B_t - C_t}{(1+i)^t}} \quad \text{Dimana} \quad \frac{B_t - C_t > 0}{B_t - C_t < 0}$$

Notes:
Bt = benefit that obtained each year.
Ct = cost that taken out each year n = number of year.
i = *discount rate* (%).

Investation worthiness measurement based on Net B/C value are as follows:
1) Net B/C > 1, it means that the bussiness is worth (profitable).
2) Net B/C = 1, it means that the bussiness has no profit neither loss.
3) Net B/C < 1, it means that the bussiness is not worth (unprofitable).

2.2.3. Internal Rate of Return (IRR). Internal Rate of Return (IRR) is a tool to measure the level of result repayment from investation [17]. Quantities is obtained from the percentage calculation. A bussiness is worth if it has IRR value bigger than the level of interest rate, otherwise if IRR that obtained smaller than the valid level of interest rate so that the bussiness is not worth to run. The formula to count IRR value is as follows:

$$\text{IRR} = \text{i} + \frac{\text{NPV}}{\text{NPV} - \text{NPV}'}(i' + i)$$

Notes:
I = *Discount rate* that obtain positive NPV.
i' = *Discount rate* that obtain positive NPV.
NPV = NPV that has positive value.
NPV' = NPV that has negative value.

2.2.4. Discounted Payback Period (DPP). Discounted Payback Period is a method to measure the worthiness of a bussiness about how fast the investation that had been taken out could be repaid. It is counted by using net benefit multiplied with *Discount Rate*. If *Discounted Payback Period* is shorter than the investation time, so that the bussiness is worth to run, otherwise if *Discounted Payback Period* is longer than investation time, so that the bussiness is not worth to run. *Discounted Payback Period* can be counted by using the following formula:

$$Discounted\ Payback\ Period = \frac{\text{I}}{\text{A}_\text{b}\, discounted}$$

Keterangan:
I = investation magnitude needed
$Ab_{discounted}$ = net benefit that obtained each year multiplied with DR.

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3. Results and Discussion

3.1. Financial worthiness of catfish cultivation with aquaponics technology

Cultivation of local fish increased year by year, it was because the cost was worth enough and the demand increased continuously. Time of investation with aquaponics technology was assumed could gain in three years (customized to the time of aquaponics investation). For that reason, the worthiness financial study of this research was done in 3 years. The cost that consumed on fish cultivation by using aquaponics technology can be seen on the following table 2, 3, and 4:

Table 2. Shrinkage cost of the outcome on fish cultivation of aquaponics technology (Rp/Year)

No	Kinf of Outcome	Economic Age	Basic Value	Ending Value	Shrinkage/ year
1	Terpaulin pool	1	37.500	0	37.500
2	Fishpond terpaulin	5	65.000	0	13.000
3	Concrete brick pool	2	625.000	100000	262.500
4	Water pipe	5	200.000	0	40.000
5	Filter pump	1	150.000	0	150.000
6	Small water pump	1	140.000	0	140.000
7	Boreholes	20	10.000.000	5000000	250.000
8	Basin	1	150.000	0	150.000
9	Aquaponics installation	3	4.375.000	1000000	1.125.000
10	Rokol	1	200.000	0	200.000
	Total investation &/Shrinkage		15.942.500		2.368.000

Tabel 3. Maintenance /reparation cost of the outcome on fish cultivation of aquaponics technology (Rp/Year)

No	Kind of Outcome	Frequency	Unit Price	Amount	Total
1	Instalation	2	100.000	1	200.000
2	Reparation aquaponics instalation	2	200.000	1	400.000
3	Water reparation	3	100.000	1	300.000

Tabel 4. Variable cost of the outcome on fish cultivation of aquaponic technology (Rp/Year)

No	Kind of Outcome	Frequency	Unit Price	Amount	Total
1	Labor wage	1	60.000	120	7.200.000
2	Food nature cost	12	60.000	1	720.000
3	Catfish seeds	5	350	1050	1.837.500
4	Plastic	2	100.000	1	200.000
5	Group contribution	12	10.000	1	120.000
6	Salt	12	10.000	1	120.000
7	Electricity	12	200.000	1	2.400.000

Meanwhile, The income of fish cultivation by using aquaponics technology can be seen on the following table 5 and 6:

Table 5. The income of fish cultivation by using aquaponics technology

No	Kinf of Income	Frequency	Unit Price	Amount	Total
1.	Catfish	5	20000	210	21.000.000
2.	Mustard Greens/Pakcoy	12	25000	20	6.000.000

Table 6. Worthiness criteria of catfish cultivation financial by using aquaponics technology

Worthiness Criteria	
NVP	Rp12.809.096,10
IRR	46,01%
NET B/C	1,80
PBP	1,51

The description of investation worthiness measurement were as follows:

1. NPV value > 0, it means that the bussiness of snakehead fish cultivation, bagrid catfish, and catfish were worth to run. It was because along with the bussiness time, this investation was benefical, therefore in the end of investation year it gained profit for each kind of fish were Rp 40.424.744,80, Rp56.095.019,88, and Rp12.809.096,10.
2. IRR value > Valid interest rate. A bussiness was worth if it had IRR value higher than the level of valid interest rate. Interest rate value was 5,25% (Based on interest rate BI reference).
3. B/C > 1 Net Value, it means that the bussiness was worth (profitable). B/C Net described the profit ratio on outcome. The value 3,54, 4,52, and 1,80 were shown that each outcome was Rp.1, therefore the bussiness could gain profit 3,54, 4,52, and Rp.1,80.
4. *Discounted Payback Period* was a method to measure the worthiness of a bussiness that used to determine how fast investation outcome could be repaid.
5. If *Discounted Payback Period* was shorter than the investation time, so the bussiness worth to run. DPP/PBP showed that number 1 was meant the first year of investation, the bussiness could return its capital.

Based on the calculation of financial worthiness above, it can be concluded that the bussiness of catfish cultivation by using aquaponics technology could be profitable.

3.2. Aquaponics System and Environmental Sustainability

The bussiness of cultivation by using aquaponics system at Central Lampung regency had an environment aspect. On the environment/ecosystem aspects, the first thing that must done was to maintain and protect the waste from cultivation activity of aquaponics system so that it would not contaminate to surrounding environment. The purpose of this aspect was to make the bussiness of cultivation aquaponics system could be applied continuously (sustainable). Aquaponics is a combination of aquaculture and hydroponic which has function to maintain the fish and plant in one connecting system. In this system, the waste that produced by nile tilapia fish can be used as fertilizer for water spinach, the water with the resirculation system from fish maintenance filtered by the water spinach media, then it can be reused by nile tilapia fish.

In this case, nile tilapia fish and water spinach obtained are healthy, because they are free from the chemical things. The interaction between nile tilapia fish and water spinach can produce ideal environment to grow more productive more than general cultivation method. Aquaponics biofilter is a system on cultivation technique of fish and plant that is expected to preserve water quality for fish and plant tolerance in some specific periods, without disturbing fish growth and aquatic plant which has function as biofilter [18].

Aquatic plant can utilize the nutrient effectively, so that it could have some benefits and the use of water could be more efficient [19],[20]. It could also descrease the waste pollution effect to the public water. The advantage of aquaponics system are utilizing the water more efficient and environmental friendly, because the condition of water that uses for aquaponics can be controlled well [21]. Besides, another advantage of aquaponics system is it can minimalize the use of fertilizer, because the fertilizer can take from fish dung in the water.

Aquaponics research had been started by Virgin Island University (UVI) in 1971. The research had started due to the difficulty of having freshwater fish and plant in Semiarid island, Australia. The result of this research was used as basic aquaponics system which is aim as commercial, but there are still many difficulties on the effort of system development. Aquaponics system is started to develop widely around 1980 [18].

All of bussiness in case of combaining the aquaculture with hydroponic are not work out well until around 1980, but there are some innovations that had been done to change the technology of aquaponics to become one of the system that could produce food material [4]. Aquaponics is saving much energies, so that it could prevent the waste to the public area. It could produce organic fertilizer for plant (better than chemical thing). The reuse of waste water on biofilter could ensure the material food production from multiculture, it makes the aquaponics is worth to be declared as role model for green technology [11], [22].

4. Conclusion

The cultivation of freshwater catfish with mustard greens/Pakcoy using an aquaponics system was worth economically and profitable. The aquaponics system's principle was to utilize nutrients from food waste on fish metabolism through mutualism symbiosis among fish, plants, and bacteria. Aquaponics system with closed recirculation could produce fish optimally by saving water use and utilizing fish cultivation waste. The aquaponics system can be said as a fish cultivation system that is environmentally friendly.

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