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# ASSESSING EFFICIENCY OF PADDY FARMING IN DELI SERDANG REGENCY, NORTH SUMATRA, INDONESIA

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## ABSTRACT

*The use of agricultural input is significant for farm management. It would relate to productivity and efficiency. The problem is that the paddy farmers still needed to determine the appropriate agricultural input use level to achieve efficiency. This study aims to assess the efficiency of paddy farming in Deli Serdang Regency, North Sumatra, Indonesia. This study evaluated the efficiency of paddy farming with three types: technical efficiency, allocative efficiency, and economic efficiency. A survey was conducted with 40 paddy farmers to obtain data on paddy production and agricultural input use such as seed, fertilizer, chemicals, and labor. Data envelopment analysis with an input approach was employed to analyze the data. The scores of technical efficiency, allocative efficiency, and economic efficiency were 0.935, 0.711, and 0.668, respectively. This study indicated that paddy farming in Deli Serdang Regency, North Sumatra, Indonesia, was technically efficient. However, it was allocative and economically inefficient. The unachieved cost minimization was the driving factor of the allocative inefficiency. Furthermore, this study also found that the condition of paddy farming increased the return to scale (IRS). This condition implied that the paddy farmers could escalate the paddy production and achieve efficiency by improving agricultural input use. Moreover, eco-friendly agricultural input is encouraged to minimize costs to improve*

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*allocative efficiency and support sustainable agriculture. Also, the government should take some actions and policies to improve the efficiency of paddy farming in Deli Serdang.*

***Keywords: Allocative Efficiency, Data Envelopment Analysis, Economic Efficiency, Technical Efficiency***

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## INTRODUCTION

Paddy has a vital role in boosting Indonesia's economy. Empirical evidence shows that food commodities contribute 9.85% to Indonesia's gross domestic product (The Ministry of Agriculture, 2022). From now on, the demand and consumption for paddy are pretty high since it is a daily staple food needs for all Indonesians. Population growth is also a cause of the increase in the need and demand for food. However, the productivity and supply of rice to fulfill the needs are lacking (Listiani et al., 2019). Central Bureau of Statistics (2024a) mentioned that Indonesia's rice production is 31.10 million tons. On the other hand, the consumption rate of paddy is 31.54 million tons. Thus, maximizing paddy production is urgently required to equalize the demand and supply of food in Indonesia.

One of the paddy-producing provinces in Indonesia is North Sumatra Province. Total paddy production in North Sumatra is 2.08 million tons (Central Bureau of Statistics, 2024b). One of the paddy-producing regions in North Sumatra is Deli Serdang Regency. Deli Serdang Regency has lowland and wetland paddy farming areas. The regency has potential in food production—most of the farmers in the regency cultivated paddy as their source of livelihood. Deli Serdang is the paddy-producing regency with the highest production in North Sumatra Province of 307,608 tons. However, the productivity of paddy in Deli Serdang is only 5.87 tons/ha (Central Bureau of Statistics, 2024c). Meanwhile, the expected productivity of paddy is 8 tons/ha. It showed the gap between actual and scheduled paddy productivity existed. The difference between actual and expected output is due to the unachieved efficiency (Sickles & Zelenyuk, 2019). Despite the region being well-known as a paddy-producing region. The efficiency level of paddy farming in Deli Serdang has not been identified. Sukiyono & Sriyoto (2010) declared that it is essential to figure out the extent to which farmers have achieved the efficiency of their paddy farming practices. Hence, this study is crucial to be conducted.

Daniel (2001) revealed that agribusiness production is obtained through a risky and lengthy process. It depends on the type of cultivation, climate, land, technology, and management. Furthermore, the sufficiency of production factors or agricultural inputs determined the achievement of agricultural production (Wang & Zhang, 2023). The studies by Nowak et al. (2015) and Abiola et al. (2016) emphasized the importance of optimizing existing resources as a practical approach to enhancing agricultural production. It also indicated that the existing agricultural inputs would affect the production. Therefore, it should support the appropriate and efficient use of agricultural input (Siregar et al., 2016).

Soekartawi (2002) stated that efficiency involves using appropriate and efficient inputs to maximize output. Based on the concept of efficiency, efficiency has 3 types, which are technical efficiency, allocative efficiency, and economic efficiency. A production technology's technical efficiency refers to its ability to achieve an optimal output with a given set of inputs. Meanwhile, the allocative efficiency concept focuses on the farmer's capacity to utilize the optimal input level at a given price. Combining both efficiencies is commonly called "economic efficiency" (Simar & Wilson, 2020). The price increases of the agricultural inputs are suspected to be the problem that causes the paddy farmers to use inappropriate agricultural inputs, affecting efficiency and production maximization.

This study aims to assess the efficiency of paddy farming in Deli Serdang Regency. This research will calculate the three types of efficiency and provide information regarding the performance of paddy farming in Deli Serdang in terms of agricultural input use. Measuring the efficiency is required to evaluate the agricultural input used by the paddy farmers. The findings of this study accommodate reference for the government in policy-making to formulate strategy, program, and policy for agricultural development focusing on paddy production and food security.

Efficiency can be assessed through methods and analyses. One of the analyses is Data Envelopment Analysis (DEA). DEA is an analysis that calculates efficiency using the linear programming nonparametric technique. DEA can detect the best frontier solution to all observations or decision-making units (DMUs) (Atici & Podinovski, 2015). DEA has been applied in some research for agricultural farming, such as maize in Ghana (Abdulai et al., 2018; Anang et al., 2022) rice and wheat in Pakistan, India and China (Aslam et al., 2021), tomato in Ghana (Nanii et al., 2020), coffee in Nepal (Poudel et al., 2015), catfish in Nigeria (Oluwatayo & Adedeji, 2019), cattle in Algeria (Ameur et al., 2024), olive in Italy (Stillitano et al., 2019), etc.

This paper has four sections. The first section is an introduction explaining the existing problem, background, significance, and aim of this research. The second section is research methods, including study location, data analysis, and tools used to assess the efficiency of paddy farming in this research. The following section is the result and discussion. The section discloses and discusses the findings obtained, justifies this research, and elaborates on the previous studies. Finally, this research is closed by the conclusion and suggestion as the policy implication statement regarding the food agribusiness development.

## RESEARCH METHOD

### Location

This study was conducted in Deli Serdang, North Sumatra. The research location was purposively selected, with some considerations including (1) This location is one of the paddy producers in North Sumatra. (2) This location has implemented technology to improve paddy production and productivity in North Sumatra. Figure 1. shows the location study. This study was conducted from October 2023 to February 2024. Data was gathered through a survey of the 40 paddy farmers randomly selected.

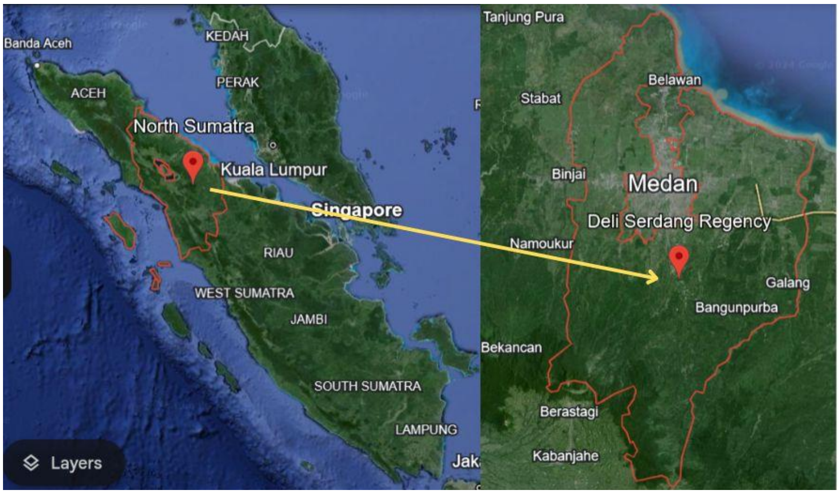


Figure 1.
Study Location

### Data Analysis

Efficiency can be defined as a measure of the ability to manage and utilize production assets cost-effectively. Therefore, efficiency is related to how an asset is properly managed. The closer to the ideal condition, it would be more efficient and vice versa (Noor, 2007). There are three efficiency types: technical, allocative, and economic. The approach employed to calculate all the efficiencies was Data Envelopment Analysis (DEA), which was initially developed by Battese & Coelli (1993). Technical efficiency is considered the ability to produce at an isoquant level. The Data Envelopment Analysis (DEA) for technical efficiency (TE) applied in this study was estimated with the following equation (Vörösmarty & Dobos, 2023):

$$\text{Min } \theta,$$
$$\text{Subject to: } \quad -y_i + Y\lambda \geq 0,$$
$$\theta \chi_i^* - X\lambda \geq 0,$$
$$N1'\lambda = 1$$
$$\lambda \geq 0$$

$\theta$ = a vector of input use for the i-th DMU

$\chi_i^*$ = is the the input use-minimizing vector of input quantities for the i-th DMU, given the input $\theta$ and the output level yi.

Economic efficiency is a combination of technical efficiency and allocative efficiency. Efficiency was measured through the approach of input orientation or output orientation (Camanho et al., 2024). Economic efficiency was estimated using the following equation:

$$\min_{\lambda, x_i^*} w_i' x_i^*$$
$$\text{subject to: } \quad -y_i + Y\lambda \geq 0,$$
$$x_i^* - X\lambda \geq 0,$$
$$N1'\lambda = 1$$
$$\lambda \geq 0$$

$w_i$ = a vector of input prices for the i-th DMU

$x_i^*$ = is the cost-minimizing vector of input quantities for the i-th DMU, given the input prices wi and the output level yi. Furthermore, EE or economic efficiency was calculated as:

$$EE = w_i' x_i^* / w_i' x_i$$

The value was $0 \leq EE \leq 1$. Camanho et al. (2024) conveyed that allocative efficiency assessed the success of farmers in achieving maximum profits. It was achieved when the marginal product of each given production factor equals the marginal cost. It also indicated the ability to use inputs with optimal proportions. AE is $0 \leq AE \leq 1$. Allocative efficiency was estimated using the following equation:

$$AE = \frac{EE}{TE}$$

## RESULT AND DISCUSSION

### Socio-Demographic Characteristics of Respondents

The respondents' characteristics are shown in Table 1. divided based on socioeconomic characteristics: age, sex, education, farming experience, and land area. The majority of paddy farmers were at the age of 40 – 49 years. The paddy farmers were categorized as the productive age group. The majority of paddy farming in Deli Serdang was Male. Siriwardana & Jayawardena (2014) conveyed that male farmers were superior to female farmers in the performance of farming practices and productivity. Furthermore, most of the respondents had an education in high school. Furthermore, this finding showed that 42.5 percent of the paddy farmers had farming experience of approximately 11 – 20 years. Thus, the paddy farmers were experienced in paddy cultivation and farming. Kalimuthu & Applanaidu (2024) revealed that socio-demographic characteristics such as sex, education, land area, and farming experience influenced paddy productivity in the MADA regions of Malaysia.

The land tenure of farmers in Pasar Miring Village was mainly private ownership. Samarpitha et al. (2016) classified the paddy farmers into five categories based on the size of land area which is large (>10 ha), medium (4–9.99 ha), semi-medium (2 – 3.99 ha), small (1 – 1.99 ha) and marginal (<1 ha).

Table 1. Characteristics Of Respondents

| Characteristics | Frequency | Percentage (%) |
|---|---|---|
| Age (Years Old) | | |
| 30 – 39 | 10 | 25.0 |
| 40 – 49 | 19 | 47.5 |
| 50 – 59 | 9 | 22.5 |
| 60 – 69 | 2 | 5.0 |
| | | Sex |
| Male | 38 | 95.0 |
| Female | 2 | 5.0 |
| Education | | |
| Primary School | 10 | 25.0 |
| Secondary School | 4 | 10.0 |
| High School | 26 | 65.0 |
| Farming experience (Years) | | |
| 0-10 | 12 | 30.0 |
| 11-20 | 17 | 42.5 |
| 21-30 | 9 | 22.5 |
| 31-40 | 2 | 5.0 |
| Land Area (Ha) | | |
| < 0.5 | 21 | 52.5 |
| 0.5 – 1.0 | 17 | 42.5 |
| > 1.0 | 2 | 5.0 |

Source: Data Processed, 2024

According to the categories, the majority of respondents was the farmers who had marginal-sized land (< 1 ha). It caused the inefficiency of paddy farming. (Yan et al., 2019) found that farm size influenced the production and efficiency. An increase in farm size resulted in enhanced productivity and efficiency in agricultural production.

**Efficiency of Paddy Farming in Deli Serdang**

The average paddy productivity in general, where in 2008-2021 paddy productivity is at least 8 tons per hectare (The Ministry of Agriculture, 2017). According to the study's findings, Table 2. shows the average paddy production is 6.8 tons per hectare. The fact denoted that the gap between expected and potential paddy productivity is 1.2 tons. The difference between actual and expected productivity was caused by inefficiency (Mamo et al., 2018). The gap could be improved by improving efficiency and using technology (Obianefo et al., 2021).

Table 2. The Amount of Output and Use of Inputs

| Variable | Mean | Std. Deviation | Min. | Max. |
|---|---|---|---|---|
| Production (kg/ha) | 6,812.5 | 257.89 | 6.25 | 7.500 |
| Seed (kg/ha) | 42.0 | 10.00 | 25.00 | 75.00 |
| Urea (kg/ha) | 166.0 | 43.00 | 100.00 | 250.00 |
| SP-36 (kg/ha) | 116.0 | 81.00 | 0.00 | 250.00 |
| Za (kg/ha) | 82.0 | 78.00 | 0.00 | 250.00 |
| Phonska (kg/ha) | 135,08.0 | 75.44 | 0.00 | 250.00 |
| Dolomite (kg/ha) | 168.0 | 46.00 | 83.00 | 250.00 |
| Complementary fertilizers (kg/ha) | 2.0 | 1.00 | 1.00 | 5.00 |
| Labor (day/ha) | 56.8 | 16.30 | 42.50 | 110.00 |

Source: Data Processed, 2024

The inputs used in paddy farming in Pasar Miring Village, Pagar Merbau District, Deli Serdang Regency were seeds, fertilizers consisting of urea, SP-36, Za, Phonska, Dolomite, complementary fertilizer, and labor. Based on the Ministry of Agriculture (2017), the recommendation for using N, P, K fertilizers is 200 kg/ha, 75 kg/ha and 50 kg/ha respectively. The paddy farmers did not follow this recommendation. It was shown by the overuse of fertilizer by the paddy farmers rather than the government recommendation. The agricultural input overuse impacted inefficiency. Furthermore, the consequences of fertilizer overuse are economic profit loss, environmental degradation, and sustainability (Pandey & Diwan, 2021; Ren et al., 2021).

 

Tabel 3. Descriptive Statistics of Efficiency Score

| Efficiency | Mean | Std. Deviation | Min. | Max | Category |
|---|---|---|---|---|---|
| Technical Efficiency | 0.93 | 0.04 | 0.83 | 1.00 | Best |
| Allocative Efficiency | 0.71 | 0.13 | 0.43 | 1.00 | Poor |
| Economic Efficiency | 0.66 | 0.15 | 0.38 | 1.00 | Poor |

Source: Data Processed, 2024

Jalilov et al. (2019) classified 3 categories of farm performance based on the efficiency score. 1. Best performance (efficiency score ≥ 0.9); 2. Good performance (efficiency score of 0.80–0.89); 3. Poor performance (efficiency score ≤ 0.79). According to Table 3. paddy farming was technically efficient and performed the best in the technical aspects. It indicated that the paddy farmers could allocate and adequately combine the agricultural input to raise the maximum output (Pradhan, 2018). The paddy farming in Deli Serdang performed the best since the technical efficiency score was 0.93. Purba et al., (2020) conveyed that 73% of paddy farming in tidal lowlands of South Sumatra, Indonesia had the technical efficiency score of 0.90 to 10.00. It indicated that the paddy farmer had used the appropriate combination of agricultural input and has been well in technical aspects and management. This study is in line with Bhattacharyya & Mandal (2016), measuring the technical efficiency of paddy farming in Assam, India, which was 0.91. Consequently, it was technically efficient. Table 4. shows that more than 55% of paddy farming in Deli Serdang Regency, North Sumatra, Indonesia, was technically efficient. This finding was supported by (Haryanto et al., 2015), who concluded that 77% of the paddy farming areas were technically efficient in Indonesia. Furthermore, the technical efficiency score of paddy farming in Telanga, India, was 86%, indicating the technical efficiency achieved for paddy production. The achievement was supported by the appropriate agricultural inputs such as seed, fertilizer, water use, and organic manure (Kumar, 2022).

On the other hand, this study showed that paddy farming was allocatively inefficient or had poor performance. The score of allocative efficiency was only 0.71. It indicated that the paddy farmer needed help optimally allocating the agricultural input at the given price. The inefficiency of paddy farming was due to the rising price of chemicals such as insecticides, fungicides, and herbicides. Furthermore, the lateness of subsidized fertilizer distribution could have been more problematic. Consequently, the paddy farmer used the non-subsidy fertilizer more expensively. It caused a higher production cost of paddy farming, and cost minimization could not be achieved. Cost minimization is required to achieve allocative or price efficiency (Holmes et al., 2014). According to Kabeakan et al. (2021), fertilizer significantly influences agricultural production. Hence, the fertilizer should be always available and affordable for the paddy farmers. This study's allocative efficiency score was similar to that of paddy farming in Gulu dan Amuru, Uganda, which was 0.75 (Okello et al., 2019). A study conducted by Zhang et al. (2019) found that the higher production cost impeded the allocative efficiency of paddy farming in China. Hidayah et al. (2013) investigated the high production cost caused by the high agricultural input prices, which resulted in allocative inefficiency. Therefore, the previous studies supported and justified the research findings. The allocative efficiency could be achieved once the agricultural input price minimizes paddy farming costs.

Economic efficiency can be achieved through the simultaneous attainment of technical and allocative efficiency (Gunes & Guldal, 2019). This research exhibited that paddy farming was economically inefficient. This finding was supported by Utaranakorn & Yasunobu (2016), who noted that the economic efficiency score of family food farming in Northeastern Thailand was 0.60.

Table 4. Distribution of Efficiency Score

| Score | Technical Efficiency | | Allocative Efficiency | | Economic Efficiency | |
|---|---|---|---|---|---|---|
| | Freq. | % | Freq. | % | Freq. | % |
| < 0.4 | 0 | 0.00 | 0 | 0.00 | 1 | 2.50 |
| 0.41 – 0.50 | 0 | 0.00 | 5 | 12.50 | 6 | 15.00 |
| 0.51 – 0.60 | 0 | 0.00 | 5 | 12.50 | 4 | 10.00 |
| 0.61 – 0.70 | 0 | 0.00 | 6 | 15.00 | 10 | 25.00 |
| 0.71 – 0.80 | 0 | 0.00 | 15 | 37.50 | 11 | 27.50 |
| 0.81 – 0.90 | 18 | 45.00 | 8 | 20.00 | 7 | 17.50 |
| 0.91 – 1.00 | 22 | 55.00 | 1 | 2.50 | 1 | 2.50 |

Source: Data Processed, 2024

A recent study by Nwahia et al. (2020) showed that the allocative efficiency and economic efficiency scores of paddy farming were 0.63 and 0.54, respectively. Furthermore, Ahmad et al. (2017) found the same finding in this study: paddy farming in Bihar, India, was technically efficient yet allocative and economically inefficient. Moreover, paddy farming in Arkansas, USA, showed the same findings: technical efficiency was achieved, but allocative efficiency and economic efficiency were inefficient (Watkins et al., 2014). Paddy farming in Myanmar also exhibited an excellent technical efficiency score. However, it could have been more allocative and economically efficient (Linn & Maenhout, 2019).

 

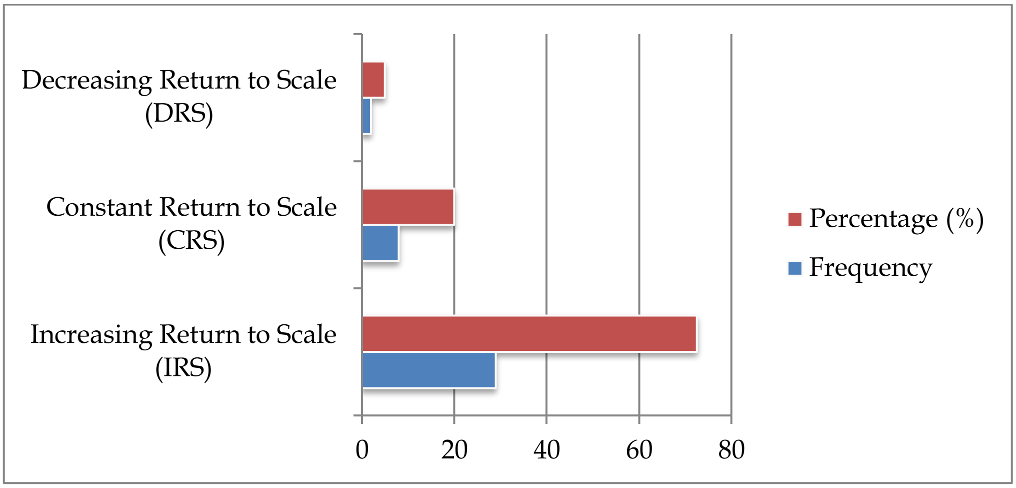


Figure 2.
Condition of Economic Scale

Figure 2. illustrates that most paddy farming in Deli Serdang was on the economic scale of increasing returns to scale (IRS). In this condition, the paddy farmers should add and improve agricultural inputs to achieve maximum output or efficiency. Meanwhile, the paddy farmers who were in decreasing return to scale (DRS) must reduce agricultural input use. Then, the paddy farmers use the appropriate and proper agricultural input combination in constant return to scale (CRS). This finding was supported by Khan et al. (2016), who showed that most paddy farming was a condition of increasing return to scale in Malaysia.

Then, 91.9% of the paddy farming in Southwestern Niger were in the condition of increasing return to scale (Boubacar et al., 2016). The efficiency is related to combined input use. Therefore, the paddy farmers were encouraged to use the cheaper agricultural input coming from the good agricultural input to minimize cost and achieve allocative efficiency. Mariyono (2018) claimed that using good agricultural input would achieve higher allocative efficiency scores. The paddy farmers could recycle agricultural waste such as husk and straw to make eco-friendly agricultural inputs. Good agricultural input comes from eco-friendly inputs such as green manure, compost, natural pesticides, and others supporting sustainable agriculture (Santhoshkumar, 2017; Tho & Umetsu, 2022).

## CONCLUSION AND SUGGESTION

### Conclusion

The scores of technical efficiency, allocative efficiency, and economic efficiency were 0.935, 0.711, and 0.668, respectively. The paddy farming in Deli Serdang, Indonesia, was technically efficient. It indicated that the paddy farmers have correctly used the agricultural input. However, it was allocative and economically inefficient. The high agricultural input prices and the unavailable agricultural input subsidies caused it. The subsidy and price regulation by the government are related to cost minimization, impacting the allocative and economic efficiency.

**Suggestion**

We suggest that paddy farmers improve their agricultural input and use eco-friendly agricultural input towards sustainable agriculture to achieve efficiency. The paddy farmers were advised to manage and recycle agricultural waste such as husk and straw as the local resource for the organic fertilizer to minimize the cost of the external or chemical input used to achieve allocative and economic efficiency and sustainability. Furthermore, the role of government should be more active in monitoring, controlling, and evaluating the mechanism of subsidy programs to avoid the lateness of fertilizer subsidies distribution, provide micro-financial credit to solve the limitation of capital by the paddy farmers, consider the performance of the agricultural extension workers to transfer knowledge for the paddy farmers.

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