Research article

Technical Efficiency of Rice Yield: Insights from IADA North-West Selangor, Malaysia

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Abstract Despite Malaysia's concerted efforts to increase rice production, the self-sufficiency ratio significantly declined from 70.0% in 2018 to 62.6% in 2022. The country's rice production primarily relies on ten granary areas in Peninsular Malaysia, with the Integrated Agricultural Development Area *(*IADA) North-West Selangor known for its high productivity. In the 2015 - 2016 main season, the region achieved a rice production rate of 6.0 tons per hectare, higher than the national average of 4.6 tons per hectare and 5.0 tons per hectare for other granary areas. However, by the 2020 - 2021 main season, productivity in IADA North-West Selangor had fallen to 4.8 tons per hectare, mirroring a worrying trend observed across other granary areas. Concurrently, the average national yield fell to 3.8 tons per hectare, while the average in granary areas dropped to 4.4 tons per hectare, indicating an overall downward trend. This study aims to identify factors influencing rice productivity in IADA North-West Selangor, a region struggling to maintain its historically high productivity levels. We conducted interviews with 74 Malay and Chinese farmers using a structured questionnaire to assess technical efficiency, which is a key determinant of yield. Stochastic frontier analysis (SFA) revealed significant variations in technical efficiency among farmers, suggesting potential for improvement across the region. Although farmers in IADA North-West Selangor currently exhibit lower yields and technical efficiency compared to their historically high values, there are promising signs of improved productivity with the right interventions which are applicable in other rice granaries.

Keywords paddy farmer, yield, technical efficiency, trust, agricultural information

INTRODUCTION

Given the critical role of rice in Malaysian diets, achieving self-sufficiency in rice production is a top priority for the agricultural sector. Malaysia is not self-sufficient and importing rice to meet their need is well established. In 2023 however, the country grappled with economic strain due to the soaring prices of imported white rice, resulting in widespread confusion among consumers over costs and retailer stock levels (Goh, 2023; The Asahi Shinbun, 2023). This situation intensified public anxiety about food security, prompting the government to encourage the purchase of locally grown rice, which led to a surge in consumer stockpiling. With the price control for local white rice at 2.6 ringgit per kg (Khoo, 2023), it suggests a potential revitalization of domestic rice production and a renewed appreciation for its significance.

According to the national report by the Ministry of Agriculture and Agro-Based Industry (2008), the self-sufficiency level recorded relative stability at 70.0 percent and even grew to 72.2 percent

from 2004 to 2007. However, by 2022, the level plummeted to an unprecedented low of 62.6 percent. In response, the Malaysian government set an ambitious target to achieve 75 percent self-sufficiency by 2025. In this context, optimizing rice farming areas and technology are critical for economic and national security. A secure domestic rice supply insulates the nation against potential disruptions in the global food chain and ensures that Malaysians have access to this critical dietary staple.

The main granary areas in Malaysia are responsible for producing and meeting the country's rice demand. Ten of these areas are located along the peninsula's coastlines. In 2022 - 2023, these regions produced a modest yield of 4.0 tons per hectare. This underwhelming national production reflects a concerning trend as the shrinking number of paddy farmers and contracting cultivated areas contribute to lower yields, further impacting overall rice production. IADA North-West Selangor historically outperforms other granary areas, though its output decreased from 6.3 tons per hectare in 2015 to 4.4 tons per hectare in 2023. This area traditionally excels, and the farmers were able to sell their harvested rice as seeds for the following year rather than only for consumption purposes. As a comparison, the national average yield was 4.0 tons per hectare in 2015, which further declined to about 3.7 tons per hectare in 2020 (Table 1). Therefore, investigating yield patterns and determining key factors to boost production are critical for the future of Malaysian rice farming (IADA North-West Selangor, unpublished).

Table 1 Rice production indicators in Peninsular Malaysia's granaries

	2015	2016	2017	2018	2019	2020
Number of paddy farmers (people)	197,189	194,931	193,679	193,378	192,663	189,500
Paddy planted area (hectare)	681,559	688,770	685,548	699,980	672,084	644,908
Rice production (’000 tons)	1,767	1,766	1,656	1,700	1,516	1,624
Average yield (kg)	4,022	3,978	3,750	3,770	3,501	3,654

Source: Ministry of Agriculture and Food Industries, 2020

OBJECTIVE

This study seeks to identify key input factors that can enhance yield in Malaysia's main granary areas by examining what influences farmers' technical efficiency (TE). By measuring the TE levels in IADA North-West Selangor, Malaysia, using Stochastic Frontier Analysis (SFA), the research reveals the distribution of TE among paddy farmers. The analysis will also provide insights into crucial determinants of yield and the distribution patterns of TE among paddy farmers in IADA North-West Selangor.

METHODOLOGY

Respondents of the Study

Table 2 presents the profile of the 74 paddy farmers surveyed from Sungai Burung and Sekinchan, comprising 44 Malay and 30 Chinese farmers (Fig. 1). Most of these farmers are male owner-tenant cultivators specializing in producing rice seeds through a transplanting method. The average age of the farmers is 51.8 years old, which is younger than the national average of 55 years old (Engku Ariff et al., 2023). These farmers operate on an average farm size of 3.65 hectares and achieve yields exceeding the average of IADA North-West Selangor.

Study Area

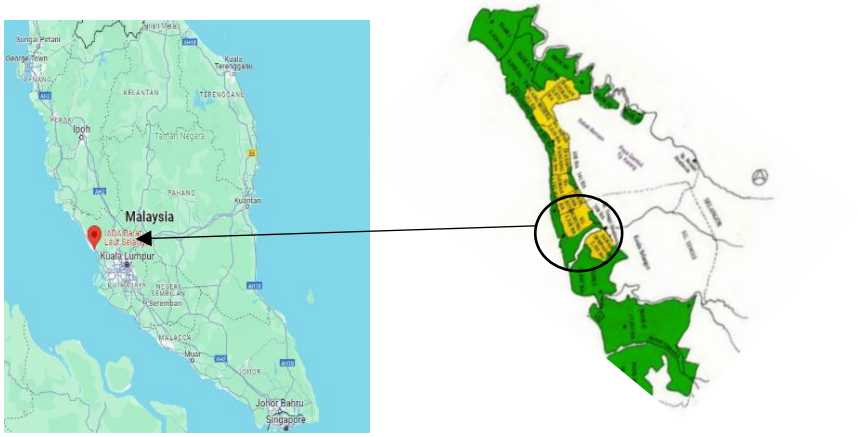
We conducted the study in the IADA North-West Selangor, Malaysia, a prominent granary area known for its high productivity and advanced rice farming technology. Since its establishment in 1978, the area spanning 20,000 hectares has benefited from river improvement works and irrigation facilities that enable large-scale rice farming. IADA North-West Selangor supports 10,200 farmers across eight blocks who utilize advanced transplanting farming practices that transform the area into

a leading producer of rice, not just for consumption but also for seed production. The widespread adoption of these technologies and a solid knowledge base among the farmers make IADA an ideal location for this study. The survey focused on two key areas, namely Sungai Burung and Sekinchan.

Table 2 Profile of the respondents (*n*=74)

Items	Number of farmers and size	
Gender (people)	Male (70)	Female (4)
Ethnicity (people)	Malay (44)	Chinese (30)
Average age (years old)	51.8	
Family size (Number of people)	3.9	
Average farming experience (years)	21.4	
Yield (tons per hectare)	6.6	
Average farm size (hectares)	3.6	

Source: Own survey



Source: IADA North-West Selangor (unpublished)

Fig. 1 Map of IADA north-west Selangor

Data Collection

We conducted a field study in September 2023 with 74 farmers in Kampung Burung and Sekinchan (Fig.1), the two villages in IADA North-West Selangor, Malaysia. The farmers were selected randomly by their heads of villages. These areas operate under the extension system of IADA, where extension and administrative officers actively monitor, support, and guide farmers toward improved farming practices. There is also an experiment field used to conduct trials and errors to help farmers overcome potential issues with rice farming techniques. The survey specifically focused on the amount of rice production input and output. A structured questionnaire was designed that included questions on demographic profiles, farming inputs and outputs, and farming methods. To ensure accuracy and reliability, we chose face-to-face interviews to allow clarification and minimize the risk of misinterpretations that can arise from written responses on a questionnaire.

Analysis of the Study

Technical efficiency is commonly used to find potential to improve yield among crops (Elias et al., 2023). We utilized the Stochastic Frontier Analysis 4.1 (University of Queensland, 2018) to calculate the technical efficiency of rice yield. The software program was developed by Professor Tim Coeli at the University of Queensland (Coelli et al., 2005). The inputs used in this analysis include seed (kilograms per hectare), fertilizer (kilograms per hectare) from the first to the fourth application, and labor (persons per season). The Maximum Likelihood technique was used to analyze the explanatory variables among the inputs for rice production.

RESULTS AND DISCUSSION

The study collected data from 74 Malay and Chinese farmers. Rice yield from the two villages (i.e., Kampung Burung and Sekinchan) averaged 6.67 kg per hectare, with a distribution ranging from 1.6 to 8.23 tons per hectare. This variability in yield is influenced by several factors, with the amount of fertilizer application emerging as a significant factor contributing to the differences in yield and technical efficiency (TE). While the mean rice production is 5.75 tons per hectare, the typical yield tends to be closer to the average of 6.67 tons per hectare. This indicates that the overall yield is generally higher than the mean production figure. The farmers in the area are involved in seed production. In terms of inputs, the farmers used an average of 93.3 kg of seed per hectare for transplanting (Table 3). Fertilizer applications typically occur four times per season, with some instances of only three applications. Fertilizers are primarily subsidized by the government, with the supply of Sebatian (nitrogen, phosphorus, potassium (NPK) mixed at 240 kg per hectare), urea (80 kg per hectare) and NPK (150 kg per hectare). Labor input comprised 3.3 workers per season.

Table 3 Input details for paddy farming in Kampung Besar and Sekinchan

Input	Quantity
Seed (kg/hectare)	93.3
Fertilizer application	
First application after transplanting	134.1
Second application	204.6
Third application	186.6
Fourth application	107.7
Labor (workers per season)	3.3

Source: Own survey

The Stochastic Frontier Analysis was applied to analyze yield data from 74 farmers. The Maximum Likelihood Estimate (MLE) results, as shown in Table 4, revealed varying impacts on the frequency of fertilizer applications for the farming season from 2021 to 2022. The application frequency varies depending on individual management decisions. The SFA indicated that the first, third, and fourth applications significantly influenced yield, whereas seed and labor input did not significantly affect the model. Although all farmers applied fertilizer the first three times, only 50 out of 74 applied it a fourth time. This suggests that the frequency and the amount of fertilizer applications could be critical factors influencing yield. Moreover, the results indicate that seed and labor, previously considered crucial for yield, may be less important. Instead, the model highlights the potential importance of optimizing fertilizer applications, particularly during the first four applications.

Table 4 Maximum Likelihood Estimates (MLE) of Technical Efficiency (TE)

Input	Coefficient	SE	t-ratio	Sig.
Seed	-0.0893	0.1280	-0.6974	
Fertilizer				
First application after transplanting	0.2561	0.1032	2.4821	**
Second application	0.1910	0.1341	1.4257	
Third application	0.3924	0.1618	2.4246	**
Fourth application	0.0427	0.0177	2.4122	**
Labor	0.1381	0.0917	1.5062	

*Source: Own survey, Note: ** indicates 5% significance*

The SFA calculated the technical efficiency (TE) for rice production in the study area. TE scores range from 0 to 100, with higher scores indicating more efficient use of inputs like seed, fertilizer, and labor. Table 5 shows that the TE scores in the study area varied considerably, ranging from 30.65 to 87.56.

Over half the farmers (47) achieved TE scores in the 70-100 range, suggesting relatively efficient practices, while 27 achieved scores in 0-69. The analysis suggests potential improvements, particularly in fertilizer application. Farmers might benefit from reevaluating fertilizer application practices, particularly the amount used in the first and third applications. Based on these findings, investigating the impact of introducing a fourth fertilizer application on rice productivity could provide valuable insights into enhancing overall efficiency.

Table 5 Distribution of technical efficiency, TE (*n*=74)

TE distribution	Average TE in the category	No. of farmers
80-100	85.1	23
70-79	75.0	24
60-69	65.1	18
00-59	48.1	9
Overall average	72.6	74

Source: Own survey 2023

CONCLUSION

IADA North-West Selangor is one of Malaysia's most productive rice farming areas. This study surveyed local farmers to assess their technical efficiency (TE) levels and analyze the distribution of these levels. Although many farmers achieve high yields, there remains significant room for improvement among those with lower yields. A key finding of this study is the critical role of fertilizer in achieving higher yields. Specifically, the frequency and timing of fertilizer applications significantly impact TE, with the first, third, and fourth applications being influential. Although some farmers apply fertilizer only three times per season, the addition of a fourth application can further enhance both TE and yield. This implies that farmers with lower TE can improve significantly by optimizing their fertilizer practices, particularly by adjusting the frequency and quantity of application throughout the season. To further this understanding, future research should investigate the factors influencing farmers' fertilizer practices to develop strategies that promote higher technical efficiency.

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