Paddy-fish integrated agricultural system to increase income and food security

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Abstract. Paddy-Fish integrated system has been applied by Indonesian farmers. They practiced diversification farming in correlation to get more benefit and minimized risk. The objective of this research was to analyse technical and economical feasibility of paddy-fish integrated systemat lowland rice field. This research used the experimental field method. Fish pond was created surrounded the rice field with 3 m in width and 0.5 m in depth where the fish was grown for 4 months. Fishes were fed till they stopped eating. Economical analysis was calculated by comparing between paddy-fish farming system and paddy farmer only. The results of project analysis showed that farmer that grew paddy got a NPV value of IDR 14,925,987 and B/C value of 1.63 so that both were suitable to cultivated. At the same area of 840 m² the income was IDR 4,773,000 while income of paddy cultivation was IDR 675,000. There was an extra income of IDR 4,098,000 (33.94 %) when farmer applied paddy-fish cultivation and also minimized a risk if a part of the component failed.

1. Introduction
The main problem in food security is that the growing food demand is always higher than food supply. Import food dependency is a crucial problem where in recent time world food production was often disturbed by weather anomaly due to climate changes. Last experience proved that food producer countries did not share their food to guarantee their citizens which caused world food supply less than it should be. That is why Indonesian government has decided to reach self-sufficient and independent in food production. The objective is to anticipate the competition in buying food especially for poor people. Indonesia has ever reached self-sufficient for rice in 1984 and this achievement but now Indonesia become an imported country again. Many efforts have been done to provide enough food, especially rice, in enhancing people prosperous. One of the indicators of people prosperity is that they are easy to get and access food. In relation to the goal, agricultural food security is the primary program of government so that food is available at right amount and good quality [1].

Based on the SWOT analysis, there were 5 primary problems found swamp area, they are: 1) its production and productivity were low and the planting index less than 100, 2) difficult to access to this land, 3) un-optimal of management organization and capital, 4) processed-product from local source was not developed yet, 5) fish cultivation has not been developed [2]. The best solution for these problems are to set an effective innovation related to the characteristic of the land started from the existing local technology. The action should also involve surrounding ecological aspects. It could be
gained by comprehensive researches included at soil aspect, improvement of cultivation technique, postharvest, transportation system, processing, and increasing the quality of human resources.

Integration system of paddy and fish has been practiced by Indonesian farmer especially village farmer. The main goal is to get benefit as much as possible as well as farming risk minimization. Some farming risks are production, business and financial, and deterioration risks. Integration plant-fish could be having the minimum risk by maximizing each functional role. Paddy-fish integration system has not been widely practiced in Indonesia. In this system, the water has two functions, as a part of paddy grow and as a media for fish live. At the end of season, farmer harvested paddy rice and fish.

Water management technology in growing both plant and fish could be applied to increase the planting index to IP 200 so the food security could be built. The objective of this research was to analyse feasibility of techno-economical on paddy-fish integration.

2. Methods
This research was conducted on lowland rice field sub-district of Pemulutan, District of OganIlir, South Sumatera. Location was chosen using purposive sampling. Some reasons in deciding the location were: (1) Sub-district of Pemulutan was the centre of rice producer that near the city of Palembang, (2) Methodologically, this location was suitable for research requirement, and (3) This location could be reached by all type of transportation mode so that it need not too high expenses. Primary data and observation were collected for eight months from February to November 2018.

Direct field practice was completed by spreading fish to the rice field where paddy was also planted. Fish was grown for four months. Fish food was given continuously until fish stop eating. Fish food was made of fermented rice powder as much as 40%, freshwater fish powder 25%, sea-fish powder 25%, and tapioca powder 10 %. Special design of physical rice field was needed so that it could function as rice field and fish pond which called surjan. Surrounding rice field and pond was made an embankment functions to retain water that is going flow into rice field and also store water inside for dry season use.

Embarkment soil was taken from surroundings. The ground where soil has been taken became fish pond and the water was used to irrigate the paddy at the dry season. The embarkment could be planted perennial trees or horticulture to get some more money. Water management used water pump placed on the embarkment. The height of the embarkment was made based on the farmer information on location and field agricultural officer. The information stated that the average water height was 90 cm at rainy season. To compensate the compaction and to avoid too much water enter the rice field the embarkment was made 140 cm. Rice field was surrounded by pond to grow fish by 3 m in width. Business analysis carried out by comparing paddy rice and fish revenues, technology applied in integrating paddy and fish, they were Net Present Value (NPV) and Benefit/Cost ratio (B/C ratio).

2.1. Net Present Value (NPV)
Net Present Value (NPV) was the difference between benefit and cost that the values have been adjusted. By this criterion the project would be run if NPV > 0, and conversely, the project will not be profitable if NPV < 0. The NPV is formulated as:

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

Where:
NPV = Net Present value
N = Time
B_t = Benefit at year-t
C_t = Cost at year-t
i = Interest
2.2. Fund useful ratio
This method was comparing or dividing between revenue that has been discounted and expenses that has been discounted. The formula is:

\[
Net \frac{B}{C} = \frac{\sum [B(i)]}{\sum (1+i)} + Co \tag{2}
\]

If the value of \( B/C > 1 \) means project revenue higher than expenses and said the business was profitable. Conversely, if \( B/C < 1 \) means the business was not profitable.

3. Results and discussion
Fish pond was formed by digging soil at the edge of rice field as wide as 3 m and 0.5 m in depth. It was like a rectangular-ring pond. The embankment was made to avoid water flood enter the rice field. Small fish was kept in the nest until they were big enough when they placed in the pond. Primary and secondary tillage was done one time for each operation [3]. Paddy seed was spread in a special box called baki with 20 cm in width and 40 cm in length [4]. It made easier to move it to the field. It was moved when it was 14 days old in jajarlegowo method. Organic fertilizer was applied and weeding was done continuously. Pump was used in the dry season.

3.1. Income analysis of paddy cultivation

3.1.1. Production cost. Production cost consisted of seed, land preparation, planting, maintenance, fertilizer, pump, and harvesting. Production cost component was presented at Table 1.

| Kind of production cost | Average production cost (IDR) |
|-------------------------|-------------------------------|
| Seed 40 kg @ IDR30,000  | 1,200,000                     |
| Land preparation        | 900,000                       |
| Planting                | 2,000,000                     |
| Plant maintenance       | 1,500,000                     |
| Fertilizer              | 1,000,000                     |
| Pump                    | 574,000                       |
| Harvesting              | 1,500,000                     |
| **Total**               | **8,674,000**                 |

3.1.2. Production. Production was calculated by weighing the paddy rice harvested from the field. The research showed that the production was 5,684 kg harvested dry paddy (GKP) per hectare.

3.1.3. Revenue. Revenue was the production times selling price. The revenue was 5,684 kg times IDR 4,000 per kg equals to IDR 22,736,000.-.

3.1.4. Income. Income was the difference between revenue and expenses. The income was IDR 14,062,000.- per hectare per planting season (IDR 22,736,000.- - IDR 8,674,000.-).
3.2. Feasibility analysis of paddy cultivation

Feasibility analysis of paddy cultivation used net present value (NPV) and benefit cost ratio (B/C) criteria. NPV was the difference between benefit and cost that the values have been adjusted to the present value. By this criterion, the project would be chosen if NPV > 0, and rejected if NPV < 0. Benefit Cost Analysis Ratio means comparing the benefit with cost. The project was feasible if B/C ratio > 1.

Table 2. Cash flow of paddy cultivation.

| Year | Revenue (IDR) | Expenses (IDR) | DF (18%) | Revenue (IDR) | Expenses (IDR) |
|------|---------------|----------------|----------|---------------|----------------|
| 1    | 22,736,000    | 8,674,000      | 0.8475   | 19,267,797    | 7,350,847      |
| 2    | 22,736,000    | 8,674,000      | 0.7182   | 16,328,641    | 6,229,532      |
| 3    | 22,736,000    | 8,674,000      | 0.6086   | 13,837,832    | 5,279,264      |
| 4    | 22,736,000    | 8,674,000      | 0.5158   | 11,726,976    | 4,473,953      |
| 5    | 22,736,000    | 8,674,000      | 0.4371   | 9,938,115     | 3,791,485      |
| Total|               |                |          | 71,099,360    | 27,125,081     |

NPV = IDR 43,974,279
B/C ratio = 2.62

From the calculation NPV value was IDR 43,974,279.- and B/C ratio 2.62 showed that the business was feasible to run.

3.3. Revenue analysis of fish

3.3.1. Production cost. Production cost fish business were soil digging cost as much as IDR 60,000.- per cubic meter (length of pond 116.9 m, width 3.1 m and depth 0.5 m) so that the digging volume was 181 cubic meter; fish seed cost, fish food, fuel of pump, and labour cost. Detail production costs were presented at Table 3.

Table 3. Production cost of fish per hectare per planting season.

| Kind of cost component                | Average cost production (IDR) |
|---------------------------------------|-------------------------------|
| Depreciation of fish pond infestation | 1,086,000                     |
| Pump depreciation                     | 490,000                       |
| Fish seed 3,000 @ IDR. 300            | 900,000                       |
| Fish food 400 kg @ IDR.10.500         | 4,200,000                     |
| Fuel for pump                         | 320,000                       |
| Labour                                | 600,000                       |
| Total                                 | 7,596,000                     |

3.3.2. Production. The result showed that fish production was 883.5 kg which kept in pond for 4 months.

3.3.3. Revenue. Revenue was the sum of production times selling. Fish production was 883.5 kg while the selling price was IDR 14,000 per kg so the revenue was IDR 12,369,000.-

3.3.4. Income. Farmstead income was the difference between revenue and all expenses. Income from selling fish was IDR 4,773,000.- for 4 months (IDR 12,369,000.- - IDR 7,596,000.-). Integrated farm business of paddy and fish showed that there was an additional income as much as 33.94 %.
3.4. **Feasibility analysis of fish**

Feasibility Analysis of paddy estate used Net Present Value (NPV), and Benefit Cost Ratio (B/C ratio). Net Present Value (NPV) was the difference between benefit and cost that its value has been adjusted at present time. This criterion showed that the project was chosen if NPV > 0. Conversely, the project was rejected if NPV < 0. Benefit Cost Ratio Analysis was an important instrument in feasibility study. It calculated the income and cost ratio. If B/C ratio > 1, the business is feasible to run.

### Table 4. Cash flow of farm business of fish.

| Year | Revenue  | Cost  | DF (18%) | Revenue | Cost  |
|------|----------|-------|----------|---------|-------|
| 1    | 12,369,000 | 7,596,000 | 0.8475 | 10,482,203 | 6,437,288 |
| 2    | 12,369,000 | 7,596,000 | 0.7182 | 8,883,223  | 5,455,329  |
| 3    | 12,369,000 | 7,596,000 | 0.6086 | 7,528,155  | 4,623,160  |
| 4    | 12,369,000 | 7,596,000 | 0.5158 | 6,379,793  | 3,917,932  |
| 5    | 12,369,000 | 7,596,000 | 0.4371 | 5,406,604  | 3,320,282  |

NPV = IDR. 14,925,987

B/C ratio = 1.63

Analysis showed that NPV value was IDR. 14,925,987.- and B/C ratio 1.63 that means the farm business of paddy-fish was feasible to realize.

3.5. **Paddy vs fish cultivation**

Fish that was kept at 480 m\(^2\) pond earned IDR. 4,773,000.- while paddy cultivation for the same area earned IDR. 675,000.- (480 m\(^2\)/10,000 m\(^2\) x IDR. 14,062,000.-). From this calculation farmer got extra money as much as IDR.4,098,000.- (33.94 %) if farmer run the mixed commodity of paddy-fish. Mixed farming decreased the risk of failure if one component failed to be harvested.

A research by [5] showed that paddy-fish cultivation system was feasible to run because the R/C ratio 2,08 means the business was efficient where the R/C ratio more than 1.0, and B/C ratio more than 1.0 (1.08). The net benefit was IDR.10,562,500.

Agricultural diversification like mixing of paddy and fish could increase yield, farmer income, soil fertility, and decrease the insect attack at paddy [3]. a system called jajarlegowo gave some extra money as much as US$1,700 or IDR22,000,000.- at change rate IDR13,000 per US$. This sum of money was big enough because if farmer cultivate only paddy, the benefit was just IDR10,000,000. The real advantage of paddy-fish with cluster base were lowered insects attacked, no pesticide, low fertilizer application, and higher income. Jajarlegowo not only increase higher income, but also produced better rice quality that create a sustainable agriculture which the product was good to consumed. Paddy-fish agribusiness could increase net benefit IDR 7,165,250.- (35.29 %), R/C ratio of 2.97 and B/C ratio 1.97 [6].

4. **Conclusions**

Feasibility analysis of paddy was NPV as much as IDR. 43,974,279.- and B/C ratio 2.62 and patin fish with NPV of IDR. 14,925,987.- and B/C ratio of 1.63; both indicated that the business was feasible to run. At that area of 480 m\(^2\), growing fish could earn money as much as IDR. 4,773,000.- and the yield of paddy at the same area raise money IDR. 675,000.- that mean there was an additional money of IDR.4,098,000.- (33.94 %). Integrated agricultural system of paddy and fish increase farmer income and decrease farm business failure.
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