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# DETERMINANTS OF RICE FARMING EFFICIENCY IN KARANGANYAR CENTRAL JAVA IN THE PERIOD OF ONE DECADE AFTER REFORMATION

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## Abstract

One of the rice producer districts in Central Java is the Karanganyar district. The productivity of rice in Karanganyar district can still be improved because until 2010 the average productivity achieved at the farm level was still below potential or the research results were 8 ton ha-1. The low performance of farming because farmers are faced by the situation of limited production factors used in business to achieve the goal of maximizing income/welfare. The popular approach to measure the level of efficiency at the farm level is to use the frontier production function to determine technical efficiency. This study aims to determine the level of efficiency, in term of technical, allocation, and economy. This study also determines the factors that influence the technical and economic inefficiency of rice farming in Karanganyar district. This study uses Stochastic Production Frontier, by using 159 farmer respondents from 8 villages in 4 selected sub-districts. The result shows that rice farming in Karanganyar district already achieved technical and economic efficiency but has not yet for allocative efficiency. Factors of farmer's age, education, experience in rice farming, type of irrigation, and location (regional elevation) affect the technical inefficiency of rice farming in Karanganyar district significantly. While the factors that influence economic inefficiency are the type of irrigation and location. Farming households need to improve their technical efficiency, allocative efficiency, and economy efficiency.

**Keywords**: Efficiency; Karanganyar district; Rice farming; Stochastic Production Frontier.

## 1. Introduction

National food security still relies on rice to meet food sufficiency. On the other hand, increasing rice production is constrained by many things, including the conversion of agricultural land, pest and disease attacks, technology adoption by farmers, damage to irrigation facilities and climate change. Rice is the main staple food for Indonesian people, including during the economic crisis in 1997-1999. Since the reformation era, national rice production has been boosted to recover economic conditions and food stability. National rice production is relatively increasing and in 2011 its production reached 68,061,715 tons of milled dry grain. Central Java is the second-largest rice producer after East Java with a production of 779 thousand ton in 2012. One of the rice producer districts in Central Java is the Karanganyar district. Rice has the highest harvested area compared to other food crops and tends to increase from year to year. Table 1 shows rice productivity in Karanganyar district compared to the provincial and national levels

Table 1: Rice productivity in Karanganyar District, Central Java Province and Indonesia from 2009 to 2015

| Year | Productivity (ton ha$^{-1}$) | | |
|---|---|---|---|
| | Karanganyar District | Central Java | Indonesia |
| 2010 | 59,93 | 56.13 | 50.15 |
| 2011 | 52,40 | 54.47 | 49.80 |
| 2012 | 60,17 | 57.70 | 51.36 |
| 2013 | 60,07 | 56.06 | 51.52 |
| 2014 | 62,00 | 53.57 | 51.35 |
| 2015 | 64,78 | 60.25 | 53.41 |

Source: Ministry of Agriculture (2015)

Table 1 shows that rice productivity in Karanganyar Regency is higher than provincial and national productivity during the period 2009 – 2015. The productivity of rice the in Karanganyar district can still be improved because until 2015 the average productivity achieved at the farm level was still below potential or the research results were 8-ton ha (Ministry of Agriculture). The low performance of farming reflected in the low productivity is influenced by many obstacles that can be controlled by farmers such as land ownership, access to capital, institutions, agricultural infrastructure in which those cannot be controlled by farmers such as climate change. The productivity gap indicates that farmers have not been optimal in applying the recommended technology.

The topography of Karanganyar district is very diverse ranging from lowlands to highlands with a range of 90 asl to 2000 asl. Commodity rice is grown in all regions so that variations in production, productivity, and efficiency are very diverse. Farmers have the freedom to combine the production factors owned in the form of labor, seeds, fertilizers, capital, and technology appropriately so as to increase the productivity of agricultural land. Every production process

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requires a technical basis to produce certain outputs. Farmers are faced with the situation of limited production factors used in business to achieve the goal of maximizing income/welfare.

The production function shows the maximum amount of output that can be achieved by combining various inputs. The frontier production function is used to emphasize the maximum output conditions that can be produced in the production process (Debertin, 1986). The Farel methodology in 1957 concerning economic efficiency was widely applied and obtained improvements from (Kopp & Diewert, 1982) and subsequently modified by Bravo-Ureta. A number of studies have examined rice farmers' technical efficiency (Coelli et al., 2005; Rahman et al., 1999; Sharif & Dar, 1996; Wadud & White, 2000). The popular approach to measure the level of efficiency at the farm level is to use the frontier production function to determine technical efficiency (Battesse & Coelli 1995; Sharma et al., 1999; Tzouvelekas et al., 2001; Wadud & White 2000). Khai and Yabe (2011) made the effort of the technical efficiency (TE) of rice production and identified several technical efficiencies of rice farmers in Vietnam. The Vietnam Household Living Standard Survey (VHLSS) 2005-2006 was analyzed using the Cobb Douglas Production Function.

Mishra et al. (2015) helped policymakers to design increased production, profitability, and food security of rice farmers in the rainy rice ecosystem. They followed Ali & Flinn (1989) and Ali et al. (1994) and apply the stochastic production model to rice farmers in Bangladesh. They also have efficiency, particularly submergence and climate variables (e.g., rainfall) on rice farmers' efficiency.

In addition, there are also some studies about the efficiency of Indonesian rice farming. Muslim (2011) conducted research in East Java and found that the average rice field area for irrigated rice farmers in Kediri and Nganjuk by 0.37 ha with productivity of 54.7 quintals ha. The average technical efficiency is 0.74. Analysis with Frontier produces a value $\Upsilon$ close to 1, which means that almost all output variations are due to the achievement of technical efficiency related to managerial problems in the management of rice farming.

Suharyanto et al. (2013) studied the efficiency of rice farming in Bali which is the study area that applied Integrated Crop Management has technically been efficient with a range of 71.60 to 99.28 percent with an average rate of 88.24%. There were seven variables that have a significant effect and have a positive coefficient (land area, seeds, N fertilizer, organic fertilizer, pesticide, labor, and planting season) and one variable that has a significant effect on negative coefficients.

Socio-economic factors that are often used to explain the efficiency of rice and non-rice, the size of the typical farm, education, age and experience, contact farmers and extension workers, income, availability and accessibility of irrigation water, accessibility to cooperative institutions, and crop rotation (Saptana, 2012).

Kusnadi et al. (2011) examined the rice farming efficiency in West Java and found that land is the most responsive variable. In addition, the variable of seed, N fertilizer, 0.0045 for P fertilizer and 0.0678 for labor, while the variable fertilizer K does not significantly affect rice production. Antriyandarti (2015) also investigated the cost efficiency of rice farming in 5 provinces in Indonesia, including Central Java. She found that rice farming in Central Java already achieved cost efficiency. This study focusses to determine the level of efficiency, in term of technical, allocation, economy, and factors that influence the technical and economic inefficiency of rice farming in Karanganyar district.

## 2. Methods

The basic research method is descriptive analytical survey technique. Primary data is obtained through the results of interviews and direct observation. The research location was determined purposively, namely Karanganyar Regency with various topographic considerations. (the lowest altitude is only 90 m above sea level and the highest is 2000 m above sea level). Furthermore, from 17 sub-districts, Gondangrejo and Jaten sub-districts were selected representing the lowlands and Jatipuro and Karanganyar sub-districts which represent the highlands. Then 2 villages were selected from each sub-district. The study was conducted in 2013 and took farmer's household as the unit of analysis. The number of respondents was 159 people.

Table 2. Location and Number of Research Respondents

| Location | Productivity | District | Productivity | Village | Number of Respondents |
|---|---|---|---|---|---|
| Lowland | Low | Gondangrejo | Low | Plesungan | 20 |
| | | | High | Tuban | 20 |
| | High | Jaten | Low | Brujul | 20 |
| | | | High | Sroyo | 20 |
| Highland | Low | Jatipuro | Low | Jatimulyo | 20 |
| | | | High | Jatiharjo | 19 |

| Location | Productivity | District | Productivity | Village | Number of Respondents |
|---|---|---|---|---|---|
| | High | Karanganyar | Low | Bolong | 20 |
| | | | High | Jantiharjo | 20 |
| Total of Respondents | | | | | 159 |

Source: Primary Data

Analytical method used is the production function of the Cobb-Douglas Stochastic Frontier. The model specifications for estimating the parameters of the Cobb-Douglas rice production function in Karanganyar district with the Stochastic Production Frontier approach are as follows:

$$\mathrm{Ln(Yi)} = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + v_i - \mu_i$$

$$\mu_i = \delta_0 + Z_1\delta_1 + Z_2\delta_2 + Z_3\delta_3 + Z_4\delta_4 + Z_5\delta_5 + W_{it} \quad (1)$$

Whereas Y: rice production (kg $ha^{-1}$), $X_1$: cultivated land area ($m^2$), $X_2$: number of seeds (kg), $X_3$: number of family labor (JKP); $X_4$: number of workers in exams (JKP), $X_5$: amount of urea fertilizer (kg), $X_6$: number of NPK fertilizer, β0: intercept, βi: coefficient of estimating parameters, where i = 1,2,3,4,5, Zi: estimator parameter coefficient, where i = 1,2, vi-ui: error term (ui = effect of technical inefficiency in the model).

In achieving maximum profits, farming must be able to allocate costs minimally from existing inputs (farming is able to achieve allocative efficiency). The dual frontier cost function equations are as follows:

$$C = C(y_i, p_i, \beta_i) + ui \quad (2)$$

Whereas, C = production costs; yi = number of outputs; pi = input price; βi = parameter coefficient, and ui = error term.

Cost inefficiency (CEi) was defined as the ratio between total actual cost (C) and estimated total minimum cost (C*), so that CEi value ranged between one and infinity. Thus, the inverse of CEi was the cost-efficiency level. Cost efficiency was defined as allocative efficiency (EA). The EA was formulated as follows: AEi = 1 / CEi. The value of allocative efficiency (ae) obtained ranged between 0 and 1. Economic efficiency is a combination of technical and allocative efficiency which is defined as the ratio of the minimum total production costs observed with the total actual production costs, where $0 \leq EE \leq 1$ so that the equation is obtained.

To measure the economic efficiency (EE) per individual farmer, the formula of $EE_i = ET_i \cdot EA_i$. was used. Factor affecting the level of technical efficiency, EA and EE were estimated simultaneously with the frontier production function using Ordinary Least Square (OLS) method of multiple linear regression model. Linear regression model factors affecting the technical efficiency, EA, EE were formulated as follows :

$$EE = AE \times TE \quad (3)$$

Where: EE: Economic Efficiency; EA: Allocative Efficiency, and ET: Technical Efficiency

## 3. Results and discussion

### 3.1. Characteristics

From the table 2, it can be seen that the farmer is 57 years old with most of the education graduating from elementary school. Formal education is not an obstacle because farmer households rely more on 33 years of experience and involve their wives in rice farming.

Table 3. Characteristics of Rice Farming Households in Karanganyar Regency

| Description | | Husband | | Wife | |
|---|---|---|---|---|---|
| | | People | Percentage | People | Percentage |
| Age (year) | | 57 | | 47 | |
| Formal Education | Under primary school | 43 | 27,4 | 38 | 25,5 |
| | Primary School | 62 | 39,5 | 70 | 47,0 |
| | Junior High School | 28 | 17,8 | 22 | 14,8 |
| | Senior High School | 20 | 12,7 | 14 | 9,4 |
| | D2/D3/Bachelor | 4 | 2,5 | 5 | 3,4 |
| Farm Experience (year) | | 33 | | 30 | |
| Non formal Education | | 6,7 | | 0 | |

Source: Primery Data Analysis (2013)

Table 4. Description of Respondent's Rice Farming

| Description | Total | Percentage |
|---|---|---|
| Average Cultivated Land Area (Ha/year) | 4,835 | |
| Own Land | 1,315 | 27,2 |
| Land Rent | 1,94 | 40,1 |
| Land Area | 1,58 | 32,7 |
| Farm System (Household) | | |
| Monoculture | 140 | 88,1 |
| Intercropping | 19 | 11,9 |
| Frequency of Rice Planting (household) | | |
| 3 times/year | 109 | 68,6 |
| 2 times/year | 35 | 22,0 |
| 1 times/year | 15 | 9,4 |
| Watering (household) | | |
| Irrigation | 101 | 63,5 |
| Rainfed | 58 | 36,5 |

Source: Primary Data Analysis (2013)

The table 4, shows that farmers have limited land. Owned land is only 27.2% of it. Farmers seek to increase land tenure by renting or buying. As many as 40.1% of farmers choose to rent farmland because they have enough capital to rent and consider the results obtained from renting will be higher than buying. Meanwhile, 32.7% chose to answer because the farmer did not have enough capital and was still enthusiastic about working on other people's farmlands by relying on the power they had.

Rice farming is the main source of income so that 88.1% of farmers cultivate it in monoculture. Most of the farmers use a spacing of 20 cm x 20 cm and 18 cm x 18 cm, but some use a spacing of 15 cm x 15 cm, 25 cm x 25 cm, and 16 cm x 16 cm. To increase production, some farmers plant by way of "*jejer legowo*". Efforts to increase production are also carried out by fertilizing, irrigating, and spraying pests properly and some are developing organic rice by reducing the use of chemical fertilizers or not using chemical fertilizers at all. For land with technical irrigation, farmers can cultivate rice three times a year. However, for rainfed land, farmers combine it with secondary crops, so that they only plant rice twice or only once.

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### 3.2. Technical Efficiency

Efficiency is (1) the maximum ability to produce output on the use of certain inputs and on certain technologies; (2) achieving minimal production costs to obtain maximum added value, through the use of technology, management, scale of production and a combination of optimal production factors.

Table 5. Household Distribution of Rice Farmers in Karanganyar District based on Technical Efficiency

| Range | Number of Farmers | Percent |
|---|---|---|
| ≥ 0,9 - 1,0 | 5 | 3,14 |
| ≥ 0,8 -0,9 | 53 | 33,33 |
| ≥ 0,7 -0,8 | 32 | 20,13 |
| ≥ 0,6 -0,7 | 17 | 10,69 |
| ≥ 0,5 -0,6 | 22 | 13,84 |
| ≥ 0,4 -0,5 | 8 | 5,03 |
| ≥ 0,3 -0,4 | 14 | 8,81 |
| ≥ 0,2 -0,3 | 3 | 1,89 |
| ≥ 0,1 -0,2 | 3 | 1,89 |
| ≥ 0,0 -0,1 | 2 | 1,26 |
| Total | 159 | 100,00 |
| Mean | 0,669 | |
| Minimum | 0,020 | |
| Maximum | 0,934 | |

Source: Primary Data Analysis (2013)

Table 5. Shows that most rice farming households (33.33%) have rice farming efficiency in the range of ≥ 0.8 -0.9. A total of 56.60% of household rice farmers have achieved technical efficiency (efficiency value ≥ 0.7) and as much as 44.40% of farm households have not yet reached the efficiency of the technique. The results of the econometric analysis show that the range of technical efficiency of rice farming in Karanganyar district is 2% - 93.4%. this number is lower than the technical efficiency in Sri Lanka from 27% to 99% (Thayaparan & Jayathilaka, 2020). The estimated mean technical efficiency of rice in Karanganyar District has been found to be 0.669, indicating 66,9 percent efficiency in their use of production inputs.

This number is lower than the research Hasnain in Bangladesh (89,5 %), Jyoti Kachrooa in India (84 %); Lidya Sari in Lampung (76,3 %) and Aruna Shanta in Sri Lanka (72,80 %).

This means there is an opportunity to improve technical efficiency through improving factors that significantly affect efficiency. It suggested that farmers in the study area still have the room to improve their farming efficiency by 33,1% from its present level and this variation has arisen from differences in demographic. The magnitude and distribution of technical efficiency have important implications. The target group of counselling is better directed to farmers with less than 0.7 technical efficiency, arguing that the difference between actual productivity and the maximum potential that should have been achieved is quite large and the opportunity to obtain a productivity increase is generally greater and significant, so that not only the impact is felt by farmers, but also has a wider demonstration effect.

### 3.3. Factors Affecting Technical Efficiency

Production function analysis is used to analyze the factors that influence the production function of rice farming in Karanganyar Regency. The results of the Cobb-Douglas production function estimation using the MLE method.

Table 6. Estimation Results of Stochastic Frontier Production Function for Rice Farming in Karanganyar using the MLE. Method

| Notation | Variable | Coefficient | Std Error | T Ratio |
|---|---|---|---|---|
| Beta 0 | | 2,735*** | 0,363 | 7.529 |
| Beta 1 | Land Area ($m^2$) | 0,453*** | 0,077 | 5.862 |
| Beta 2 | Family Labor (JKP) | -0,041$^{ns}$ | 0,032 | -1.308 |
| Beta 3 | Foreign Workers (JKP) | 0,161*** | 0,053 | 3.001 |
| Beta 4 | Number of seeds (Kg) | 0,421*** | 0,079 | 5.339 |
| Beta 5 | Amount of Urea Fertilizer (Kg) | 0,029$^{ns}$ | 0,027 | 1.052 |
| Beta 6 | Amount of NPK Fertilizer (Kg) | 0,011$^{ns}$ | 0,019 | 0.576 |
| Sigma-Squared | | 5.402* | 3,076 | 1,756 |
| Gamma | | 0.986*** | 0,009 | 107,737 |
| Log LF MLE | | -117.886 | | |

| Notation | Variable | Coefficient | Std Error | T Ratio |
|---|---|---|---|---|
| Log LF OLS | | -153.145 | | |
| Mean Efficiency | | 0.669 | | |

Notes : *** Significant at 1 % level
** Significant at 5 % level
* Significant at 10 % level
ns Not Significant

The production function model used is Cobb Douglas Stochastic Frontier. The log-likelihood value using the MLE method (-117.886) is greater than the log-likelihood value using the OLS method (-153.145). This means that the production function using the MLE method is good and in accordance with the conditions in the field.

The sigma squared value of 5.402 shows the distribution of the inefficiency error term (ui). The value of the gamma parameter is the contribution of technical efficiency in the total residual effect. The gamma value is the ratio between the deviation of technical inefficiency (ui) to the deviation that may be caused by a random variable (vi). The gamma value is close to 1, i.e., 0.986, indicating that 98.6% of the error terms are only caused by technical inefficiency variables (ui), while the remaining 1.4% is caused by random variables.

From the results of the analysis, it is known that the variables that affect rice production are the area of land, the number of workers outside the family and the number of seeds used. The variable area of land is significant at an error rate of 1%. This result is in line with the research with (Chandio et al., 2019) in Pakistan (Itam et al., 2015). This means that an expansion of 1% the area of land will increase rice production by 0.453 %. If it is seen that the average land tenure of farmers is only 4,834 m2 (0.4834 ha) with a composition of 27.20% is own land, 40.12% is leased land and 32.68% is occupied land. Based on these data, it is indicated that farmers have been trying to increase the area of arable land, namely by renting and buying. And from the positive coefficient analysis, it means that the addition of land area is proven to increase rice production. Opportunities to increase the area of land (by rent or lease) are still possible both in the highlands (many residents are lazy, namely working and living outside the area so they do not work on their own rice fields) and in the lowlands (where agriculture is only a side job).

The variable of labor outside the family is significant at an error rate of 1%. These results are in line with research (Chandio et al., 2019; Chepng'etich et al., 2015; Hasnain et al., 2015;

Itam et al., 2015; Indah et al., 2015). From the results of the analysis, it is known that the average use of family workers is 534.82 JKP, far above family workers (173.17 JKP). The regression coefficient of 0.161 means that if the use of outside labor is added by 1% of JKP, it will increase production by 0.161 %. However, this is constrained by the increasing difficulty of obtaining external workers.

The variable number of seeds is significant at an error rate of 1% (Itam et al., 2015). Hasnain et al. (2015) stated the things that needs to be observed is the average use of seeds in Karanganyar Regency as much as 27.47 kg. This amount is close to the recommended seed standard of 30 kg/ha. If we look further, the original composition of the seeds is 5% of own seeds (left over from the previous growing season) and 95% of seeds purchased from production and production shops. The existence and benefits of KUD have not been widely felt by farmers. The regression coefficient of 0.421 means that every 1% increase in seed will increase production by 0.421 %. For this reason, it is necessary to provide quality, timely and affordable seeds by farmers so that they can increase rice production. Some of the advantages of using quality seeds include (1) Seeds grow fast and simultaneously, (2) If sown will produce strong and healthy seeds, (3) When transplanted, the seeds grow faster (Haile, 2015).

The findings revealed that land related factors such as land distance, ownership, and fragmentation explain much of the technical inefficiencies in addition to other socio-economic characteristics of farm households (Haile, 2015). Age, market access, training access, years of experience in onion production, farm income, responsibility and field visit were found to be significant at different levels of significance for technical efficiency.

### 3.4. Inefficient Technical Factors

The function of production inefficiency is determined by factors other than input. In this study the variables suspected of influencing inefficiency as managerial aspects of input include age, education, experience, type of irrigation (as variable dummy, irrigation = 1 and rain fed rice fields = 0) and research locations (as variable dummies, if in lowland = 1 and plateau = 0).

The results of the analysis of the factors that influence the inefficiency of rice farming in Karanganyar district presented in Table 7 show that all variables used, namely age, education, farming experience, irrigation type and location have a significant effect on technical inefficiencies at an error rate of 10%.

Table 7. Factors Affecting Technical Inef(ficiencies of Rice Farming in Karanganyar District

| Notation | Variable | Coefficient | St Error | t Ratio |
|---|---|---|---|---|
| Delta 0 | | -21,736* | 13,072 | -1.663 |
| Delta 1 | Age (years) | 0,248* | 0,137 | 1.812 |
| Delta 2 | Education (years) | 0,114* | 0,068 | 1.678 |
| Delta 3 | Farming Experience (years) | -0,076* | 0,045 | -1.684 |
| Delta 4 | Type of irrigation | -5,996* | 3,385 | -1.771 |
| Delta 5 | Location | 3,965* | 2,166 | 1.830 |
| Sigma-Squared | | 5,402* | 3,076 | 1.756 |
| Gamma | | | 0,986*** | 0,009 |
| LL MLE | | | -117,886 | |
| LL OLS | | | -153,145 | |
| Mean Efficiency | | | 0,669 | |

Note :

*** Significant at 1% level

** Significant at 5% level

* Significant at 10% level

ns Not Significant

The results of the analysis show that the age variable is positive, meaning that the more farmers grow, the technical inefficiencies of rice farming will increase, or the efficiency of rice farming will be lower when the age of farmers increases. Increasing age, the energy that is possessed begins to weaken so that it cannot work like when he was young. The implication is that rice farming requires productive young workers, so farming becomes more efficient.

Formal education has a positive effect on the technical inefficiencies of rice farming. The higher the farmer's education, the more inefficiencies. This is because formal education is not directly needed in rice farming because rice cultivation is more inheritance farming with descending knowledge.

Based on Maurice et al. (2015), since education is an important variable that influenced technical efficiency, farmers in Nigeria should be encouraged to acquire formal education to at least the primary level. This could be achieved by strengthening the capacity of the available. Adult and Continuing education centers in the area. In line with Chepng'etich (2015) in Kenya.

The farming experience variable is negative, meaning that the mohre farmers experience rice farming, the technical inefficiency decreases or becomes more efficient. Experience here is measured based on the length of time the farmers pursue farming. This is in line with research Thayaparan and Jayathilaka (2020), Srilangka farming experience were negatively related to technical inefficiency which means that, they were found to be significantly contributing to the variation in farm specific technical efficiency.

Irrigation type variables have a significant effect on the coefficient marked negative. This means that the technical inefficiency of irrigated lowland rice farming is lower than rainfed rice fields. In other words, rice farming in irrigated rice fields is more technically efficient. This is because rice is a plant whose cultivation requires water. Water availability in irrigated rice fields is better than rainfed rice fields so technically, rice cultivation in irrigated rice fields will be more technically efficient This is in line with research of Shantha et al. (2013). If producers can use new equipment and better water management practices, they would be able to upgrade their technical efficiency more than 50%.%. Further, by usage of new technologies and following a common cultivation schedule may further enhance their efficiency around 50%.

Location variables have a significant effect with a regression coefficient of 3.965. This means that if rice farming is cultivated in the highlands, technical inefficiency will increase, or rice cultivation is technically more efficient if cultivated in the lowlands. Based on Haile (2015), the result also revealed variables that contribute for allocative efficiency were plot distance, market access, sources of irrigation water, extension visit, farm income and field visit. Maurice et al. (2015) stated that the variables that were identified as having significant effects on technical efficiency levels of the Nigeria's farmers were age, education, farming experience, family size and sex.

### 3.5. Allocative Efficiency

Based on the decrease in dual frontier cost function, the allocation efficiency index (AE) and economic efficiency index (EE) can be calculated from each farmer where EE = C * / C and AE = EE / TE. The results of the analysis show that the allocative efficiency of farmer households is 0.224 to 1.993 with an average of 1.005 (already efficient). Distribution of farmer households according to allocative efficiency is presented in Table 8.

Table 8. Household Distribution of Rice Farmers in Karanganyar District Based on Allocative Efficiency

| Range | Number of Farmers | Percent |
|---|---|---|
| ≥ 1.0 | 84 | 52,83 |
| ≥ 0,9 - 1,0 | 28 | 17,61 |
| ≥ 0,8 -0,9 | 18 | 11,32 |
| ≥ 0,7 -0,8 | 11 | 6,92 |
| ≥ 0,6 -0,7 | 10 | 6,29 |
| ≥ 0,5 -0,6 | 5 | 3,14 |
| ≥ 0,4 -0,5 | 2 | 1,26 |
| ≥ 0,3 -0,4 | 0 | 0,00 |
| ≥ 0,2 -0,3 | 1 | 0,63 |
| ≥ 0,1 -0,2 | 0 | 0,00 |
| ≥ 0,0 -0,1 | 0 | 0,00 |
| Total | 159 | 100,00 |
| Mean | 1,005 | |
| Minimum | 0,244 | |
| Maximum | 1,993 | |

Source: Primary Data Analysis (2013)

Table 8 shows that 52.85% of farmer households have more than 1.00 allocation efficiency. This implies that most farmers are efficient on an allocation basis, but there are still opportunities for improvement because there are still households that are not yet efficient. Allocative efficiency improvements can be done by allocating inputs precisely according to input prices. This allocation efficiency will reduce costs so that the benefits of farmer households will increase. The effort that can be made is to increase the transparency of input prices and subsidize input prices.

### 3.6. Economic Efficiency

The results of the combined analysis of technical and allocative efficiency show that the average economic efficiency of rice farming in Karanganyar district is 0.676 (not yet efficient) with a range between 0.037 and 0.923. Distribution of farmer households according to economic efficiency is presented in Table 9.

Table 9. shows that 57.23% of farmer households have economic efficiency values with a range of ≥ 0.7 -0.8 (efficient). But as many as 42.77% of households have efficiency values of less than 0.7 (not yet efficient).

Table 9. Household Distribution of Rice Farmers in Karanganyar District Based on Economic Efficiency

| Range | Number of Farmers | Percent |
|---|---|---|
| ≥ 0,9 - 1,0 | 5 | 3,14 |
| ≥ 0,8 -0,9 | 38 | 23,90 |
| ≥ 0,7 -0,8 | 48 | 30,19 |
| ≥ 0,6 -0,7 | 26 | 16,35 |
| ≥ 0,5 -0,6 | 15 | 9,43 |
| ≥ 0,4 -0,5 | 12 | 7,55 |
| ≥ 0,3 -0,4 | 7 | 4,40 |
| ≥ 0,2 -0,3 | 4 | 2,52 |
| ≥ 0,1 -0,2 | 2 | 1,26 |
| ≥ 0,0 -0,1 | 2 | 1,26 |
| Total | 159 | 100,00 |
| Mean | 0,676 | |
| Minimum | 0,037 | |
| Maximum | 0,923 | |

Source: Primary Data Analysis (2013)

Economic efficiency can be improved by saving farming costs. Based on its economic efficiency range, sample farmers who have an average economic efficiency of 0.6765 can achieve maximum economic efficiency with a cost savings of 0.267 (1- 0.676 / 0.923). Farmers who have the lowest economic efficiency (0.037) can achieve maximum economic efficiency by making cost savings of 0.960 (1-0.037 / 0.923).

This result implies that economic efficiency can still be improved, and technical inefficiency is a serious problem compared to allocative inefficiency because the average technical efficiency is less than the average allocative efficiency. This illustrates that the ability of farmers to combine inputs to achieve a certain level of output is still low. However, even so, the handling of the problem of allocative inefficiency is more important when compared to the problem of technical inefficiency in an effort to achieve higher economic efficiency. This is because the opportunity to increase technical efficiency is smaller (28.3%) while cost savings as a result of cost savings as a result of achieving allocative efficiency are greater (49.6%) (Haile, 2015). Major determinants for economic efficiency were age of the household, plot distance, fertility, source of irrigation water, extension visit, experience in onion production, land fragmentation and farm income.

### 3.7. Inefficient Economic Cause Factors

The economic inefficiency of farming is assumed to increase with increasing production costs. The results of the analysis of factors that influence the economic inefficiency of rice farming in Karanganyar district are presented in Table 10. Table 10. shows that the factors that cause economic inefficiencies are the type of irrigation and location (altitude). This means that the existence of irrigation facilities can reduce farming costs so that technically irrigated rice fields (dummy type of irrigation = 1) are economically more efficient than rainfed rice fields. Conversely, farming in the highlands requires greater costs so it is not economically efficient.

Table 10. Factors Affecting the Economic Inefficiency of Rice Farming in Karanganyar District

| Notation | Variable | Coefficient | St Error | t Ratio |
|---|---|---|---|---|
| delta 0 | | -15.431 | 9.940 | 2.112 |
| delta 1 | Type of irrigation | -8.065* | 4.226 | -1.908 |
| delta 2 | Location | 2.338* | 1.300 | -1.908 |
| Sigma-Squared | | 8.256 | 4.743 | 1.741 |
| Gamma | | 0.989 | 0.008 | 128.965 |
| LL MLE | | | -110.918 | |
| LL OLS | | | -129.311 | |
| Mean Efficiency | | | 1.865 | |

Note :

*** Significant at 1% level

** Significant at 5% level

* Significant at 10% level

ns Not Significant

Rice cultivation carried out in irrigated rice fields can reduce cost inefficiencies or can increase economic efficiency because of lower costs. With the existence of irrigation facilities, farmers do not need to pay for gasoline/diesel, rent machines or labor to collect water from artesian wells (suck water). Conversely, for farmers whose rice fields rely solely on rainwater, they must spend several additional costs to obtain water. Many of the farmers meet their water needs by making and utilizing wells (with diesel pumps) so they must add to the use of inputs (labor, fuel) which in turn causes their farming to become economically inefficient. However, age, gender, farming experience, household size, access to credit, access to information, adoption of improved variety and location of rice farmers as sources of technical inefficiencies in Nigeria.

Indah et al. (2015) stated that variable prices of seeds and prices of fertilizers have a positive and significant effect on production costs, while labor wages and pesticide prices have a negative and insignificant effect on production costs. Lowland rice farming in Langkat Regency is technically efficient and not yet cost and economic efficient.

Based on Sulistyorini & Sunaryanto (2020), rice productivity in Kutukan Village is influenced by the type of land, the amount of urea fertilizer and labor. There is a significant difference in the use of seeds, urea, and pesticides, while the use of SP36 and labor has no significant difference. The use of seeds and urea on rainfed land is higher than that of irrigated land and the use of pesticides on irrigated land is higher than that of rainfed land.

The technical efficiency analysis suggests that about 90% of farmers in the sample are between 60 and 75% efficient, with an average efficiency in the sample of 65% (Mango et al, 2015). The significant determinants of technical efficiency were the gender of the household head, household size, frequency of extension visits, farm size and the farming region. The results imply that the average efficiency of maize production could be improved by 35% through better use of existing resources and technology. The results highlight the need for government and private sector assistance in improving efficiency by promoting access to productive resources and ensuring better and more reliable agricultural extension services.

The cost efficiency index ranged from 0.18-0.98, with a mean of 0.84 implying that an average farm in the study area has the scope for increasing cost efficiency by 16% given the existing technology (Maurice et al, 2015). The study recommended farmers education on fundamental farm management skills to enable farmers plan, evaluate and appraise their farm business activities among others.

## 4. Conclusion

Rice farming in Karanganyar district not technically and economically efficient but has been efficient in the allocative. The average value of technical, economic, and allocative efficiency is 66.9%, 67.60%, and 100.5%.

Factors of farmer's age, farmer education, farmers' experience in rice farming, type of irrigation, and location significantly affected the technical inefficiency of rice farming in Karanganyar District. While the factors that influence economic inefficiency are the type of irrigation and location (altitude).


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## Author Contribution

The contribution of each author, namely Umi Barokah, oversees formulating concepts, methodology, analysis, discussion, finishing. Wiwit Rahayu oversees the initial draft preparation, analysis, and review. Agustono oversees interpretation, review, and editing. Ernoiz Antriyandarti oversees library enrichment, translation, and review.

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