THE USE OF THE STOCHASTIC FRONTIER METHOD FOR MEASURING THE PERFORMANCE OF RICE FARMING IN THE FRONTIER, REMOTE, AND UNDERDEVELOPED AREAS IN MERAUKE REGENCY, SOUTH PAPUA PROVINCE, INDONESIA

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ABSTRACT

Merauke is one of the regencies in South Papua Province with flatland areas, making it very suitable for agriculture. In 2011, Merauke Regency was declared a food barn for Eastern Indonesia by President Jokowi. Tanah Miring District is one of the rice centers in Merauke. One of the villages in Tanah Miring District is Sumber Harapan Village.

This study aims to examine (1) factors that influence the production of rice farming in Sumber Harapan Village, Merauke Regency; (2) factors that influence the technical efficiency of rice farming in Sumber Harapan Village, Merauke Regency; and (3) the level of technical efficiency of rice farming in Sumber Harapan Village, Merauke Regency.

This research was conducted in Sumber Harapan Village, Tanah Miring District, Merauke Regency, from June to August 2022. The data used were primary data and secondary data. Primary data were obtained from interviews, questionnaires, and observations. Meanwhile, the secondary data were obtained from Statistics Indonesia (BPS) and other literature. The number of samples used was 50 rice farmers.

The results showed that the factors influencing the production of rice farming in Sumber Harapan Village, Merauke Regency, were machines, labor, and land area. Meanwhile, the factors influencing the technical efficiency of farming production in Sumber Harapan Village, Merauke Regency were a family burden, education, land status, and membership in farmer groups. The average level of technical efficiency of rice farming in Sumber Harapan Village, Merauke Regency, was 0.97, which is said to be inefficient since it is below one.

Keywords: technical efficiency, stochastic frontier, production, rice, Merauke
INTRODUCTION

Rice is a very important crop for humans (Ishaq et al., 2016, Dissanayaka et al., 2018), which can adapt to various climatic conditions (Fahad et al., 2019), and the most important strategic crop for food & security nutrition globally (Fukagawa & Ziska, 2019). Rice is the staple food of most populations in the world (Ghosh et al., 2018, Pathak et al., 2018, Hori & Sun, 2022), especially in developing countries (Zhang et al., 2020, Oliveira et al., 2020). More than one hundred countries grow rice, and 90 percent of them are Asian countries (Fukagawa & Ziska, 2019) and consume it (Bandumula, 2018). Rice is also the staple food of the majority of the population in Indonesia (Heriqbaldi et al., 2015, Yunianti et al., 2022) and a strategic commodity significantly influences the social, economic, political, and security aspects of the Indonesian people (Prasekti, 2015). Rice consumption will continue to increase as the population increases (Santoso, 2015, Andrias et al., 2017, Tsujimoto et al., 2019). However, rice productivity is still low (A. A. Santoso et al., 2022), and the increase in the amount of rice production is not proportional to the increase in population, resulting in a shortage of rice. Thus, the government must import rice from outside to overcome this problem (Marlina et al., 2017). Additionally, a serious effort is needed by the government to meet the demand for rice (Supriatna & Thahir, 2007).

Merauke Regency is one of the regencies in South Papua Province, which is geographically located between 137° - 141° East Longitude and 5° - 9° South Latitude. Its area reaches up to 46,791.63 km². Merauke Regency consists of flatland areas, making Merauke Regency very suitable to be used as an agricultural area. In 2015, Merauke Regency was declared a food barn for Eastern Indonesia by President Jokowi. Even though it is designated as a food barn with the main commodity being rice (Widyantari & Maulany, 2020), rice farming in Merauke Regency is not yet technically efficient, both those managed by migrant farmers (Widyantari et al., 2019) or local farmers (Widyantari et al., 2018). Fortunately, the rice milling business in Merauke Regency is technically efficient (Widyantari et al., 2020). Tanah Miring District is one of the rice centers in Merauke Regency (Widyantari & Maulany, 2020), divided into fifteen villages. One of the villages in Tanah Miring District is Sumber Harapan Village. It has an area of 574 hectares of rice fields cultivated by a total of 477 farmers. With a comparison between land area and the number of farmers, then each farmer in Sumber Harapan Village has an average paddy field of 1.2 ha per person since most of the residents of Sumber Harapan Village have their main livelihood as rice farmers. Two methods of planting rice used by farmers are shifting and broadcasting. Broadcasting is more widely used by farmers since it is considered to be able to minimize costs and labor, considering that labor costs in Merauke are expensive. Moreover, farmers usually use rice seeds from the harvest of the previous planting season, and
the quality of the rice seeds must be different from superior seeds. This habit will certainly affect the amount of rice production. Even worse, there is a shortage of fuel which causes an increase in fuel prices. It also affects the increase in rental prices for four-wheeled tractor and combine harvester machines.

Based on the problems above, it is necessary to conduct research that aims to examine (1) factors that influence the production of rice farming in Sumber Harapan Village, Merauke Regency; (2) factors that influence the technical efficiency of rice farming in Sumber Harapan Village, Merauke Regency; and (3) the level of technical efficiency of rice farming in Sumber Harapan Village, Merauke Regency. The novelty in this study is the location and year the research is conducted, where the samples in this study are the Javanese and NTT tribes.

**RESEARCH METHOD**

This research is analytical descriptive research conducted from June to September 2022. The research location was Sumber Harapan Village, Tanah Miring District, Merauke Regency. The population of this study was all rice farmers in Sumber Harapan Village, Tanah Miring District, Merauke Regency, with a total of 477 farmers. Of the total population, 50 respondents were taken as samples in this study. The sample of farmers was selected by random sampling technique. Types and sources of data were primary data obtained by questionnaires, interviews, and direct observation and secondary data obtained from journals and other literature. The data was analyzed using the Stochastic Frontier Efficiency analysis tool. The equation model for the rice production function in this study is as follows:

\[
\ln Y = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 (v_i - \mu_i) \quad \text{(1)}
\]

Where:
- \( Y \) = Rice production (kg)
- \( \beta_0 \) = Constant (intercept)
- \( \beta_i \) = Coefficient parameter estimation (where \( i = 1-6 \))
- \( X_1 \) = Fertilizer (kg)
- \( X_2 \) = Seeds (kg)
- \( X_3 \) = Machine (jam)
- \( X_4 \) = Labor (HOK)
- \( X_5 \) = Land area (ha)
- \( X_6 \) = Pesticide (ml)
- \( v_i \) = Error term
- \( \mu_i \) = Technical inefficiency effect parameter,
- \( \delta_i \) is obtained from:

\[
\mu_i = \delta_0 + \delta_1 z_1 + \delta_2 z_2 + \delta_3 z_3 + \delta_4 z_4 \quad \text{(2)}
\]

Where:
- \( \delta_0 \) = Intercept
- \( \delta_i \) = Coefficient parameter estimation
- \( z_1 \) = Family burden (family members)
- \( z_2 \) = Education (year)
- \( z_3 \) = Dummy land status (1 = personal ownership, dan 0 = somebody else’s ownership).
- \( z_4 \) = Dummy membership in farmer groups (1 = member, dan 0 = non-member).

The parameter estimation of the inefficiency of rice farming techniques was processed using the Frontier 41 program. Mathematically, technical efficiency analysis can be calculated using the following formula:

\[
TE_i = \frac{Y_i}{\tilde{Y}_i} = \frac{E(Y_i/\tilde{U}_i;X_i)}{E(Y_i/\tilde{U}_i;\theta;X_i)} = E[\exp(-\mu_i/\varepsilon)] \quad \text{(3)}
\]
Description:

\[ TE_i = \text{The } i\text{-th farm technical efficiency} \]
\[ Y_i = \text{Actual output function (without error term)} \]
\[ Y_i^* = \text{Potential output function} \]
\[ U_i = \text{Random variable that describes the technical inefficiency of the } i\text{-th attempt assumed to be independent, and the distribution is truncated with the normal } N(\mu_i, \sigma^2) \]

\[ E[exp(-U_i)] = \text{hope value (mean of } U_i \text{ where } \mu_i, \text{ so } 0 \leq \text{TE} \leq 1 \]

An effort is said to be efficient if \( TE = 1 \), and inefficient if \( TE < 1 \).

The efficiency value is inversely related to the technical inefficiency value and is only used for functions with a certain number of outputs and inputs (cross-section data).

RESULTS AND DISCUSSION

Characteristics of Respondents, Production, and Use of Input

Characteristics of respondents in this study include age, length of education, experience, and number of family members.

Table 1 shows that the average age of the respondents was 46 years, which means that the rice farmers in Sumber Harapan Village are still at a productive age. Basically, young and healthy farmers are physically stronger than old farmers. Young farmers will more quickly accept recommended things since they are more willing to take risks (Purwanti, 2007).

The average length of farmers’ education was 8 years. In other words, the average farmer in Sumber Harapan Village had an education until 2 junior high school, which means that the education of farmers was still relatively low. Low education will affect the inability to plan agriculture (Dewi et al., 2018). Meanwhile, Charina et al., (2018) said that the level of education is related to the knowledge and abilities of farmers in analyzing various information before applying it in their farming.

The average farming experience in Sumber Harapan Village was 21 years. The expertise of rice farmers in Sumber Harapan Village was very different from that of farmers in Margamulya Village, who had an average experience of 30-39 years (Widyantari et al., 2022). In other words, the experience of rice farmers in Margamulya Village is longer

<table>
<thead>
<tr>
<th>NO</th>
<th>Description</th>
<th>Mean</th>
<th>St.Dev</th>
<th>Max</th>
<th>Min</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Age (year)</td>
<td>46</td>
<td>12.38</td>
<td>79</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>The length of education (year)</td>
<td>8</td>
<td>2.51</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>Farming experience (year)</td>
<td>21</td>
<td>11.48</td>
<td>60</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>Family members (people)</td>
<td>3</td>
<td>1.27</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>Rice Production (kg/ha)</td>
<td>918</td>
<td>427.35</td>
<td>2220</td>
<td>148</td>
</tr>
<tr>
<td>6</td>
<td>Land Area (ha)</td>
<td>0.99</td>
<td>0.18</td>
<td>2</td>
<td>0.5</td>
</tr>
<tr>
<td>7</td>
<td>Seeds (kg/ha)</td>
<td>50.2</td>
<td>9.58</td>
<td>100</td>
<td>25</td>
</tr>
<tr>
<td>8</td>
<td>Urea fertilizer (kg)</td>
<td>106</td>
<td>29.69</td>
<td>200</td>
<td>50</td>
</tr>
<tr>
<td>9</td>
<td>Phonska fertilizer (kg)</td>
<td>105</td>
<td>40.720</td>
<td>200</td>
<td>50</td>
</tr>
<tr>
<td>10</td>
<td>Pesticide (ml)</td>
<td>1116.32</td>
<td>671.06</td>
<td>2900</td>
<td>200</td>
</tr>
<tr>
<td>11</td>
<td>Human Labor (HOK)</td>
<td>9.68</td>
<td>1.60</td>
<td>13.25</td>
<td>5.12</td>
</tr>
<tr>
<td>12</td>
<td>Machine</td>
<td>28.5</td>
<td>9.38</td>
<td>54</td>
<td>11</td>
</tr>
</tbody>
</table>

Source: Processed primary data
than that of farmers in Sumber Harapan Village. Long experience in farming will affect the behavior of farmers in cultivating their farming. Farmers with more farming experience tend to have a lot of farming knowledge compared to those with little experience. Thus, farmers who have longer experience tend to be more careful in making decisions (Samun et al., 2011).

The average number of family members among farmers was three, which was not that many. The number of family members will affect the total costs incurred by farmers (Yusup et al., 2022). The more the number of family members, the lower the allocation of funds for each child if they do not have sufficient income (Purwanto & Tafazani, 2018).

The minimum rice production yield in Sumber Harapan Village was 148 kg, with a land area of 0.5 ha. Meanwhile, the highest production yield was 2220 kg, with a land area of 2 ha. The average use of rice seeds was 50.2 kg, and most of the seeds used by farmers come from previous crops. The fertilizers used by farmers were urea and Ponska fertilizer. They started using pesticides when the rice plants began to be attacked by pests, with an average use of pesticides of 1116.32 ml. Meanwhile, human labor was used only when fertilizing and treating plants against weeds and pests. Farmers used tractors to cultivate the land, while harvesting was done using a combine harvester. The length of the harvest time depends on the condition of the land. Farmers usually needed 4 hours/ha to harvest rice.

Stochastic Frontier Production Function Analysis

The results of the stochastic frontier estimation in Table 2 describes the best performance (best practice) of rice farmers in Merauke Regency at the level of existing technology. The log-likelihood value with the OLS method was 36 4.56, which was greater than the log-likelihood value with the MLE method, which was 362.02. This shows that the production function with the MLE method was good according to field conditions.

The constant value in this study was 612.65 significant. The value of the sigma-squared parameter for rice farming in Merauke Regency was 130250.05, which is significant at the level of $\alpha = 1\%$. It shows that the conformity with the distribution assumptions used is the normal half/normal distribution.

The gamma value ($\gamma$) indicates the ratio between the technical inefficiency deviation ($\mu$) and the deviation caused by the random variable ($v$). The gamma value in this study was 0.70, which had a significant effect on the level of $\alpha = 1\%$. This shows that there is an influence of technical inefficiency factors on the model used. The error term variation in the model was 70 percent, which was caused by technical inefficiency factors, and the rest (30 percent) was caused by random variables, which were factors that cannot be controlled by humans (noise), such as weather, natural disasters, pests, and diseases, and so on.

The machine variable has a positive effect on rice production with a coefficient value
Table 2 Results of Stochastic Frontier Production Function Estimation

<table>
<thead>
<tr>
<th>Variable</th>
<th>Hops Sign</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>t-Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>+</td>
<td>612.65</td>
<td>1.85</td>
<td>329.9t</td>
</tr>
<tr>
<td>Fertilizer</td>
<td>+</td>
<td>0.43</td>
<td>0.58</td>
<td>0.7</td>
</tr>
<tr>
<td>Seed</td>
<td>+</td>
<td>-0.44</td>
<td>3.84</td>
<td>-0.1</td>
</tr>
<tr>
<td>Machine</td>
<td>+</td>
<td>10.60</td>
<td>3.60</td>
<td>2.9</td>
</tr>
<tr>
<td>Labor</td>
<td>+</td>
<td>-107.39</td>
<td>5.90</td>
<td>-18.1'</td>
</tr>
<tr>
<td>Land area</td>
<td>+</td>
<td>860.42</td>
<td>1.03</td>
<td>834.9</td>
</tr>
<tr>
<td>Pesticide</td>
<td>+</td>
<td>0.10</td>
<td>0.07</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Sigma-squared 130250.05 *** 1.00 130193.09
Gamma 0.70 *** 0.30 2.3
Log-likelihood OLS 364.56
Log-likelihood MLE 362.02
LR test of the one-sided error 5.05

Source: Primary Data Analysis, 2022
Description:
*** : Significant at α = 1%  t-table= 2.68
** : Significant at α = 5%  t-table= 2.01

of 10.60 at the level of α=1 percent. In other words, every 1 percent addition of machines will increase rice production by 10.60 percent, assuming other factors are constant. The more machines available, the more land area can be processed using machines. With the extent of agricultural land, mechanization plays a major role in rice farming. Agricultural mechanization is very suitable to be applied in Merauke Regency with its large land area, and limited human labor, plus the wages that must be paid for labor are expensive (Widyantari et al., 2019). Machines that are now widely used in Merauke Regency are tractors for cultivating land, both two-wheeled tractors and four-wheeled tractors. Transplanters are used to plant rice seeds, but this tool is still not widely used by farmers because it is considered very complicated. Meanwhile, the combine harvester is used when harvesting rice.

The labor variable in this study had a negative effect on rice production with a coefficient value of -107.39 at the level of α=1 percent. This means that every 1 percent addition of labor will decrease rice production by 107.39 percent, assuming other factors are constant. This is because the average agricultural land area owned by the farmers was 0.99 ha, so it did not require too much human labor since land processing and harvesting are already using machines. The addition of labor makes rice farming inefficient.

The land area variable in this study had a positive effect on rice production with a coefficient value of 860.42 at the level of α=1 percent. This means that every 1 percent addition of land area will increase rice production by 860.42 percent. With the increasing area of agricultural land and the additional use of machines, rice production will increase.

Rice Farming Technical Efficiency

Table 3. shows that the average technical efficiency achieved by farmers in Sumber Harapan Village, Tanah Miring, Merauke Regency was 0.97, while the lowest technical efficiency score was 0.91 and the highest technical efficiency was 0.99. This means that the technical efficiency of rice farming in Sumber Harapan Village is higher than
The technical efficiency of other villages in Merauke Regency, namely 0.69 for local farmers and 0.85 for transmigrant farmers (Widyantari et al., 2019). Differences in the level of technical efficiency achieved by farmers show differences in the level of mastery in technology applications, the farmers’ ability to obtain production inputs, and the number of productive-age family members of farmers (Prayoga, 2010).

Factors Causing Technical Inefficiency in Rice Farming

A negative sign on the inefficiency parameter of the frontier processing results indicates that the variable decreases technical inefficiency or increases technical efficiency. On the other hand, a positive sign on the inefficiency parameter of the frontier processing results indicates that the variable increases technical inefficiency or means decreasing technical efficiency (Nahraeni, 2012). Cendrawasih et al. (2018) confirmed the same thing, namely that the variable has a negative sign which indicates that the variable has a positive effect in increasing the level of technical efficiency.

Table 4. shows that the technical inefficiency factor of the number of family dependents is significantly negative ($\alpha = 1\%$). This means that the increasing number of family members will further reduce the level of technical inefficiency. In other words, the increasing number of farmer family members will increase technical efficiency. The more labor in the family, the greater the farmer’s dependency on his family members to work his land. This result confirms the suitability of the research of Yoko et al. (2014), which states that the greater the number of family members who have productive age, the higher the technical efficiency because it can reduce the use of labor from outside the family, besides that they also have better performance because they have a high sense of responsibility because they are the economic foundation of the family.

The technical inefficiency factor of education is significantly positive ($\alpha = 1\%$), meaning that the higher the education level of the farmer, the higher the technical inefficiency. In other words, the higher the education level of the farmer, the lower the technical efficiency. This is due to the fact that farmers who have a high level of education are farmers with a low level of experience or are new farmers. Thus, it is still in the
process of becoming efficient. However, even though it is not efficient, it is easier for farmers who have higher education to accept or adopt changes in cultivation technology and choose the right inputs for use in farming so that they affect farm management and are able to reduce inefficiencies in farming (Pratama et al., 2020).

The technical inefficiency factor for land status was significantly positive ($\alpha=1\%$). It means that rented land was more efficient than personal ownership. This study has two land ownership statuses: personal and rented land. The farmers who used rented land should have worked hard so the harvest could be used to rent land in the next planting season.

The membership factor of farmers in farmer groups was significantly negative ($\alpha=1\%$). It means that the farmers who were members of farmer groups were more efficient than those who were not. It is because the farmers who were members of farmer groups received government assistance, subsidized fertilizers, and agricultural technology training.

**CONCLUSION**

An average technical efficiency value of 0.97 shows that the farming in Sumber Harapan Village of Merauke Regency is inefficient. The factors influencing the farming production in Sumber Harapan Village of Merauke Regency are machines, labor, and land area. In contrast, the factors influencing the technical inefficiency of farming production in Sumber Harapan Village of Merauke Regency are family responsibilities, education, land status, and membership in farmer groups. Therefore, assistance and training by the relevant agencies must be carried out to achieve efficiency.

**ACKNOWLEDGEMENT**

We would like to thank the Rector of Musamus University, Dr. Beatus Tambaip, and LP2M for supporting us. We also appreciate the assistance of all parties participating in this research.

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The Use of the Stochastic Frontier Method for Measuring the Performance of Rice Farming in the Frontier, Remote, and Underdeveloped Areas in Merauke Regency, South Papua Province, Indonesia | Ineke Nursih Widyantari


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