The efficiency of duck rice integrated system for sustainable farming

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Abstract. Duck rice integrated system is one of the innovations that can be applied by farmers to increase the efficiency and sustainability of land use in rice field. Research on the effect of ducks in cultivation and rice fields has been carried out but has not examined the effect of production factors and the efficiency of using these production factors in ducks rice integrated system. This study aimed to analyze the production function and efficiency of production factors in implementation of duck rice integrated system (STIP). All farmers who implemented an integrated system in Subak Lanyah, Bongan Village, Tabanan District were selected as respondent (100%) and compare with 13 farmers who not implemented it chosen by stratified random sampling. Data analysis used the cobb-douglas production function to determine the influencing factors and the efficiency of the production factors. The results showed that 1) Implementation of duck rice integrated system on paddy field in Subak Lanyah, Tabanan gave a significant effect on rice production together with an organic fertilizer use (urea and ponska). Farmers who apply duck rice integrated system tend to use fewer input factor. 2) The use of input factors such as paddy field, an organic fertilizer (urea and ponska), pesticides in farming are not efficient yet, while labor is not efficient. The total value of the regression coefficient of all production factors is equal to 1.029 indicated that the ducks rice were at increasing returns to scale. Therefore, integrated rice farming with ducks is feasible to develop.

1. Introduction.
Development in the agricultural sector is made as a top priority in improving the economy and achieving food security. According to Soekartawi [1], in addition to meeting food needs, agricultural development is directed at increasing agricultural production, meeting domestic industry needs, increasing exports, increasing farmers' income, expanding job opportunities and encouraging equal distribution of business opportunities.

Rice is the main food source that supports national food security. Rice production in 2015 reached 75.55 million tons of milled dry grain and experienced an increase of 4.70 million tons (6.64%) when compared to 2014. The increase in production occurred due to the addition of harvested area of 0.51 million hectares (30.71%) and an increase in productivity of 1.45 quintal/hectare (2.82%). Efforts to increase rice production by means of modern agriculture in the form of integrated agriculture. Integrated agriculture that involves crops and livestock is a diverse source of food so that it can improve the welfare of the population.
The increase in agricultural production has not yet fully provided tangible results for improving the welfare of farmers, especially rice farmers [3]. Cultivation of rice plants in paddy fields in monoculture throughout the year without being accompanied by diversification of farming will be able to reduce the level of productivity of paddy fields. This is because the physical and chemical properties of the soil will be disturbed which will eventually have consequences for the income and welfare of farmers. The existence of a combination system of rice-duck farming is very supportive of the government's program in planting rice in various regions for rice self-sufficiency.

The amount of 300 duck per ha paddy field is expected to increase rice production, on the other hand there will be an increase in livestock resources such as rice straw, bran and groats. The introduction of ducks rice system of rice planting is estimated to reduce weeds, insects, rice plants, nuisance snails and can provide fertilizer and stimulate rice growth [4].

Efforts to increase competitiveness are carried out simultaneously by realizing harmonization of policies that are cross-departmental. This is done by considering internal factors such as implementing business efficiency, improving product quality, ensuring supply continuity and in accordance with market demand [5]. The role of livestock sub-sector to agriculture is quite significant, where the poultry industry is the main trigger for business development in the livestock sub-sector. Generally, rural residents focus more on their main business as farmers so that livestock maintenance is not given much attention. Even though the livestock business is a supporting business, this business provides a large enough income for a farming family. To maintain this income, farmers can develop ducks with rice. This livestock is one of the commodities that have the potential and a strategic role in providing animal protein that is easily obtained at an affordable price. Efforts to develop ducks with rice are an integration pattern that can generate daily income for farmers so that they can assist farmers in meeting their daily needs, where rice cultivation is their main business and duck farming is their side. Rice plants can produce fine bran, rice bran, groats, and husks that can be used as feed for ducks, while ducks produce waste such as feces (compost) which is very useful for rice. The combination of the two makes all inputs and can be used as outputs to increase farmers' income where rice plants and raising ducks provide mutual benefits so that better results are obtained in the two businesses that are run.

Based on the background above, several problems can be formulated as follows: 1) How is the influence of production factors on rice production in the integrated system of rice ducks in Subak Lanyah, Bongan Village, Tabanan District? and 2) How is the efficiency of the use of production factors in the integrated system of rice ducks in Subak Lanyah, Bongan Village, Tabanan District?

This study aims to: 1) analyze the production factors that affect the integrated system of duck rice and 2) analyze the level of efficiency in the use of production factors in the integrated system of duck rice in Subak Lanyah, Bongan Village, Tabanan District.

2. Material and Methods.
The research location was chosen intentionally. This research took place from December 2020 to February 2021. The types of data used were qualitative and quantitative data. The total population in this study were farmers who applied the duck rice integration system (STIP) in Subak Lanyah, Bongan Village, Tabanan District, which amount 13 farmers (100%). Respondents in this study were determined by the census method. This number of farmers compared with 13 farmer who was not apply duck rice integrated system (STIP) were determined by stratified random sampling.

To find out the model of rice duck integration system, a Cobb-Douglass production function analysis was carried out because this production function can provide a good estimation and can be used as the
basis for further calculations. The mathematical model of the Cobb-Douglas production function used as follows:

$$Y = \beta_0 X_1^{\beta_1} X_2^{\beta_2} X_3^{\beta_3} X_4^{\beta_4} X_5^{\beta_5} D^{\beta_6}$$

$X_1$ : paddy field area (acre)
$X_2$ : urea fertilizer (kg)
$X_3$ : ponska fertilizer (kg)
$X_4$ : pesticide (liter)
$X_5$ : labor (workdays/HOK)
$D$ : dummy variable (duck rice integrated system, $D = 1$ for farmer that implemented rice duck integrated system; $D = 0$ for farmer whose not implemented rice duck integrated system)
$Y$ : paddy grain yield
$\beta_0$ : constanta
$\beta_i$ : regression coefficient

The second step, Cobb-Douglas production function was changed into logarithms equation as follow:

$$\log Y = \log \beta_0 + \beta_1 \log X_1 + \beta_2 \log X_2 + \beta_3 \log X_3 + \beta_4 \log X_4 + \beta_5 \log X_5 + \beta_6 \log D$$

The coefficient regression was tested by t-test.

Efficiency is the ratio between inputs (inputs) and outputs (results between profits and the resources used), as well as the optimal results achieved with the use of limited resources. Price efficiency is achieved when the ratio of the marginal productivity value of each input (NPMXi) to the input price (vi) or $k_i = 1$. This condition requires that NPMX be the same as the price of production factor X or can be written as follows.

$$\frac{\beta Y P_y}{X} = \frac{P_x}{X}$$

where: $PXi$ is price of production factor Xi. In many ways NPMX is not always the same as PX.

1. If $(NPMX/PX) > 1$: this means that the use of input X is not yet efficient, to achieve efficiency, input X needs to be added.
2. If $(NPMX/PX) < 1$: means that the use of input X is not efficient, to be efficient input X needs to be reduced.
3. If $K_i = 1$, meaning that the use of production factors has been efficient.
4. If $K_i > 1$, meaning that the use of production factors is not yet efficient, so it is necessary to add inputs.
5. If $K_i < 1$, meaning that the use of production factors is not efficient. To achieve an efficient level, it is necessary to reduce the use of inputs.

3. Results and discussion
Duck rice integrated system only implemented at Subak Lanyah, Bongan Village, Tabanan District. The characteristic of farmers whose implemented this system listed in Table 1.

| Table 1. Characteristics of farmer’s household, 2020. |
|-----------------|---------------------------------|---------------------------------|
| **Age (years)** | **Farmers whose implemented STIP (people)** | **Farmer whose not implemented STIP** |
| 15 - 65         | 10 (76.92%)                          | 13 (100%)                       |
| $\geq 68$       | 3 (23.07%)                           | 0 (0%)                          |
| **Total**       | 13                                  | 13                               |
Based on Table 1, it can be concluded that the average age of the farmers whose implemented STIP was 54.31 with maximum and minimum range of 15-76 years. The most group age of farmer was between 15-65. This means that the age of farmers in Subak Lanyah, Bongan Village, belongs to the productive age. The age of farmers influences in carrying out their farming. Generally, young farmers have a stronger physique and more innovative than old farmers, in the other side, older farmers have more experience. But in Subak Lanyah, old farmer still participated in new innovation such as duck rice integrated system.

**Table 2.** Farmer distribution based on amount of household member, 2020.

| Number of household member (people) | Farmer whose implemented STIP (people) | Farmer whose not implemented STIP |
|-------------------------------------|----------------------------------------|----------------------------------|
| 2-3                                 | 8 (61.53%)                             | 10 (76.92%)                      |
| 4-5                                 | 5 (38.46%)                             | 3 (23.07%)                       |
| Total                               | 13                                     | 13                               |

Based on Table 2 it can be seen that the size of farmer household was relatively small. This is quite beneficial because the bigger size of family, the more cost is needed. The large number of household member will result in the amount of production to meet all household needs must be greater, so that the production results of farmers can not cover their family need.

**Table 3.** Amount of factor production in rice duck integrated system, 2020.

| No | Yield or factor production | Amount per farm | Amount per ha |
|----|---------------------------|-----------------|---------------|
| 1  | $X_1$: rice farm (acre)   | 24              | 100           |
| 2  | $X_2$: urea (kg)          | 47              | 196           |
| 3  | $X_3$: ponska (kg)        | 44              | 183           |
| 4  | $X_4$: pesticide (liter)  | 3               | 13            |
| 5  | $X_5$: labor (HOK)        | 26              | 108           |
| 8  | $Y$: yield (kg)           | 2608            | 10867         |

Based on Table 3. rice productivity in Subak Lanyah, Bongan Village, has an average of 2,608 kg of dry grain harvested per 24 acre or 10,867 kg/ha. This productivity is quite high. The use of pesticides is relatively high due to high attack by rats and also stink bug. Furthermore, it will be studied how the influence of inputs and the effect of the integration system on rice production.

Table 4 showed the correlation value between each independent variable (production factor) $X_1$, $X_2$, $X_3$, $X_4$, $X_5$, $D$ with the dependent variable (production) $Y$ is 0.613; 0.587; 0.720; 0.600; 0.529; 0.517; quite high (more than 0.50). This means that the higher the use of each production factor tend to increase the yield, both on farms that apply rice duck integration (STIP) and farms that do not apply rice duck integration.

**Table 4.** Correlation value between independent variable, 2020.

| Variable | (Y)   | (X$_1$) | (X$_2$) | (X$_3$) | (X$_4$) | (X$_5$) | (D)  |
|----------|-------|---------|---------|---------|---------|---------|------|
| (Y)      | 1.000 | 0.613   | 0.587   | 0.720   | 0.600   | 0.529   | 0.51 |
| (X$_1$)  | 0.613 | 1.000   | 0.772   | 0.814   | 0.469   | 0.642   | -0.52|
| (X$_2$)  | 0.587 | 0.772   | 1.000   | 0.575   | 0.420   | 0.0586  | -0.42|
| (X$_3$)  | 0.720 | 0.814   | 0.575   | 1.000   | 0.475   | 0.766   | -0.31|
| (X$_4$)  | 0.600 | 0.469   | 0.420   | 0.475   | 1.000   | 0.414   | 0.108|
| (X$_5$)  | 0.529 | 0.642   | 0.586   | 0.766   | 0.414   | 1.000   | -0.36|
| (D)      | 0.517 | -0.520  | -0.420  | -0.310  | 0.108   | -0.360  | 1.00 |
The correlation value of dummy variable (D) with the independent variable Xi was negative, so there was a tendency for farmers who apply rice duck integration to use lower inputs than farmers who do not apply rice duck integration. The correlation value of variable D with Y was quite high and positive, meaning that there was a tendency that farmers who apply rice duck integration produced higher rice production than farmers who do not apply rice duck integration [6,7].

The analysis of variance of duck rice integrated production function listed in Table 5 showed that the R-square (determination value) is 0.784, and the adjusted determination value (R-square adjusted) is 0.715 indicates that 78.4% of production variation can be explained by all production factors such as land area, urea fertilizer, ponska fertilizer, pesticides and labor and the rice duck integration system, while another 21.6% was explained by other factors outside the model. This finding in line with the research results Hu and Teng and Nurawan et al. [4,8].

### Table 5. Analysis of variance of duck rice integrated system, 2020.

| Source of deviation | Sum of squares | Degree of freedom (df) | Mean square | F       | Sig.     |
|---------------------|----------------|------------------------|-------------|---------|----------|
| Regression          | 0.239          | 6                      | 0.040       | 11.478  | 0.000a   |
| Residual            | 0.066          | 19                     | 0.003       |         |          |
| Total               | 0.305          | 25                     | R² = 0.784  | R² adjusted = 0.715 |

The influence of production factors is Land area (X1), urea fertilizer (X2), ponska fertilizer (X3), pesticides (X4) and labor (X5), and the integration of rice ducks (D) together is very significant for rice production (Y), which is indicated by the F value equal to 11.478 with a significance of 0.000.

The use of production factors on land is closely related to the level of production produced, where the use of production factors land area, urea fertilizer, pesticides, and labor, as well as the introduction of the integration system of rice ducks have an important role in the development, growth and rice productivity.

The value of the variance inflation factor (VIF) of each production factor is less than 20, indicated that there is no multicollinearity that causes a bias in the estimated production function obtained. The production factors that have a statistically significant effect were: urea fertilizer, ponska fertilizer, and the Rice Duck Integration System, while planting area, pesticides and labor have no statistically significant effect on rice production. The total value of the regression coefficient of all production factors (not including the regression coefficient of the rice duck integration) is equal to 1.029 indicated that the production activities in farming in the duck rice integration are in the increasing return to scale, which means that the increase in the use of all production factors is equal to 100% will give an increase in rice production of 100.29% (>100%).

Compared with paddy field that does not apply the duck rice integration system, on average the rice duck integration system provides an increase in rice production of 60.25 kg up to 77.6 kg per 24 acres or 323.3 kg per hectare planting area. In addition, farmer whose implemented STIP, have additional income from the 20 ducks per 45 days or 40 ducks per 3 month, in an average of IDR 430,000,- per one cycle of paddy plantation [3,9].

Table 6 showed the efficiency of paddy field was 3.47, meaning that the use of the production factor of land area has not been efficient yet. The use of production factors for e planting area needs to be increased from 24 acres. The efficiency value of urea fertilizer equal to 47.53, meaning that the use of the urea fertilizer production factor is not efficient. The use of urea fertilizer production factors in rice farming have to be increased from 196 kg/ha. The efficiency of ponska fertilizer equal to 131.00, meaning that the use of it is not efficient. The use of it needs to be increased from 183 kg/ha. The pesticide production factor has an efficiency value equal to 6.05, meaning that not efficient yet. The use of pesticide needs to be increased from 13 liters/ha. The labor factor has negative value (-1.28), mean that the use of the labor was inefficient so it needs to be reduced from 26 HOK per 24 acre or 108 HOK/ha. This result in line with [4,10,11].
4. Conclusions
The results showed that 1) Implementation of duck rice integrated system on paddy field in Subak Lanyah, Tabanan gave a significant effect on rice production together with anorganic fertilizer use (urea and ponska). Farmers who apply duck rice integrated system tend to use fewer input factor. 2) The use of input factors such as paddy field, anorganic fertilizer (urea and ponska), pesticides in farming were not efficient yet, while labor was not efficient. The total value of the regression coefficient of all production factors (excluding the regression coefficient of the integration of rice ducks) is equal to 1.029 indicated that the production activities of farming in the integration of rice ducks were at increasing returns to scale. Unfortunately, this result not supporting Bali Organic Farming that proposed by Bali Province Government. So that recommended to arrange next research that increase the amount of ducks per ha paddy field.

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