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# Hydroganic and Mina Padi Innovation: An Economic and Land Efficiency Study

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***ABSTRACT***

***Keywords:***
Economy Feasibility; Hydroganic System; Land Efficiency; Mina Padi

**Abstract**

Agricultural efficiency and sustainability are major challenges amidst limited land availability and increasing food demand. Pusat Pelatihan Pertanian dan Pedesaan Swadaya (P4S) Bengkel Mimpi in Malang Regency integrates the agriculture and fisheries sectors through two methods: hydroganic and mina padi systems. This study aims to analyze the economic feasibility and land efficiency of the two systems applied for rice and catfish cultivation at P4S Bengkel Mimpi. Using quantitative descriptive method, the analysis was conducted using cost and income approach, NPV, DPP, B/C Ratio, BEP, and IRR. The results of the analysis on 100 m$^2$ of land show that the hydroganic system has an NPV of IDR 57,655,541.40, a DPP of 13.65 months, a B/C of 3.95, and an IRR of 20%, with an increase in land productivity of up to 580%. Meanwhile, the mina padi system has an NPV of IDR 3,706,655.25, DPP of 5.67 months, B/C of 3.05, and IRR of 58%, with a faster return on investment. These findings suggest that hydroganic system is superior in land productivity, while the mina padi offers a shorter return on investment, providing strategic recommendations for the application of agricultural and aquaculture integration technologies.

## INTRODUCTION

Food security is one of the world's most important issues, as reflected in the seventeen goals of the Sustainable Development Goals (SDGs), specifically Goal 2: "Zero Hunger." To achieve food security, several essential aspects must be fulfilled, including availability, accessibility, utility, and the stability of adequate supply, quality, and nutrition (Ghalibaf et al., 2022). According to (Lolaso et al., 2024), household-level food security is closely linked to the nutritional deficiencies and health conditions of household members, which in turn affect the overall productivity of the household. One strategic aspect that must be addressed to achieve food security is agriculture (Pawlak & Kołodziejczak, 2020).

As a staple food in Indonesia, rice plays a crucial role in achieving food security. However, rice cultivation faces several challenges in implementing sustainable agricultural practices. One of the major challenges is the widespread conversion of agricultural land. It is recorded that the harvested area of rice in Indonesia has shown a significant decline over the past six years. In 2018, the total harvested area reached 11,331,943.46 hectares, whereas by 2023, it had decreased to 10,210,768.35 hectares (BDSP2, 2024). In addition to land scarcity, conventional rice cultivation is highly dependent on climatic factors due to its reliance on abundant water resources (Ikhwali et al., 2022). This heavy dependence on water also highlights inefficiencies in resource utilization. Moreover, inefficiencies are also evident in the excessive use of chemical fertilizers, which is often applied through spraying methods commonly practiced in Indonesia, which reduces the effectiveness of fertilization (Putra et al., 2021). The intensive use of chemical fertilizers and pesticides has also led to environmental issues that compromise the sustainability of rice production (Irawan & Antriyandarti, 2021). Given these challenges, there is a pressing need for technologies that can enhance the efficiency, productivity, and sustainability of rice cultivation. One of the strategies to address these challenges is the integration of agriculture and aquaculture.

The integration of aquaculture and agriculture can be implemented through various methods. One traditional and widely practiced technique is mina padi, which involves the integration of rice farming with fish cultivation in paddy fields, allowing farmers to produce two commodities together. This method is favored for its simplicity, rapid return on investment, reduction in chemical fertilizer and pesticide use, and its support for natural pest and weed control (Yassi et al., 2020). An alternative solution is the hydroganic system, which combines hydroponic agriculture with organic farming practices. In practice, hydroganic systems integrate aquaculture with hydroponics, where aquaculture waste is expected to be mineralized by bacteria and subsequently serve as nutrients for plants (Szekely & Jijakli, 2022). The practice of hydroganics for rice cultivation has been demonstrated by the previous study (Goda et al., 2023). In their study, it was found that a multicultural aquaponic system involving rice and *Nile tilapia* can increase water use efficiency by up to 31%, nitrogen by 10%, and phosphorus by 18%.

In Malang Regency, one institution has implemented both integrated agriculture-aquaculture systems in rice cultivation—namely, the Pusat Pelatihan Pertanian dan Pedesaan Swadaya (P4S) Bengkel Mimpi. With the principle of optimizing the use of unused household land for food crop farming, the initiative aims to produce safe and economically valuable food (Ridwan et al., 2022). In practice, the integrated system involves cultivating rice and catfish. Catfish is selected due to its ease and low cost of maintenance, as well as its status as one of the most widely consumed fish species in Indonesia. According to Statistics Indonesia (2024), in 2023, per capita catfish consumption in Indonesia reached 1 kilogram per month.

To date, there has been no economic feasibility analysis comparing the hydroganic and mina padi systems, leaving a gap in understanding which system offers better productivity and investment viability. In response to this, the present study aims to assess the economic feasibility of both the hydroganic and mina padi systems using Net Present Value (NPV), Benefit-Cost Ratio (B/C), Break-Even Point (BEP), Discounted Payback Period (DPP), and

Internal Rate of Return (IRR), to support future optimization of land use for more efficient agricultural practices.

## RESEARCH METHOD

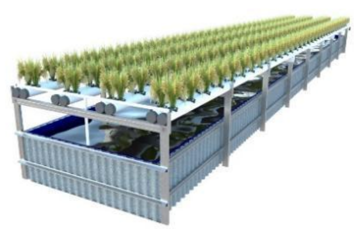
This study was conducted at the Pusat Pelatihan Pertanian dan Pedesaan Swadaya (P4S) Bengkel Mimpi, located in Kanigoro Village, Pagelaran District, Malang Regency. The study employed a quantitative descriptive approach and aimed to analyze the economic feasibility of implementing hydroganic and mina padi systems at P4S Bengkel Mimpi. The feasibility analysis was conducted using modified parameters based on the framework proposed by Zappernick et al. (2022). The parameters used included total cost and revenue analysis, Net Present Value (NPV), Benefit-Cost Ratio (B/C), Discounted Payback Period (DPP), Break-Even Point (BEP), and Internal Rate of Return (IRR). In addition, the production capacity of rice and catfish was calculated to assess land productivity in each system, thereby providing a comparative overview of which agricultural system offers greater efficiency and optimal application.

Calculations were conducted under the assumption of a five-year evaluation period. The land area allocated for both the mina padi and hydroganic systems was set at 100 m² each. Both systems were assumed to produce three cultivation cycles per year. A discount rate of 12% was applied. Primary data were collected through direct observation and interviews, while secondary data were obtained through literature reviews and surveys conducted via e-commerce platforms to determine the prevailing market prices of rice and catfish.

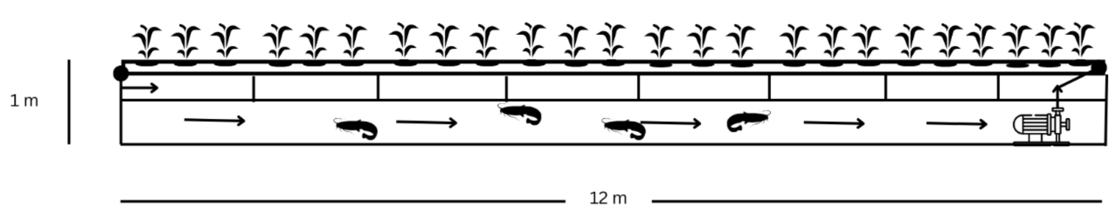
### Hydroganic and Mina Padi System Design

The hydroganic system installation is illustrated in **Figure 1.** The structure measures 12 meters in length, 2 meters in width, and 1 meter in height. It is supported by a lightweight steel frame, designed for long-term durability. The system comprises 24 pipes arranged in 8 rows, with each row consisting of 3 pipes, each with a diameter of 4 inches. The total number of planting holes per installation is 384. The fish pond is constructed using a tarpaulin measuring 14 meters in length and 4 meters in width, with corrugated asbestos sheets placed along the sides to serve as pond walls. Cultivation in the hydroganic system uses organic fertilizer derived from animal manure, which serves as a source of organic nutrients. This fertilizer is mixed with rice husk charcoal to form the planting medium. The total land area required for one hydroganic installation is 50 m².

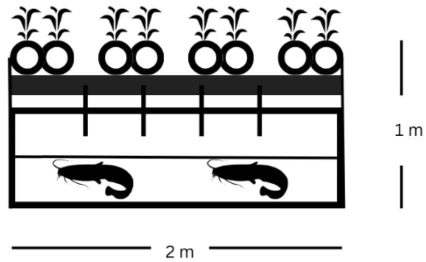
The mina padi system is depicted in **Figure 2.** As shown, the mina padi system is essentially a conventional paddy field integrated with specific fish commodities.



**a)**




**b)**




**c)**

**Figure 1. a)** Three-dimensional design of the hydroganic system installation, **b)** Side view schematic of the hydroganic system, **c)** Front view schematic of the hydroganic system

**Figure 2.** Illustration of the Mina Padi Aquaponic System

**Total Cost and Revenue Analysis**

**a. Investment Costs**

Investment costs are calculated based on the total expenditure required to construct a single hydroganic system installation. The tools and materials included in the investment cost for the hydroganic system are detailed in **Table 1.** Meanwhile, the breakdown of investment costs for the mina padi system is presented in **Table 2.**

**Table 1.** Breakdown of Tools and Materials for the Hydroganic System

| NO | ITEM | UNIT | QUANTITY | UNIT PRICE | ECONOMIC LIFE (MONTHS) |
|---|---|---|---|---|---|
| 1 | 4-inch PVC Pipe | stick | 25 | IDR 170,000 | 60 |
| 2 | 3-inch PVC Pipe | stick | 1 | IDR 100,000 | 60 |
| 3 | 1-inch PVC Pipe | stick | 1 | IDR 45,000 | 60 |
| 4 | 3/4-inch PVC Pipe | stick | 2 | IDR 35,000 | 60 |
| 5 | 4-inch PVC Pipe Cap | piece | 10 | IDR 10,000 | 60 |
| 6 | 3/4-inch PVC Pipe Cap | piece | 2 | IDR 4,000 | 60 |
| 7 | Light Steel C-Channel | stick | 10 | IDR 95,000 | 120 |
| 8 | 3-inch Outer-Inner Socket | piece | 3 | IDR 6,000 | 60 |
| 9 | 3-inch Elbow Connector (Knee) | piece | 1 | IDR 10,000 | 60 |
| 10 | 3 cm Drilling Screws | piece | 2,000 | IDR 200 | 60 |

| | | | | | |
|---|---|---|---|---|---|
| 11 | Corrugated Asbestos 60cm x 70cm | sheet | 40 | IDR 16,000 | 60 |
| 12 | Tarp 4m x 14m | sheet | 1 | IDR 960,000 | 60 |
| 13 | Water Pump ACT 5300 | piece | 1 | IDR 410,000 | 36 |
| 14 | Power Outlet | piece | 1 | IDR 7,000 | 60 |
| 15 | Electrical Cable | meter | 25 | IDR 7,000 | 60 |
| 16 | Grinder Cutting Blade Set | pack | 1 | IDR 85,000 | 36 |
| 17 | 16 Oz Plastic Cup | piece | 400 | IDR 250 | 4 |

Source: Processed Primary Data, 2024

**Table 2.** Rincian Alat dan Bahan Sistem Mina padi

| NO | ITEM | UNIT | QUANTITY | UNIT PRICE | ECONOMIC LIFE (MONTHS) |
|---|---|---|---|---|---|
| 1 | Hoe | Piece | 2 | IDR 80,000 | 60 |
| 2 | Rake | Piece | 2 | IDE 100,000 | 60 |

Source: Processed Primary Data, 2024

**b. Total Costs**

Total costs are obtained by summing fixed and variable costs for both the hydroganic and mina padi systems over one production cycle. The expenses incurred in a single cycle are expected to generate returns in the form of the desired outputs (Maharani et al., 2022). Total cost is calculated using the following formula:

$$\mathbf{TC = FC + VC}$$

Where:
TC = Total cost of the system
FC = Total fixed costs of the system
VC = Total variable costs of the system

**c. Revenue**

Revenue refers to the monetary value obtained from the operation of the hydroganic and mina padi systems in producing rice and Nile tilapia. It is calculated by multiplying the quantity of production by the selling price (Bakari, 2019). The formula used is as follows:

$$\mathbf{TR = Y \times Py}$$

Where:
TR = Total revenue
Y = Quantity of production
Py = Selling price of the product

**d. Income**

Income is derived from the difference between the total revenue and the total production costs (Bakari, 2019). The formula to calculate income is as follows:

$$\mathbf{\Pi = TR - TC}$$

Where:
Π = Income
TR = Total revenue
TC = Total costs

**1. Net Present Value (NPV)**

Net Present Value (NPV) is an investment criterion obtained by calculating the difference between the present value of benefits and production costs. To determine the present value, the time value of money is taken into account through discounting, allowing future monetary values to be brought to their present value (Žižlavský, 2014) A positive NPV indicates that the investment project is feasible at the given discount rate, while a negative NPV suggests that the project should be rejected (Souza et al., 2019). In this study, the NPV is calculated using the following formula:

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

Where:
Bt = Annual benefit (IDR)
Ct = Annual cost (IDR)
t = Year (time)
i = Interest rate

Interpretation Indicators:
a. If NPV < 0, the project is not feasible and will incur a loss.
b. If NPV = 0, the project is marginally feasible and likely unprofitable.
c. If NPV > 0, the project is feasible and profitable.

**2. Net Benefit Cost Ratio (Net B/C)**

The Net Benefit Cost Ratio (Net B/C) is the ratio between the present value of benefits and the present value of costs. The effect of the analysis period must be considered. Therefore, present value is used in the calculation by applying the appropriate discount factor (Wicaksono & Handayani, 2021). The formula used is:

$$Net\ B/CRatio = \frac{PV\ Net\ B\ (+)}{PV\ Net\ B\ (-)}$$

Where:
PV B (+) = Total present value of benefits during the analysis period (positive)
PV B (-) = Total present value of costs during the analysis period (negative)

Interpretation Indicators:
a. If Net B/C <1, the project is not feasible
b. If Net B/C = 1, the project is at BEP
c. If Net B/C >1, the project is feasible

**3. *Break-Event Point* (BEP)**

The Break-Even Point (BEP) is the point at which total revenue equals total cost. It is used to determine the minimum production or income level required in a given period for the business to avoid losses (Emanauli et al., 2021). The BEP is calculated using the following formula:

$$BEP = \frac{FC}{P - VC}$$

Where:
FC = Fixed Cost
P = Price
VC = Variable Cost (per product)

**4. Discounted Payback Period *(DPP)***

The Discounted Payback Period (DPP) is an economic analysis instrument used to determine the amount of time required for an investment to be recovered, taking into account the time value of money. Unlike the standard payback period, DPP includes the discount factor in the calculation of the payback time (Sharma et al., 2016). The DPP is calculated using the following equation:

$$DPP = Period\ Before\ Payback + \frac{PV\ of\ remaining\ Cashflow}{PV\ of\ Cashflow\ in\ payback\ period}$$

Where:
PV = Present Value

**5. *Internal Rate of Return* (IRR)**

The Internal Rate of Return (IRR) is one of the investment criteria used to estimate the percentage of return, calculated as the interest rate at which the Net Present Value (NPV) equals zero. An investment is considered feasible if the IRR exceeds the predetermined discount rate (Wicaksono & Handayani, 2021). The IRR is calculated using the following formula:

$$IRR\ = Df1 + \frac{NPV\ 1}{(NPV\ 1 - NPV\ 2)}\ x\ (Df\ 2 - Df1)$$

Where:
NPV 1 = Positive NPV value
NPV 2 = Negative NPV value
Df 1 = Interest rate that yields NPV 1
Df 2 = Interest rate that yields NPV 2

**RESULTS AND DISCUSSION**

To analyze the economic feasibility of the hydroganic and mina padi systems, the total investment cost of each system must be calculated. Based on **Table 1** and **Table 2**, the investment required to construct a single hydroganic installation amounts to IDR 8,328,000. Assuming that one hydroganic installation requires 50 m² of land, a 100 m² plot can accommodate two installations. Therefore, to maximize the use of a 100 m² land area with hydroganic installations, the total investment needed is IDR 16,656,000. In contrast, the mina padi system only requires basic tools such as a hoe and a harrow for the same land area. Consequently, the initial investment required to implement the mina padi system is IDR 360,000. Both investment estimates exclude land acquisition costs.

When compared to the aquaponics system using nila fish and kangkung vegetables studied by the previous study (Gunawan et al., 2020), the total investment required by P4S Bengkel Mimpi is relatively lower. In that study, the use of *nila* fish and *kangkung* vegetables required an investment of IDR 36,380,000 for a 25 m × 10 m installation. Similarly, when compared with the aquaponics system using *nila* fish and spinach as studied (Zainal et al., 2021), the investment cost at P4S Bengkel Mimpi remains lower. That study utilized catfish and *pakcoy* vegetables, with a required investment of IDR 15,942,500. The mina padi system using rice and nila fish as studied by the previous study (Sauqie et al., 2017) in Sleman Regency, for a land area of 700–1000 m², required an investment ranging from IDR 550,000 to IDR 11,000,000.

**Land Productivity Comparison**

Land productivity can be observed from the difference in the production capacity of rice and catfish between the two systems. In the hydroganic system, there are 384 planting holes per installation; thus, with two installations (100 m²), a total of 768 planting holes are available. Optimally, one hydroganic installation can yield 33.2 kg of rice, or 66.4 kg per 100

$m^2$. This yield is relatively lower compared to the mina padi system, which can produce 120 kg of rice per 100 $m^2$. When compared with the system studied (Goda et al., 2023), the hydroganic system at Bengkel Mimpi demonstrates higher rice productivity, as that study reported a yield of 25.3 kg per 100 $m^2$. Meanwhile, Barus et al. (2023) reported a maximum rice yield of 54.8 kg per 100 $m^2$ from an integrated rice-catfish cultivation system. The difference in productivity between the mina padi and hydroganic systems may be due to the greater flexibility of planting media in the mina padi system, which allows for more efficient use of planting space.

Rice yield in the hydroganic system can be influenced by several factors. The population of fish within a single pond affects the nutrient content available for the rice. According to (Barus et al., 2023), a higher fish population correlates with increased rice yield. This can also be explained by the relationship between fish population and feed input—uneaten feed can be utilized as nutrients by the rice plants. In addition to the fish population, the composition of organic fertilizer used has a significant impact on yield. A higher fertilizer ratio results in greater rice yield. Moreover, rice variety also plays a significant role in influencing yield (Khairullah et al., 2021).

Although in terms of rice productivity, the hydroganic system has not yet surpassed that of the mina padi system, it significantly outperforms mina padi in catfish productivity. Due to the deeper pond design in the hydroganic system compared to the shallower mina padi ponds, the number of catfish that can be cultivated is up to 15 times greater. In one production cycle, the hydroganic system can yield 1,000 kg of catfish per 100 $m^2$, whereas the mina padi system only produces approximately 66.7 kg per 100 $m^2$. When compared to the aquaponics system studied by Setiadi et al. (2019), the fish density in the hydroganic system at Bengkel Mimpi is lower, as that study reported a density of 300 catfish per $m^2$, while Bengkel Mimpi maintains a density of 100 catfish per $m^2$. This discrepancy may result from differences in pond depth, as well as the presence of filtration systems that support higher fish densities in the referenced study.

To assess land productivity from an economic perspective, it is essential to calculate the potential revenue from the harvests of both systems. Assuming the price of organic rice is IDR 28,383 per kg and the price of catfish is IDR 25,000 per kg, the hydroganic system is estimated to generate IDR 26,884,631 in revenue per 100 $m^2$ per production cycle. In comparison, the mina padi system yields only IDR 3,949,493.20 per cycle. Thus, the implementation of the hydroganic system increases the productivity of 100 $m^2$ of land by approximately 580%.

**Economic Feasibility Analysis**

The total operational costs are calculated by summing the variable and fixed costs. The composition of variable and fixed costs for the hydroganic system is presented in **Table 3** and **Table 4**. Based on these data, it is identified that the hydroganic system requires a total variable cost of IDR 11,898,000 for two installations and a fixed cost of IDR 2,708,133. Therefore, the total operational cost per cycle amounts to IDR 14,606,133.

**Table 3.** Components of Variable Costs for the Hydroganic System (two installations per cycle)

| VARIABLE PRICE | | | | | |
|---|---|---|---|---|---|
| No | Attribute | Unit | Quantity | Unit Price | Total Price |
| 1 | Growing media | sack | 4 | IDR 25.000 | IDR 100.000 |
| 2 | Rice seeds | ounce | 4 | IDR 5.000 | IDR 20.000 |
| 3 | Catfish fingerlings | unit | 10.000 | IDR 150 | IDR 1.500.000 |
| 4 | M-21 Decomposer | liter | 2 | IDR 15.000 | IDR 30.000 |
| 5 | EM4 for aquaculture | liter | 2 | IDR 9.000 | IDR 18.000 |
| 6 | Solid organic fertilizer | sack | 2 | IDR 75.000 | IDR 150.000 |
| 7 | Fish feed | kg | 630 | IDR.000 | IDR 10.080.000 |
| **Total** | | | | | **IDR 11.898.000** |

Source: Processed Primary Data, 2024

**Table 4.** Components of Fixed Costs for the Hydroganic System (per cycle)

| Fixed Cost | | | | | |
|---|---|---|---|---|---|
| No | Attribute | Unit | Quantity | Unit Price | Total Price |
| 1 | Electricity | kWh/month | 4 | IDR 23.800 | IDR 190.400 |
| 2 | Labor | HOK | 40 | IDR 31.000 | IDR 1.240.000 |
| 3 | Depreciation | Per month | 4 | IDR 319.433 | IDR 1.277.733 |
| **Total** | | | | | **IDR 2.708.133** |

Source: Processed Primary Data, 2024

For the mina padi system, the composition of variable and fixed costs is presented in **Table 5 and Table 6**. The variable costs amount to IDR 854,050 per cycle, while the fixed costs total IDR 2,024,000 per cycle. Thus, the total operational cost per cycle for the mina padi system is IDR 2,878,050. The cost difference in labor between the hydroganic and mina padi systems is attributed to the varying intensity of labor required for maintaining each system.

**Table 5.** Components of Variable Costs for the Mina Padi System (per cycle)

| **Variable Price** | | | | | |
|---|---|---|---|---|---|
| **No** | **Attribute** | **Unit** | **Quantity** | **Unit Price** | **Total Price** |
| 1 | Rice seeds | ounce | 1.4 | IDR 5.000 | IDR 7.000 |
| 2 | Organic fertilizer | sack | 1 | IDR 75.000 | IDR 75.000 |
| 3 | Fish feed | kg | 42 | IDR 16.000 | IDR 672.000 |
| 4 | Catfish fingerlings | piece | 667 | IDR 150 | IDR 100.050 |
| **Total** | | | | | **IDR 854.050** |

Source: Processed Primary Data, 2024

**Table 6.** Components of Fixed Costs for the Mina Padi System (per cycle)

| Fixed Costs | | | | | |
|---|---|---|---|---|---|
| **No** | **Attribute** | **Unit** | **Quantity** | **Unit Price** | **Total Price** |
| 1 | Depreciation | month | 4 | IDR 6.000 | IDR 24.000 |
| 2 | Labor | HOK | 40 | IDR 50.000 | IDR 2.000.000 |
| | | **Total** | | | **IDR 2.024.000** |

Source: Processed Primary Data, 2024

For revenue estimation, the assumed market price is IDR 28,383 per kilogram for organic-grade rice and IDR 25,000 per kilogram for catfish. Given the production capacity of the hydroganic system, 66.4 kg of rice and 1,000 kg of catfish per 100 m², the system generates an estimated revenue of IDR 80,653,893 per cycle. In contrast, the mina padi system, with a production capacity of 120 kg of rice and 66.7 kg of catfish per 100 m², yields an estimated annual revenue of IDR 11,848,478. In the hydroganic system, revenue is predominantly derived from catfish production, contributing 92.3% of the total income. Conversely, in the mina padi system, rice contributes the largest share of revenue, accounting for 57.8% of total income.

**Economic Feasibility Analysis**

Based on the calculation of variable costs and production capacities as previously outlined, the Cost of Goods Manufactured (COGM) for rice in the hydroganic system is IDR 4,518 per kilogram. Meanwhile, the COGM for catfish is IDR 11,598. In contrast, within the mina padi system, the COGM for rice is significantly lower, at IDR 1,019.9 per kilogram, while the COGM for catfish is comparable to that of the hydroganic system, at IDR 11,575. The substantial difference in rice COGM is primarily due to the additional costs associated with the purchase of media and supplements necessary for rice cultivation in the aquaponic setting.

**Table 7.** Summary of Financial Analysis

| **Analytical Parameter** | **Cultivation System** | |
|---|---|---|
| | **Mina Padi** | **Hydroganic** |
| NPV | IDR 3,706,655.25 | IDR 57,655,541.40 |
| IRR | 58% | 20% |
| B/C | 3,05 | 3,95 |
| R/C | 1,47 | 1,57 |
| DPP (Month) | 5,67 | 13,65 |

Source: Processed Primary Data, 2024

Based on the COGM and the assumptions regarding productivity and investment discussed earlier, the Net Present Value (NPV) was calculated to be IDR 57,655,541.40 for the hydroganic system and IDR 3,706,655.25 for the mina padi system over five years. These figures were derived using a monthly discount rate based on Bank Indonesia's interest rate of 6% as of the end of 2024. Under the same assumptions, the Internal Rate of Return (IRR) for the hydroganic system was found to be 20%, whereas for mina padi it reached 58%. Although the IRR of the hydroganic system is lower, both systems remain financially viable investment options based on their IRR values. The comparison of present value curves over 15 cycles (five years) is illustrated in **Figure 3.** In terms of payback period (DPP), the mina padi system requires only 5.67 months to recover the initial investment, while the hydroganic system requires 13.65 months. This indicates that the mina padi system offers a faster return on investment compared to the hydroganic system. This finding aligns with Yassi et al. (2020).

who asserted that one of the main advantages of the mina padi system lies in its rapid investment recovery.

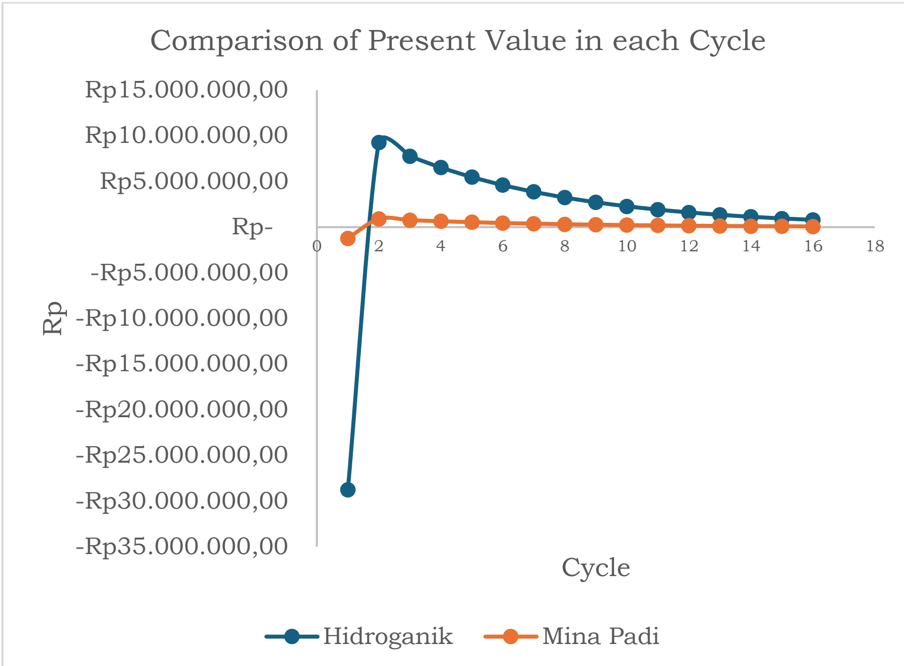



**Figure 3.** Comparison of Present Value Curves

The Benefit-Cost (B/C) ratio for both the hydroganic and mina padi systems exceeds 1, indicating profitability. The hydroganic system has a B/C ratio of 3.95, while the mina padi system shows a ratio of 3.05. These values suggest that the hydroganic system yields relatively higher financial returns. Overall, based on the financial indicators, both systems are considered worthy of investment. A summary of the financial analysis parameters is provided in **Table 7**.

The Break-Even Point (BEP) indicates the minimum level of production required to equate total revenue with total costs. This metric offers insights into the financial resilience of each cultivation system prior to generating profit. The hydroganic system reaches its annual BEP at 340 kg of rice and 606 kg of catfish. In other words, to fully cover production costs, farmers must produce at least these quantities each year. In comparison, the mina padi system, with its simpler inputs and infrastructure, demonstrates greater efficiency in resource utilization. BEP calculations reveal that the mina padi system requires only 222 kg of rice and 452 kg of catfish annually to reach the break-even point. This implies that the mina padi system necessitates a smaller production volume to generate net profit, making it lighter in terms of production burden and faster in yielding returns.

The economic feasibi20quaponic systems has also been examined by Zainal et al. (2021). It reported that aquaponic-based catfish farming over a three-year period generated an IRR of 46%, which exceeds the assumed discount rate of 5.25%. Furthermore, research by Zappernick et al. (2022) showed that aquaponic systems cultivating tilapia and lettuce achieved IRR values between 11–12% over a 20-year years, with a discount rate of 7.1%. These findings underscore the substantial business potential of aquaponic systems.

## CONCLUSION

Based on the above discussion, it can be concluded that both the mina padi and hydroganic systems are economically feasible for investment. The Net Present Value (NPV) for the hydroganic and mina padi systems are IDR 57,655,541.40 and IDR 3,706,655.25, respectively; the Internal Rate of Return (IRR) for each system is 20% for hydroganic and 58% for mina padi; the Benefit-Cost (B/C) ratios are 3.95 and 3.05, respectively; the Revenue-Cost (R/C) ratios are 1.58 and 1.48; and the Discounted Payback Periods (DPP) are 13.65 months for hydroganic and 5.67 months for mina padi.

These financial indicators suggest that the hydroganic system has the potential to increase land productivity by up to fivefold. Moreover, it also offers higher profit margins and a greater Net Present Value. Nevertheless, the mina padi system yields a higher IRR due to its significantly lower capital requirements. Additionally, mina padi offers a faster return on investment compared to the hydroganic system.

The hydroganic system is best suited for areas with limited land availability and a focus on high productivity and long-term profitability, as it can significantly increase yields and generate higher NPV. Conversely, the mina padi system is more appropriate in contexts with limited financial capital, owing to its higher IRR and shorter payback period.

## RECOMMENDATIONS

The findings indicate that both the hydroganic and mina padi systems are economically viable based on the financial indicators analyzed. Further research could explore the diversification of cultivated commodities, particularly by substituting the agricultural components in hydroganic systems. This would allow economic feasibility assessments to be conducted using shorter production cycles (e.g., 3–4 months), thus improving financial planning and system optimization).

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