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Aquaponics Cultivation of *Ipome Aquatica* and the Peasant Financial Income of Cirata Cistern

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Abstract

The research paper analyzes the financial income of a poor community living around the Cirata cistern, in West Java, Indonesia, before and after the community employed the aquaponics strategy of planting *ipomoea aquatica*. Data are gathered from observation, interviews and statistical analysis of the incomes of community members. In addition, analysis of the data applies *Net Present Value* (NPV), *Internal Rate of Return* (IRR), and *Payback Period* (PP). The findings clearly demonstrate an increased annual income of more than 1.117.296 rupiah among those community members using the aquaponics strategy. Once the community has adjusted to professionally implementing this aquaponics strategy, it would be practically useful to invite investors to invest their capital to develop this area.

Keywords : *aquaponics*, *financial income*, *West Java*, *internal rate of return*, *payback period*

Fruit and vegetable consumption in Indonesia is only 40 kg/ year per capita. This is far below the standard of the Food and Agricultural Organization (FAO), which recommends consumption of a minimum of 73 kg/ year of vegetables and 65 kg/ year of fruit per capita (Fahrurrozi, 2013). Horticulture offers the possibility of overcoming these shortfalls. Horticulture is the art and practice of garden cultivation and management. It is used to solve problems and develop technologies to grow crops of fruit, vegetables, flowers, decorative plants, and bio-farm plants to be used

as sources of food, fibre, nutrition, decoration, and luxury and also to enrich culture (Poerwanto and Susila, 2014).

Table 1. Initial Investment Expense Calculation before Aquaponic Cultivation

Before Initial Investment in Aquaponics				
Components	**Prices**	**Quantity**	**Total**	**Age**
House	Rp 15.000.000	1	Rp 15.000.000	5
Watcher's Hut	Rp 1.500.000	1	Rp 1.500.000	5
Net	Rp 100.000	64	Rp 6.400.000	5
Drum	Rp 100.000	51	Rp 5.100.000	5
Solar Cell	Rp 2.500.000	1	Rp 2.500.000	5
Total			**Rp 30.500.000**	

There are several techniques in horticultural cultivation, one of which is the aquaponics system of cultivation. Aquaponics is a combination of fish cultivation (aqua-culture) and vegetable cultivation (hydroponics) (Rakocy, 2006; Suhl, J.ab, Dannehl, D.b, Kloas, W.cd (et.al), 2016), which combines fishery and vegetable cultivation with soil. The vegetables grown do not require fertilizer and gain nutrition from fish stools. In this case, the vegetable, water kale, is grown using aquaponics as it is easy to cultivate.

Table 2. Variable Expense Calculation before Aquaponic Cultivation

Variable Expense Calculation Before Aquaponics Cultivation	**Quantity**	**Price**	**Total (4 Months)**	**Total (Year)**
Golden Fish Seed	100	Rp 26.500	Rp 2.650.000	Rp 7.950.000
Parrot Fish Seed	100	Rp 14.500		Rp 1.450.000
Golden Fish Food	2500	Rp 7.600	Rp 19.000.000	Rp 57.000.000
Total			**Rp 23.100.000**	**Rp 66.400.000**

One potential place to cultivate aquaponics is Cirata reservoir, in Cianjur, West Java. The reservoir consists of 66 of water from the Citarum river dam and spans the three regencies of Cianjur, Purwakarta and Bandung. The largest area, of 29,603,299, is in Cianjur regency (Aksomo, 2007). This reservoir is used by the surrounding people to cultivate fish using *keramba jaring apung*/floating nets (KJA). The cultivation in Cirata reservoir covers more than 51,418 terraces.

Table 3. Income Calculation before Aquaponic Cultivation

Income Without Aquaponics	**Quantity (kg)**	**Selling Price (kg)**	**Total (4 Months)**	**Total (Year)**
Golden Fish	1250	Rp 20.000	Rp 25.000.000	Rp 75.000.000
Parrot Fish	600	Rp 12.000		Rp 7.200.000
Total				**Rp 82.200.000**

Aquaponic cultivation offers high potential for implementation and expansion in this area due to the large area of the Cirata Reservoir; and the need to overcome issues of water pollution caused by the build up of fish food waste and fish stools. Aquaponics has the potential to both increase farmer income and reduce water pollution. Therefore, financial analysis is needed to show the income differences before and after aquaponic cultivation. Aquaponic cultivation shows high potential for development in Cirata reservoir despite being a new cultivation method. Cirata fish farmers do not yet have knowledge of aquaponic cultivation. This paper recommends the introduction of the aquaponic cultivation system to fish farmers; so that they can understand the principles and methods of aquaponics and implement them in the Cirata Reservoir.

Measuring NPV and IRC

This research had been carried out in February 2015 at Cirata Reservoir, Mande Village, Cianjur, West Java, Indonesia. Both primary and secondary data were used. The primary data were gained from interviews with aquaponics farmers and fish farmers. The secondary data were obtained through literature review. The qualitative research was used to see how far aquaponics is able to reduce pollution and a quantitative approach was employed to analyze farmer income before and after implementation of the aquaponics system.

The data collection methods include observation with visitation to the Cirata Reservoir, an interview with the Head of Cirata UPDT (Reservoir Fishery Cultivation Development Office) and a review of past literature on the subject. The data analysis used includes Net Present Value (NPV), Internal Rate of Return (IRR), and Payback Period (PP).

Table 4. NPV Calculation before Aquaponics

NPV Before Aquaponics				
Year	**Income**	**Expense**	**Value**	**NPV**
0		Rp 30.500.000	Rp (30.500.000)	Rp (30.500.000)
1	Rp 82.200.000	Rp 68.900.000	Rp 13.300.000	Rp 12.429.907
2	Rp 82.200.000	Rp 68.900.000	Rp 13.300.000	Rp 11.616.735
3	Rp 82.200.000	Rp 68.900.000	Rp 13.300.000	Rp 10.856.762
4	Rp 82.200.000	Rp 68.900.000	Rp 13.300.000	Rp 10.146.506
5	Rp 82.200.000	Rp 68.900.000	Rp 13.300.000	Rp 9.482.716
Total	**Rp411.000.000**	**Rp375.000.000**	**Rp36.000.000**	**Rp24.032.626**

NPV (Net Present Value) is the method gained from present number differences from net cash flow (proceed) with present value and investment expense cost (Suliyanto, 2010). The formula is:

$$NPV = \sum_{t=0}^{n} \frac{Bt - Ct}{(1+i)^t}$$

Explanation:

Bt = Acceptation in year t

Ct = Expense in year t

T = Business Activity Year (t = 0,1,2,...n)

i = Discount Rate level (%)

NPV Indicators:

If NPV > 0, the business is eligible to operate

If NPV < 0, the business is not eligible to operate

Table 5. IRR Calculation before Aquaponics

IRR Before Aquaponics			
Year	**Profit/ Loss**	**IRR 30%**	**IRR 35%**
0	Rp (30.500.000)	Rp (30.500.000)	Rp (30.500.000)
1	Rp 13.300.000	Rp 10.230.769	Rp 9.851.852
2	Rp 13.300.000	Rp 7.869.822	Rp 7.297.668
3	Rp 13.300.000	Rp 6.053.710	Rp 5.405.680
4	Rp 13.300.000	Rp 4.656.700	Rp 4.004.207
5	Rp 13.300.000	Rp 3.582.077	Rp 2.966.080
Total		**Rp 1.893.078**	**Rp (974.513)**

IRR Calculation	
i1	30%
i2	35%
NPV 1	Rp 1.893.078
NPV 2	Rp (974.513)
IRR	**33%**

IRR is a method to calculate interest level to equate present value from all input cash and output cash of an investment. The formula is:

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

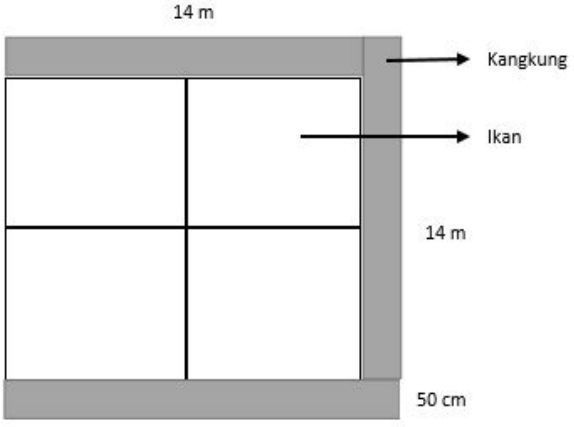
IRR indicator:
If IRR is bigger than discount rate the business is not eligible to operate.

Payback period is a method used to calculate the period needed to return the investment money from the yearly cash input (proceeds) from an investment project. The formula is:

$$\text{PP} = \frac{\text{I}}{\text{Ab}}$$

Explanation:
I : Investment
Ab : Yearly Net Income

Agricultural Policy Effects



Aquaponic cultivation with the implementation of KJA

A policy recommendation is a suggestion to the authority of policy making on a policy action to solve a problem or achieve a goal (Abidin, 2006). Agricultural policy recommendation policy is created for the farmers as aquaponics cultivation operator, for agricultural extension as aquaponics cultivation trainer and for UPTD Cirata Reservoir Fishery Cultivation Development Office as intermediate institution between agricultural extension and aquaponics farmer and controlling aquaponics cultivation process development by the farmers.

The aquaponic system cultivated and analyzed in this research is performed in a floating net (KJA) unit measuring 14 x 14 m. The aquaponics method is used to cultivate the water vegetable kale. Bamboo is used to support the floating kale above the water line. The kale grows outside the net with 50 cm wide from the furthest net. The kale is planted on three sides of the KJA. The remaining side is used to moor boats to the KJA. The aquaponics planning system is shown below:

Table 6. Initial Investment Expense Calculation after Aquaponic Cultivation

Initial Investment After Aquaponics				
Components	**Prices**	**Quantity**	**Total**	**Age**
House	Rp 15.000.000	1	Rp 15.000.000	5
Watcher's Hut	Rp 1.500.000	1	Rp 1.500.000	5
Net	Rp 100.000	64	Rp 6.400.000	5
Drum	Rp 100.000	51	Rp 5.100.000	5
Solar Cell	Rp 2.500.000	1	Rp 2.500.000	5
Bamboo	Rp 8.000	10	Rp 80.000	
Total			**Rp 30.580.000**	

Table 7. Permanent Expense Calculation

Permanent Expense	Quantity	Price	Total (Month)	Total (Year)
Drum Reduction	51	Rp 100.000	Rp 141.667	Rp 1.700.000
Land Rental	1	Rp 200.000	Rp 16.667	Rp 200.000
Net Maintenance	1	Rp 50.000	Rp 50.000	Rp 600.000
Total			**Rp 208.333**	**Rp 2.500.000**

Table 8. Variable Expense Calculation after Aquaponic Cultivation

Variable Expense Calculation After Aquaponics Cultivation	Quantity	Price	Total (Year)
Golden Fish Seed	100	Rp 26.500	Rp 7.950.000
Parrot Fish Seed	100	Rp 14.500	Rp 1.450.000
Golden Fish Food	2500	Rp 7.600	Rp 57.000.000
Water Kale Seed		Rp 10.000	Rp 10.000
Total			**Rp 66.410.000**

Table 9. Income Calculation after Aquaponics Cultivation

Income With Aquaponics	Quantity (kg)	Selling Price (kg)	Total (4 Months)	Total (Year)
Golden Fish	1250	Rp 20.000	Rp 25.000.000	Rp 75.000.000
Parrot Fish	600	Rp 12.000		Rp 7.200.000
Kale	17,5	Rp 500	Rp 464.000	Rp 1.392.000
Total				**Rp 83.592.000**

The total length of the KJA area used to plant kale is 35 m and the width is 0.5 m. The total area is 17.5 m^2. The kale harvest for each meter square is 1 kg. The harvest is performed each 2 weeks, and the total harvest is 17.5 kg. The total kale harvest every month is 35 kg. The kale harvest is bound and the weight of each bound is 150 gram. Each bound kale is sold to collectors for Rp. 500.

water kale aquaponics

The harvested fish from the KJA farmers consists of golden fish and parrot-fish. The golden fish is harvested every four months with an average harvest of 1,250 kg. The parrot fish is harvested once a year with an average harvest of 600 kg.

Table 10. NPV Calculation after Aquaponics

NPV After Aquaponics				
Year	**Income**	**Expense**	**Value**	**NPV**
0		Rp 30.580.000	Rp (30.580.000)	Rp (30.580.000)
1	Rp 83.592.000	Rp 68.910.000	Rp 14.682.000	Rp 13.721.495
2	Rp 83.592.000	Rp 68.910.000	Rp 14.682.000	Rp 12.823.827
3	Rp 83.592.000	Rp 68.910.000	Rp 14.682.000	Rp 11.984.885
4	Rp 83.592.000	Rp 68.910.000	Rp 14.682.000	Rp 11.200.828
5	Rp 83.592.000	Rp 68.910.000	Rp 14.682.000	Rp 10.468.063
Total	Rp417.960.000	Rp 375.130.000	Rp 42.830.000	**Rp 29.619.099**

Table 11. IRR Calculation after Aquaponics

IRR After Aquaponics			
Year	**Profit/ Loss**	**IRR 30%**	**IRR 40%**
0	Rp (30.580.000)	Rp (30.580.000)	Rp (30.580.000)
1	Rp 14.682.000	Rp 11.293.846	Rp 10.487.143
2	Rp 14.682.000	Rp 8.687.574	Rp 7.490.816
3	Rp 14.682.000	Rp 6.682.749	Rp 5.350.583
4	Rp 14.682.000	Rp 5.140.576	Rp 3.821.845
5	Rp 14.682.000	Rp 3.954.289	Rp 2.729.889
Total	Rp 42.830.000	**Rp 5.179.035**	**Rp (699.723)**

IRR Calculation	
i 1	30%
i 2	40%
NPV 1	Rp 5.179.035
NPV 2	Rp (699.723)
IRR	**39%**

The calculation of the result of financial analysis before and after aquaponics was implemented is shown in the table below.

Explanation	Before	after
NPV	Rp. 24,032,626	Rp. 29,619,099
IRR	33%	39%
PP	32,1 Months	27,4 Months

Table 12. Business Financial Analysis Before and After Aquaponics Implementation

The table above shows NPV before and after aquaponics cultivation implementation is increasing. NPV before aquaponics implementation

is Rp. 24,032,626 and after is Rp. 29,619,099. This means the farmers' profit five years before the implementation of aquaponics was Rp. 24,032,626, and after implementation is Rp. 29,619,099. The NPV with Rp. 29,619,099 for a five year project means farmers gain an additional income of Rp. 93,108. The interest level is 7% from a five year project. This means discount rate level to pay back the modal in business activity without aquaponic cultivation is 33%. The business activities after aquaponics implementation will increase the discount rate and make the business activities better than before the aquaponic cultivation.

Payback period before aquaponic cultivation is four years, and after the cultivation is three years. This means the business investment without aquaponics will be paid back after four years, and with aquaponics will paid back in three years. Therefore, the aquaponic cultivation will cut the payback period of the business investment. The result shows aquaponic cultivation will increase NPV, IRR and payback period. Aquaponic cultivation implementation will make more profit than without aquaponics.

Table 13. PP Calculation before Aquaponics

Payback Period Before Aquaponics				
Explanation	**Income**	**Expense**	**Profit/ Loss**	**The Effect on Initial Investment**
				Rp 30.500.000
Harvest 1	Rp 25.000.000	Rp 23.933.333	Rp 1.066.667	Rp 29.433.333
Harvest 2	Rp 25.000.000	Rp 22.483.333	Rp 2.516.667	Rp 26.916.667
Harvest 3	Rp 32.200.000	Rp 22.483.333	Rp 9.716.667	Rp 17.200.000
Harvest 4	Rp 25.000.000	Rp 23.933.333	Rp 1.066.667	Rp 16.133.333
Harvest 5	Rp 25.000.000	Rp 22.483.333	Rp 2.516.667	Rp 13.616.667
Harvest 6	Rp 32.200.000	Rp 22.483.333	Rp 9.716.667	Rp 3.900.000
Harvest 7	Rp 25.000.000	Rp 23.933.333	Rp 1.066.667	Rp 2.833.333
Harvest 8	Rp 25.000.000	Rp 22.483.333	Rp 2.516.667	Rp 316.667
Harvest 9	Rp 32.200.000	Rp 22.483.333	Rp 9.716.667	Rp (9.400.000)
Payback Period				**32,1 Months**

Table 14. PP Calculation after Aquaponics

Payback Period After Aquaponics				
Explanation	**Income**	**Expense**	**Profit/ Loss**	**The Effect on Initial Investment**
				Rp 30.660.000
Harvest 1	Rp 25.464.000	Rp 22.493.333	Rp 2.970.667	Rp 27.689.333
Harvest 2	Rp 25.464.000	Rp 23.933.333	Rp 1.530.667	Rp 26.158.667
Harvest 3	Rp 32.664.000	Rp 22.483.333	Rp 10.180.667	Rp 15.978.000
Harvest 4	Rp 25.464.000	Rp 22.493.333	Rp 2.970.667	Rp 13.007.333
Harvest 5	Rp 25.464.000	Rp 23.933.333	Rp 1.530.667	Rp 11.476.667
Harvest 6	Rp 32.664.000	Rp 22.483.333	Rp 10.180.667	Rp 1.296.000
Harvest 7	Rp 25.464.000	Rp 23.943.333	Rp 1.520.667	Rp (224.667)
Payback Period				**27,4 Months**

The financial analysis calculation shows the aquaponic cultivation activity will make more profit for agricultural businesses. Aquaponics will also reduce water pollution caused by un-eaten fish food fall-out. Several policy recommendations are needed to make fish farmers in Cirata Reservoir perform the aquaponics socialization program, the aquaponic cultivation method training, and socialization for the potential investors to collect vegetables from aquaponic cultivation harvest.

Acquisition policy recommendation states that the purpose of socialization is to provide knowledge about aquaponic cultivation to farmers. The farmers should be introduced to aquaponics due to it's categorization as new agricultural system. Most Indonesian farmers have low education levels and only know traditional agricultural systems. Therefore, the program of socialization is needed to introduce aquaponic cultivation to farmers. The related parties in the socialization program are Bapak Ade, the Head of UPTD Cirata Reservoir Fishery Cultivation Development Office as socialization provider, aquaponics cultivation extension, and farmers as aquaponic cultivation operators. Bapak Ade's position is as the one with authority to choose potential KJA farmers as aquaponics cultivators. The chosen farmers should live close by to allow time and cost efficiency in transporting the vegetable harvest.

After receiving socialization on the aquaponics and cultivation method, the farmers are given training on the method and cultivation of aquaponics including planting, maintaining, and harvesting. Wrong planting will create a poor harvest, and a bad harvesting process will damage production. Therefore, this training is needed to enable farmers to manage aquaponics in the facets of correct planting systems, maintaining, and harvesting the products. The parties involved in this policy are the aquaponics cultivation extension training provider, the farmers as aquaponics cultivation operators, and UPTD Cirata Reservoir

Fishery Cultivation Development Office as the intermediary between the extension, theresearcher and the farmers. UPTD will classify aquaponics cultivation based on the area to make the control easier in the aquaponics cultivation process.

One of the farmers' problems is assurance of aquaponics harvest reception center market. Therefore, business opportunity socialization is needed for potential investors. The targeting parties are established fish food sellers around Cirata reservoir. The reception center market enable aquaponic farmers to sell vegetables easily and to ensure a market for the vegetables. The parties involved here are the UPTD Cirata Reservoir Fishery Cultivation Development Office as socializer, and the potential investors, as the targets of this policy.

Conclusion

The analysis shows the differences between financial analysis before and after aquaponics implementation. The financial analysis criteria show NPV, IRR and PP after aquaponics implementation is higher than without implementation. The NPV before aquaponics is Rp. 24,032,626 and after is Rp. 29,619,099. The IRR before aquaponics is 33 % and after is 39%. The PP before aquaponics is four years and after aquaponics is three years. It means that the aquaponic cultivation business creates more profit than traditional methods, despite the small additional cost for vegetable plantation.

Aquaponic cultivation should be introduced and implemented by farmers. The policy recommendations are the aquaponics socialization program, the aquaponic cultivation training program, and socialization to invite potential investors as aquaponic cultivation harvest collectors. The writer suggests further research be conducted on vegetables with higher economic value to increase potential profit. There should be analysis of the aquaponic cultivation harvest reception businesses to optimize the propensity for investors to benefit from this business opportunity.

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