An analysis of technical efficiency and factors affecting rice farming business production in Bombana regency, Southeast Sulawesi

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Abstract. This study aims to (1) analyze the factors affecting production of rice farming business in Bombana Regency, (2) analyze the extent of technical efficiency of rice farming business in the Regency. The study was conducted from April to October 2019. Bombana was considered as the area in which the study took place because most of the people were rice farmers and they were potential to develop. There were 120 rice farmers participated in the study. The samples were taken using simple random sampling. Primary data were collected by interview based on questionnaire, while secondary data were collected by going over the official documents issued by authorized agency. The data were analyzed using stochastic frontier production-function analysis and Cobb-Douglas analysis. The result showed that (1) of all affecting factors, fertilizers such as NPK as well as the land area had positive and significant correlation to the rice production; (2) the average value of technical efficiency of rice farmers was 84% and there were 16% chance to increase the rice production with additional optimal production input.

1. Introduction

Agriculture is one of the dominant sectors in community income. It has an important role in Indonesia because majority of Indonesians work as farmers. Thesubsistence agricultural development requires government’s assistance especially to facilitate the facilities and infrastructure needed by farmers themselves. The development of farming has an important role to provide job field, community income, and food security [1, 2, 6].

Efforts to increase rice production can be done in various ways, including expanding land area (extensification), new technological breakthroughs by optimizing existing land area (intensification), and increasing technical efficiency in terms of the use of existing resources. The land area in Southeast Sulawesi is highly potential for farming outgrowth. According to National Statistics Center Reports (2019), the rice farming area in 2018 corresponded 131.39 ha with 499.007 tons of productions and 37.98 ku/ha of productivity. Bombana Regency is one of food-buffers districts in Southeast Sulawesi Province. The dominant rice commodity in Bombana is rice field (paddy). Therefore, the productivity of crops, especially rice, needs to be improved. Of the total available paddy fields, there are 69.34 percent or around 9,215 hectares of irrigated lands while the remaining 30.66 percent are non-irrigated land [3, 4, 5].
2. Methods

2.1. Research Location and Respondents.
This research was conducted from April to October 2019 in two sub-districts including East Poleang and North Poleang in which one village of each sub district was taken as the location. The location was chosen purposively with the consideration that most of the population in those areas worked as farmers and the area was highly potential for rice farming outgrowth. The sample were randomly selected (simple random sampling) using the Slovin formula in [7, 8, 9, 10, 11]. Data were obtained by direct interviews on samples of 120 respondents.

2.2. Data Collection.
Primary data were collected through interview based on questionnaire. Secondary data were collected through going over the related documents issued by authorized agency.

2.3. Data Analysis.
The data were analyzed using production-function stochastic frontier analysis and the Cobb-Douglas production function analysis. In determining the factors affecting the rice farming production, SPSS version 23 software was used. The function of the Cobb-Douglas can be formulated as follows [8]:

\[ Y = \beta_0 X_1^{\beta_1} X_2^{\beta_2} X_3^{\beta_3} X_4^{\beta_4} X_5^{\beta_5} X_6^{\beta_6} \]

It is transformed into multiple linear forms by using the algorithm of the equation as follows:

\[
\ln Y = \ln \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6
\]

Furthermore, statistical testing was carried out to determine the level of significance of each regression coefficient of the independent variable on the dependent variable that included:

- The coefficient of determination \( R^2 \) refers to the amount used to determine the influence of variables independent to variable dependent. The coefficient of determination ranges between zero and one. In this study, we would like to discover how much the percentage of factors of production \( X \) in influencing rice production \( Y \).
- The F test which was used to examining the entire independent variable substituted in the equation or model simultaneously influencing the dependent variable using the following formula:

\[
F_{\text{count}} = \frac{KTR}{KTG(n-k-1)}
\]

with:
- \( KTR \) = square of total regression (number of squares of regression)
- \( KTG \) = total square error (number of squares remaining)
- \( n \) = number of data or sample
- \( k \) = number of independent variables
- T-test was carried out to examine the extent of the influence of an explanatory variable individually in explaining the dependent variable using the formula

\[
F_{\text{count}} = \frac{b}{Se}
\]

with:
- \( t \) = tcount further consulted with t table \( (a = 0.05) \)
- \( b \) = regression coefficient
- \( Se \) = standard error
Calculating the technical efficiency of rice farming was conducted using the analysis of the stochastic frontier production function with software front 4.1c, using the following equation:

\[ TE_i = \frac{Y_i}{\tilde{Y}_i} \exp(\beta \tilde{X}_i + \mu - \mu_i) = \exp(-\mu_i) \]

### 3. Results and Discussion

#### 3.1. Analysis of Factors Affecting Rice Production

The Cobb-Douglas production function analysis was carried out to determine the relationship between the independent variables including seeds ($X_1$), urea fertilizer ($X_2$), NPK fertilizer ($X_3$), pesticides ($X_4$), labor ($X_5$) and land area ($X_6$) to the dependent variable of production ($Y$). It is shown in the Table 1 below:

| No | Variables         | Regression Coefficient | Partial Test |
|----|-------------------|-------------------------|--------------|
|    |                   | B          | T          | Sig.         |
| 1  | Constant          | 79,965     | -0.829     | 0.410        |
| 2  | Seeds ($X_1$)     | 7.921      | 0.708      | 0.481        |
| 3  | Urea Fertilizer ($X_2$) | 1.817 | 3.106 | 0.003* |
| 4  | NPK Fertilizer ($X_3$) | 1.845 | 3.092 | 0.003* |
| 5  | Pesticides ($X_4$) | -328,949   | -1.136     | 0.260        |
| 6  | Labor ($X_5$)     | -11,094    | -0.309     | 0.758        |
| 7  | Land Area ($X_6$) | 6362,301   | 5.085      | 0.000*       |
|    | F-Test            | 2250.151   | 0.000*     |

From Table 1 of the SPSS output, it shows significant values of the constants, land area, seeds, urea fertilizer, NPK fertilizer, pesticides and labor. Then the regression model equation can be arranged by looking at the value in column B, in this study the model formed is as follows:

\[ Y = 79,965 + 7.921X_1 + 1.817X_2 + 1.845X_3 - 328,949X_4 - 11,094X_5 + 6362.301X_6 \]

#### 3.1.1. Coefficient of Determination ($R^2$)

The coefficient of determination ($R^2$) was used to determine the accuracy of the model and to determine the influence of independent variables on the dependent variable using the value of $R^2$ coefficient. As shown on Table 1, the $R$ value is 0.998 whereas the $R$ coefficient is 0.995. This shows that 99.5% of the variable office production in the study area could be explained by the variable of seeds, urea fertilizer, NPK fertilizer, pesticides, labors and land area while 0.5% is influenced by other variables not included in the regression model.

#### 3.1.2. F-test

The result of the F-test analysis presented in Table 1 show that the significance value of the F-test is 0.000 < $\alpha$ value of 0.05 (5%). It could be concluded that the variable of land area, seeds, urea fertilizer, NPK fertilizer, pesticides, labor had equally significant effect on rice production.
3.1.3. *t*-test
Based on table 1, it is concluded that the effect of each independent variable (Xi), is partial on the production of rice farming business (Y). Meanwhile, to find out which variables having significant and significant influence on the yield of rice in Bombana Regency, significant values were compared as follows:

- Regression coefficient of seeds X1 = 7.921 had a positive yet not significant correlation with a significant value of 0.481 > 0.05. As the use of seeds was less qualified, so the power to grow was less optimal and susceptible to disease.
- Regression coefficient of urea fertilizer X2 = 1.817 correlated positively and significantly with a significant value of 0.003 < 0.05, indicating that the addition of 1% urea fertilizer would increase the production of rice by 1.817%.
- Regression coefficient of NPK fertilizer X3 = 1.845 had a positive significant correlation with a significant value of 0.003 < 0.05, indicating that the addition of 1% NPK fertilizer would increase the production of lowland rice by 1.845%.
- Regression coefficient of Pesticide X4 = -328,949 had a negative and not significant correlation with a value of 0.260 > 0.05. This might the result of the appliance of pesticide. It should have been applied before the field attacked by pests and diseases to prevent them, not when it had already been infected.
- Regression coefficient of labor X5 = -11.094 was negatively and not significant correlated with a significant value of 0.758 > 0.05. It might because of the need for additional labor skills was not only limited to the increasing of the number of workers but also to the increasing of the skills the workforces possessed such as careful maintenance of plants, providing safeguards, as well as controlling the extent of pests and disease.
- Regression coefficient of land area X6 = 6362.301 had a positive significant correlation with a significant value of 0.000 < 0.05, which meant that an increase of 1% of the land area would increase the production of lowland rice by 6362.301%.

3.2. Technical Efficiency Analysis
Stochastic Frontier production function analysis was carried out to find out what production factors affecting the production of rice farm in Bombana Regency (Table 2).

| No | Variable        | Coefficient |
|----|-----------------|-------------|
| 1  | Constant        | beta 0      | -0.10600 |
| 2  | Seeds           | beta 1      | 0.30181  |
| 3  | Urea fertilizer | beta 2      | 0.17419  |
| 4  | NPK fertilizer  | beta 3      | 0.45657  |
| 5  | Pesticide       | beta 4      | 0.46603  |
| 6  | Labors          | beta 5      | 0.22600  |

Table 2 describes the results of the stochastic frontier production function estimation using the Maximum Likelihood Estimation (MLE) method. It showed the variables that had an effect on increasing the production of rice farming business as follows:

- The coefficient value of seeds = 0.30181 was positively related indicating that production increased if there were additional seeds used.
The urea fertilizer coefficient = 0.17419 was positively related indicating that production increased if there was an addition of urea fertilizer used.

The coefficient of NPK fertilizer = 0.45657 was positively related showing that production increased if there were additional NPK fertilizers used.

The pesticide coefficient = 0.46603 was positively related showing that production increased if there were additional pesticides used.

The coefficient of labor = 0.22600 was positively related showing that production increased if there was additional labor employed.

The coefficient of land area = 0.16018 was positively related showing that production increased if there was an additional area of land used.

Analysis of the level of technical efficiency of rice farming in Bombana Regency using the stochastic frontier production function is presented in Table 3.

Table 3. Extent of Technical Efficiency of Rice farming

| Technical Efficiency | N (People) | Percentage (%) |
|----------------------|-----------|----------------|
| TE ≤ 0.7             | 28        | 23.33          |
| TE > 0.7             | 92        | 76.67          |
| Total                | 120       | 100            |
| Minimum TE           | 0.29      |                |
| Maximum TE           | 0.99      |                |
| Average TE           | 0.84      |                |

TE= technical efficiency

The technical efficiency index value of the analysis results could be categorized as technically efficient if the technical efficiency value was >0.7. As can be seen on table 3, farmers who were categorized as efficient when the technical efficiency index value > 0.7 were 76.67%. While 23.33% was not in the category of technical efficiency, because the value was ≤0.7.

The average value of technical efficiency of rice farmers corresponded 0.84 which revealed that average of technical efficiency of rice farmers in Bombana Regency corresponded 84%. It was considered that rice farming was technically efficient and remaining a 16% chance to increase rice production by adding optimal production inputs.

4. Conclusions and Suggestions

4.1. Conclusions

Based on the results and discussion, it can be concluded as follows:

- Factors that were positively and significantly correlated to rice production business in Bombana Regency were urea fertilizer, NPK fertilizer and land area.
- The extent of technical efficiency of rice farmers corresponded 0.84 which also the average of technical efficiency of rice farmers in Bombana Regency corresponded 84%. It was considered that rice farming business was technically efficient and remaining a 16% chance to increase rice production by adding optimal production inputs.

4.2. Suggestion

- Based on the conclusions of the research, it is suggested that the factors affecting production can be seen that the regression value of the pesticide coefficient and the coefficient of labor were negatively correlated, which interpreted the use of pesticides and labor should be in accordance with the conditions of the rice fields in order to increase production.
The extent of technical efficiency of rice farming was efficient and there were opportunities to increase production business in order to reach the maximum level of efficiency.

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