

## Are Rice Farming and Production in the Urban Farming Areas Still Efficient? A Stochastic Production Function Choice

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*Received: July 2021 | Revised: December 2021 | Accepted: December 2021*

### Abstract

Lowland rice farming can still be found amidst the limited empty land in DKI Jakarta, especially the North Jakarta area. The alternative of increasing production that can be done in urban farming in limited land is increasing land efficiency. The novelty of this research is the analysis of the efficiency of farming carried out in the North Jakarta area because no one has discussed the research on efficiency in rice farming in North Jakarta. Thus, this research needs to determine the efficiency achieved by rice farmers and the factors that affect rice production in the North Jakarta area. The population in this study were all rice farmers producing in the North Jakarta area. This study's sample was determined using the simple random sampling method with a total sample size of 80 respondents. The analytical method used in this research is the Stochastic Frontier Analysis (SFA) method. Based on the analysis, the average value of technical efficiency is 0.85, the value of allocative efficiency is 3.47, and the amount of economic efficiency is 2.95. The variables used indicate that the variables of land area and fertilizer have a significant and positive effect. The variables of labor and education have a significant negative effect on rice production in North Jakarta; meanwhile, the variable of ownership right does not significantly affect rice production in North Jakarta.

**Keywords:** efficiency, urban farming, frontier, rice

**JEL classification:** D240, Q1, Q120

**How to Cite:** Erissanti, T., Supadi, S., Suharno, S. (2021). Are Rice Farming and Production in the Urban Farming Areas Still Efficient? A Stochastic Production Function Choice, 22(2), 242-250. doi:<https://doi.org/10.23917/jep.v22i2.12532>

**DOI:** <https://doi.org/10.23917/jep.v22i2.12532>

### 1. Introduction

Agriculture was the primary source of economic movement in Indonesia. Over time, agriculture was increasingly displaced by the industrial sector. Indonesia, a country with a large population based on the 2010 population census, has a population growth rate of Indonesia 1.36 percent, according to the Indonesian Statistical Center Agency Badan Pusat Statistik, (2017b). This figure illustrates the population growth that

continues to increase and then causes food and land requirements for housing to increase.

The increasing need for food is not supported by the availability of agricultural land for food production. The General Director of Agricultural Infrastructure and Facilities of the Ministry of Agriculture, Sarwo Edhy, said that the area of agricultural land in Indonesia has decreased to 7.1 million hectares (ha) from 7.75 million hectares in 2013 due to the increasing area of

land conversion for food, especially rice fields to non-rice fields, which from year to year increases in line with industrial and housing growth as a result of population growth. The reflected in each province's density level in Indonesia and DKI Jakarta is the most densely populated area in Indonesia, with a population density of 15,328 people / km<sup>2</sup> (Badan Pusat Statistik, 2017a).

DKI Jakarta is the most densely populated area in Indonesia and it seems unlikely that there will be any agriculture that will survive in Jakarta. However, the reality is that currently, in the city of Jakarta, this can still find agricultural land that is still actively used for farming, as shown in the following table:

The average area of land controlled per agricultural business household is not as large as agricultural land in rural areas. Table 1 shows that, on average, one agricultural business household in DKI Jakarta controls an area of only 66.06 m<sup>2</sup> irrigated rice fields. The irrigated rice fields were spread across three cities, East Jakarta with an average area of 24.51 m<sup>2</sup> per Agricultural Business Household, West Jakarta with 24.62 m<sup>2</sup> per Agricultural Business Household, and North Jakarta covering an area of 274.9 m<sup>2</sup> per Agricultural Business Household. In South Jakarta and the Thousand Islands, there are no rice fields found.

**Table 1. Average Area of Land Controlled by Agricultural Business Households by Regency / City and Type of Land (m<sup>2</sup>) in DKI Jakarta, 2018**

District / City Administration	Agricultural Land			Non-Agricultural Land	Average
	Rice Fields		Non-Rice Fields		
	Irrigation	Non-Irrigation			
Thousand islands	-	-	12.04	102.49	114.54
South Jakarta	-	-	722.33	106.28	828.6
East Jakarta	24.51	0.9	368.25	196.95	590.61
West Jakarta	24.62	-	317	96.83	438.45
North Jakarta	274.9	931.62	578.98	132	1917.5
DKI Jakarta	66.06	166.51	386.89	135.51	754.95

Source: Badan Pusat Statistik, 2019

**Table 2. Number of Agricultural Business Households by Regency / City and Type of Main Business Operated in DKI Jakarta, 2018**

District / City Administration	Number of Agricultural Business Households	Crops		Horticulture
		Rice	Secondary Food	
Thousand islands	964	-	-	42
South Jakarta	988	-	37	566
East Jakarta	4,733	46	3	1,583
West Jakarta	5,706	52	52	3,498
North Jakarta	2,691	370	-	75
DKI Jakarta	15,082	468	92	5,764

Source: Badan Pusat Statistik, 2019

Production of food needs, especially rice, plays a vital role because it is the most important source of food in the world where it was consumed by more than 2.6 billion people in the world, and Asia is the immense contribution, namely 92% (Ouedraogo, 2015). Indonesia is also a country that requires much rice as the primary source of daily food. In contrast to horticultural agricultural business households, the number of agricultural business households in food crops, especially rice in DKI Jakarta, is only 468 agricultural business households with the largest number of agricultural business households in North Jakarta, which reaches 370 agricultural business households. In West Jakarta and East Jakarta, there are only 46 and 52 agricultural business households. The availability of land does not match the increasing number of agricultural business households in these areas.

This agricultural phenomenon is known as urban farming. Urban farming is used to describe agricultural product production activities in an urban environment (Adeyemo & Kuhlmann, 2009). In contrast to agriculture in rural areas where individuals mostly own land, based on pre-interviews conducted with the Food Security, Marine and Agricultural Service and the North Jakarta Agricultural Extension Agency, urban farming, especially paddy rice farming in Jakarta, is motivated more by the use of land owned by developers that is still unemployed. In addition to utilizing idle developer land, according to Damanik (2014), agriculture can also absorb much labor, reducing the unemployment rate because to become labor in the agricultural sector, special skills are not required, such as in the industrial sector. It becomes a problem for how these farmers produce in the city area, how farmers with limited land and environmental support can achieve economic efficiency. Therefore, this research was conducted as a follow-up to analyze rice farmers' efficiency in producing in urban areas.

Research on the efficiency of urban farming has been carried out in several countries, such as K. Mwajombe & R. S. Mlozi (2015) in Tanzania and Abdulai et al. (2018) in Kumasi, Ghana. Research on agricultural efficiency using SFA in Indonesia has been widely conducted, such

as Suharyanto et al. (2015), Indah et al. (2015), Suharno et al. (2017), and Kusnadi et al. (2016). Nevertheless, research on urban farming in Indonesia itself has not discussed its efficiency. Urban farming addressed in Indonesia's study is about its implementation, sustainability, income, or contribution to poverty. Therefore, the novelty plan in this efficiency analysis is at the location of the efficiency analysis in the North Jakarta City area, the land ownership status variable used and the stochastic frontier analysis method. Based on the data that has been explained, Jakarta is an area with the highest rice agricultural business household compared to other areas in Jakarta. Location focused on Marunda and Rorotan sub-districts, Cilincing sub-district as an area that the remaining rice-producing rice in North Jakarta. The ownership status variable of the land used is not only owned or leased but also the use of land owned by the developer. This research will use SFA to analyze efficiency because the SFA method has several advantages over other efficiency measurement methods. SFA can calculate random errors and simultaneously calculate the parameters that work directly in the production process, together with parameters that indicate farm managerial capabilities. The SFA method is also possible to measure inefficiencies without ignoring random errors.

## 2. Research Method

This research was conducted in North Jakarta, especially Marunda and Rorotan Village, Cilincing District, as Jakarta's highest rice agricultural business household. The number of samples used was 80 respondents from a total population of 370 people. The sampling method used was a simple random sampling technique.

This study uses land area, labor, fertilizer, education, and land ownership status as independent variables and production as the dependent variable. Production (Y) is measured by the amount of rice produced in kilograms (kg). Land area ( $X_1$ ) is expressed in units of land area in hectares (ha). The labor variable ( $X_2$ ) is the person used during the production process, expressed in working person-days (HoK). Fertilizer ( $X_3$ ) used during production is expressed in units of

kilograms (kg). The education variable ( $X_4$ ) is how long the formal education is taken in units of years. The variable of land ownership status ( $X_5$ ) is the ownership status of the land used for agricultural activities, either ownership or lease, which is stated by dummy variables and property rights are the basic categories. D1: 1 = status of lease rights and 0 = status of ownership rights.

Efficiency in this study will be measured by the Stochastic Frontier Analysis (SFA) approach using the frontier function, which can be illustrated by  $n$  inputs used directly ( $X_1, X_2, \dots, X_n$ ) to produce  $Y$  output. Efficiency transformation input to output is categorized by the production function  $F(X)$ , which shows the maximum output obtained from the input combination used. The stochastic frontier production function also measures factors that affect production's technical inefficiency, usually production factors that affect inefficiency, namely indirect production factors such as education, land ownership status, and other factors that affect farmer management abilities.

Aigner, Lovell, and Schmidt (1977) and Meeusen and Van de Broeck (1977) in Coelli et al. (2013) the Cobb-Douglas production limit function was developed into a Stochastic Frontier production function model by adding random error ( $V_i$ ) and non-negative random error ( $U_i$ ) which then can be written the mathematical model as follows:

$$Y_i = f(X_i, \beta) \exp(V_i - U_i) \quad i = 1, 2, \dots, n \quad (1)$$

Where:  $Y_i$  = output produced,  $X_i$  = input variable,  $\beta$  = production coefficient,  $V_i$  = random error,  $U_i$  = level of inefficiency. Then the function can be converted into multiple linear forms to make it easier to estimate the data:

$$\ln Y = \ln \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 DX_5 + v_i - u_i \quad (2)$$

Where:  $\ln Y$  = Farmer production per harvest,  $\ln \beta_0$  = constant,  $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5$  = elasticity coefficient,  $\ln X_1$  = Land,  $\ln X_2$  = Labor,  $\ln X_3$  = Fertilizer,  $\ln X_4$  = Education,  $DX_5$  1 = status

of lease rights,  $DX_5$  0 = proprietary status,  $v_i$  = random error,  $u_i$  = level of inefficiency. Testing to determine the effect of each independent variable on the dependent variable by comparing the value of t-ratio with t-table with the following decision rules:  $H_0: \theta = \theta_0$  and  $H_a: \theta \neq \theta_0$ .

This efficiency analysis will use the Frontier 4.1 program. According to research by Suharyanto et al. (2015), the result of efficiency value is between 0 to 1, where if the result of efficiency value is more than 0.7 or close to 1, it can be said that the farming is efficient and otherwise if the efficiency value is less than 0.7 and getting closer to 0, the farming being carried out can be said to be inefficient. In estimating the efficiency value, gamma and sigma-squared values are also obtained, illustrating inefficiency with the hypothesis, which states that rice farming in North Jakarta has not been efficient, where:  $H_0: \gamma = 0$  and  $H_a: \gamma > 0$ .

If the gamma value is known to be greater than zero, it indicates an effect of technical inefficiency on the production function model used. Furthermore, if the gamma value is known to be equal to zero, it indicates that there is no technical inefficiency on the production function model used.

According to Kusnadi et al. (2016), if the actual output produced by farming is under the deterministic frontier production, but the stochastic frontier output is more than the deterministic frontier production; this is due to favorable conditions that affect farmer production activities where the  $V_i$  value is positive. Meanwhile, if the actual output produced by farms is under the deterministic frontier production and the stochastic frontier output is also under the deterministic frontier production, this is due to unfavorable conditions for farmer production activities where  $V_i$  is negative.

Allocative efficiency can be achieved if the marginal product value of an input is the same as the input price (Soekartawi, 2013). So, the mathematically as follows:

$$NPM_x = P_x \text{ or } NPM_x / P_x = 1$$

Where:  $NPM_x$  = Marginal product value and  $P_x$  = Input price.

Economic efficiency is a combination of technical efficiency (TE) and allocative efficiency (AE). So, economic efficiency (EE) can be formulated as a mathematical model as follows:  $EE = TE \times A$ .

### 3. Results and Discussion

The frontier production function is used in this study, with one dependent variable and five independent variables. The dependent variable is rice production (Y), and the independent variable is the land area ( $X_1$ ), labor ( $X_2$ ), fertilizer ( $X_3$ ), education ( $X_4$ ), and land ownership ( $X_5$ ). The frontier production function is estimated using the help of the Frontier 4.1 program with the MLE method; the estimation results can be seen in the following table:

**Table 3. Frontier Production Function Estimation Results with the MLE Method**

Variable	Coefficient	Standard Error	t-ratio
Intercept	8.8388	0.6397	13.8151
Ln Land Area ( $X_1$ )	0.8650*	0.0948	9.1212*
Ln Labor ( $X_2$ )	-0.3220*	0.1403	-2.2939*
Ln Fertilizer ( $X_3$ )	0.1639*	0.0743	2.2063*
Ln Education ( $X_4$ )	-0.2091*	0.1008	-2.0741*
Dummy Land Ownership ( $X_5$ )	-0.0848	0.1511	-0.5614
Sigma-squared	0.0668	0.0218	3.0540
Gamma	0.6063	0.2524	2.4015
Log-likelihood function		14.5960	
LR test of the one-sided error		0.8062	

Information: \* = significant at  $\alpha$  5% with t-table = 1.9925

Source: Processed Data, 2020

Based on table 3, the mathematical equation can be written as follows:

$$\ln Y = 8.8388 + 0.8650 \ln X_1 - 0.3220 \ln X_2 + 0.1639 \ln X_3 - 0.2091 \ln X_4 - 0.0848 DX_5 + v_i - u_i \quad (3)$$

Each coefficient of the mathematical equation is a description of each independent variable that explains production. The coefficient of the land area variable ( $X_1$ ) is 0.8650, and the t-ratio is 9.11212, which is greater than the t-table value of 1.9925. It indicates that the land area has a positive and significant effect on rice production. The coefficient shows that land area changes have the greatest influence on rice production than other variables. Farmers' land area is still relatively narrow, and farmers who have a little more land area can produce more rice. This result was in line with Ouedraogo's (2015) research, which states that the land area has a positive and significant effect on rice production, as well as in line with Umoh (2006) that land area has a positive and significant effect on vegetable production in urban farming in Uyo, Nigeria. Lastly, this result is also in line with the research of Suharno et al. (2017) that land area has a positive and significant effect on milkfish production.

The labor variable ( $X_2$ ) in the mathematical equation obtained shows a negative and significant effect with a coefficient value of -0.3220 and the t-ratio of -2.2939, which is greater than the t-table value of 1.9925. The regression coefficient value shows that if the number of workers used increases by 1%, the resulting rice production would decrease by 0.3220%. This condition is because the labor wages that must be paid are relatively expensive, so that farmers often add additional labor to specific processes only during production. If they have to increase their workforce, farmers must increase their wage costs and reduce rice production. This result is similar to Ajibefun et al. (2006) finding, which hired labor has a significant negative effect on rural farms and urban farms.

The fertilizer variable ( $X_3$ ), the coefficient obtained, is 0.1639 with a t-ratio of 2.2063, which is greater than the t-table value of 1.9925. It shows that fertilizer has a positive and significant effect on rice production. The coefficient value means that if the amount of fertilizer used increases by

1%, rice production would increase by 0.1639%. Non-optimal fertilizer causes the amount of fertilizer used need to be increased. Farmers use a certain amount of fertilizer only based on the cost's ability, not on the requirements that must be filled. It is similar to Umoh (2006) that fertilizer has a positive and significant effect on vegetable production in urban farming in Uyo, Nigeria, and is also in line with Ouedraogo (2015).

The education variable ( $X_4$ ) is -0.2091 with a t-ratio of -2.0741, greater than the t-table value of 1.9925. The coefficient value shows that if the education taken by farmers increases by 1%, it will reduce rice production by 0.2091%. This result indicates that education has a negative and significant effect on rice production. This happened because of the conditions in the field where most of the farmers had an elementary school education background. People with high school and tertiary education backgrounds prefer to work in other industries, such as factory workers or office employees. This causes farmers in North Jakarta to have a low education level. This result, similar to Fakkhong et al. (2018) and Wardani & Waridin (2017). But, the result of this study was not in line with Ouedraogo (2015).

The dummy variable of land ownership status ( $X_5$ ), a coefficient of -0.0848, is obtained with a t-ratio of -0.5614, which is smaller than the t-table value 1.9925. It shows that land ownership has no significant effect on rice production. Farmers with land with lease rights do not significantly differ in production yields from farmers whose land is owned by ownership. This is because most farmers in North Jakarta are farming by renting land from developers that are still unused. This result, similar to Fakkhong et al. (2018). But, this result is not in line with Rondhi & Hariyanto Adi, (2018) and Koirala et al. (2016).

### 3.1 Technical Efficiency

Technical efficiency aims to determine the ability of farmers to produce within certain input combinations. The technical efficiency of rice farmers in North Jakarta is known by processing data using the Frontier 4.1 program. The level of technical efficiency achieved by rice farmers in North Jakarta can be seen in the following table:

**Table 4. Distribution of Rice Farming Technical Efficiency in North Jakarta**

Category	Total	Percentage
< 0.7	3	3.75
$\geq 0.7 < 0.8$	8	10.00
$\geq 0.8 < 0.9$	55	68.75
$\geq 0.9$	14	17.50
Total	80	100
Efficiency Average		0.85
Minimum Efficiency		0.64
Maximum Efficiency		0.95

Description: Coef. gamma = 0.6063

Coef. sigma-squared = 0.0668

Source: Processed Data, 2020

Based on table 4, it is known that technically, rice farmers in North Jakarta can be said to be efficient, which is similar to Ouedraogo (2015), K. Mwajombe & R. S. Mlozi, (2015), and Poernomo et al. (2019) because the average level of technical efficiency achieved by farmers is  $0.85 > 0.7$ . In estimating the efficiency value, gamma and sigma-squared values are also obtained, which illustrate inefficiency. The sigma-squared value is known to be 0.06, which is greater than zero, indicating an effect of technical inefficiency on the production function model used. The estimation results also obtained a gamma value of 0.60, which means that the error or error caused by the inefficiency component is 60%. Meanwhile, the remaining 40% is caused by variables outside the model, such as climate, pests, and diseases. ariables outside the model, such as climate, pests, and diseases.

### 3.2 Allocative Efficiency

Allocative efficiency or price efficiency can be obtained by calculating the ratio of each input's marginal production value (NPM) to the price of each input. In this time, the allocative efficiency analysis only uses independent variables that positively and significantly affect. Based on the results of the study of the frontier production function with the MLE method, it was found that two variables had a positive and significant effect, land area and fertilizer variable. The results of calculating allocative efficiency can be seen in the Table 5.

Table 5. Analysis of Rice Farming Allocative Efficiency in North Jakarta

Category	Land Area (X1)	Fertilizer (X3)	Y	Py
Input Average	1.13 ha	393.31 kg	5466.25 kg	4,000
Coefficient Input ( $\beta_i$ )	0.8650	0.1639		
Input Price (Pxi)	3,000,000	6,700		
Pmxi	4184.34	2.28		
NPMxi	16,737,367	9.111.58		
NPMxi/ Pxi	5.58	1.36		

Source: Processed Data, 2020

Allocative efficiency can be achieved if the value is equal to one. Based on the results of the allocative efficiency analysis in table 5, the value of allocative efficiency for each input is obtained where the land area and fertilizer variable have a value of more than one. This means that the land area and fertilizer variable have not reached allocative efficiency; this result is in line with Adeyemo & Kuhlmann, (2009) and Abdulai et al. (2018), so that additional inputs are still needed to optimize production.

### 3.3 Economic Efficiency

Economic efficiency can be achieved if technical efficiency and allocative efficiency are achieved. The value of economic efficiency can be obtained by multiplying the value of technical efficiency by allocative efficiency. The following is the calculation of economic efficiency:

Economic efficiency = Technical Efficiency  $\times$  Allocative Efficiency.

$$= 0.85 \times 3.47$$

$$= 2.95$$

The efficiency value obtained is 2.95, where this value is greater than one, and it can be said that the production of rice farmers in North Jakarta is not economically efficient. The farmers in North Jakarta have successfully achieved technical efficiency. However, allocative efficiency was not achieved. Thus, causing economic efficiency appears to be unattainable. Farmers still need to maximize the use of inputs by increasing the number of inputs to achieve

economic efficiency. This result is in line with Rakhmawati et al. (2011) research, which states that caisim mustard farming is inefficient and in line with Pius Chinwuba & Odjuvwuederhie Emmanuel, (2006), which states that yam farmers were economically inefficient.

### 4. Conclusions

This study indicates that a partial test using a value of  $\alpha$  0.05 indicates that the variables of land area, labor, fertilizer, and education significantly affect rice production in North Jakarta. However, two of the four variables that have a significant effect have a negative effect, namely, labor and education. Meanwhile, land ownership status is known to have no significant effect on rice production in North Jakarta. The efficiency analysis results show that the average rice production in North Jakarta can be technically efficient because the average efficiency value is more than 0.7. However, rice farmers in North Jakarta have not been able to achieve allocative and economic efficiency.

Even though rice farming in North Jakarta is technically efficient, farmers can still increase their technical efficiency by increasing inputs. Variables that have the potential to be added to their use are fertilizer and land area. The government can also enforce a perpetual agricultural land policy to reduce or lose agricultural sustainability in Jakarta. Mechanization minimizes labor requirements and adds subsidies fertilizer so that farmers can increase their use of fertilizer at a low cost.

This research has several deficiencies in its implementation. The lack of this research on rice farming in North Jakarta was the data collection process. The researcher only did it in Marunda and Rorotan areas by interviewing the members of some farmer groups who were successfully met. The researcher did not conduct interviews with all farmer groups due to time constraints. The model used in this study uses five socio-economic variables. The subsequent research is expected to add variables that have a direct influence on production.

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