

# Productivity and technical inefficiency: A case study of small dryland mungbean farming in East Nusa Tenggara, Indonesia

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## Abstract

Mungbeans are one of the important agricultural products for food security in East Nusa Tenggara (NTT) Province, which is one of the driest regions in Indonesia. The low productivity and profitability of mungbean farming in this region are caused by factors that influence agricultural inefficiency. This study was conducted to measure the productivity and technical efficiency levels, as well as investigate the factors affecting farm inefficiency, using the Technical Efficiency Effect Model (TEEM) applied to the frontier logarithmic transcendental production function. The method applied in this research is descriptive qualitative based on survey and interview results through primary and secondary data. Firstly, the results showed that mungbean farming was in the increasing return to scale stage of production and productivity only reached 57% of its production potential, with a technical efficiency level of 66%. Secondly, the factors that positively influence the low productivity and technical efficiency level of mungbean farming are land, seeds, labor, and the interaction between land and labor. Meanwhile, farmer experience and farm training significantly reduce the inefficiency of mungbean farming. It is suggested that increasing land productivity with appropriate and intensive modern technology and improving labor skills are the main strategies for reducing inefficiencies and increasing the income of smallholder farmers in drylands.

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## 1. Introduction

Indonesia is an agricultural country where most of the citizens are farmers. Mungbean is one of the main foods that substitutes commodities for farmers in Indonesia. However, not all regions in Indonesia produce mungbean in maximum quantity and fulfill the food needs of the community. This is due to the different characteristics of each region in Indonesia. Each region must develop commodities in accordance with their respective characteristics.

East Nusa Tenggara (NTT) province has enough potential land with 4,734,990 ha containing 3,527,112 ha (74.5 %) dry land and 200,291 ha (25.5 %) is an area with enough water for farming activities [1]. NTT is a potential area for mungbean farming development. Manggarai Regency is one of the areas with potential dry land of 107,747 ha [2]. Based on the data from the Statistics Center of Manggarai, in the last five years, the average of

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Mung bean productivity has been fluctuating. It is a fact that mung bean farming in NTT in general and Manggarai in particular is still involved in low productivity and efficiency of managerial, marketing, and non-technical management. In addition, the managerial ability of agribusiness is still under the standard, the scale of the farm is still small and the institutional weaknesses are as low as the motivation of farmers.

From this description, it is assumed that there are some problems found related to mung bean productivity; (1) what is the level of productivity and technical efficiency of mung bean farming?; (2) what factors affect the productivity and technical efficiency of mung bean farming?; and (3) what is the strategy for increasing the productivity and technical efficiency of mung bean farming? Therefore, this study aims to (1) determine the level of productivity and technical efficiency of mungbean farming; (2) investigate the factors that affect the technical efficiency of mung bean farming; and (3) recommend strategies to improve the productivity and technical efficiency of the mung bean farming. Some benefits expected after doing this research are to provide a recommendation to the government as a policy maker in developing agricultural productivity, especially mung beans. To farmers, these projects will be beneficial as suggestions in the technical management of mung bean production in terms of productivity and efficiency.

## 2. Research method

This research was conducted in Reok and West Reok Subdistrict of Manggarai. These areas were chosen deliberately considering that they are included in the center Mung beans production area in East Nusa Tenggara province. The methods applied in collecting data were primary and secondary data. The primary data was gained by a survey with direct interviews with the structured list. The survey was done in the 2018 planting season containing items of mung bean farming area, seeds, labor, the use of fertilizers, pesticides, input prices, and output prices, farmers' age, numbers of family members, education, counseling, farmer groups, credit, extensive assistance, projects and other sources of income. The populations of this study were mung bean farmers with 100 samples determined by simple random sampling. The secondary data were the results of previous studies taken from governmental institutions such as data on production, harvest area, and productivity in 2018.

There were some stages of data analysis applied in the research. They are data transfer, editing, processing, and analysis. Descriptive qualitative and quantitative analysis were used in examining the data. The data analyzed by using descriptive qualitative were summary of data described in both primary and secondary data. This was aimed to determine the stage of mung bean farming in Reok and West Reok subdistrict. The quantitative analysis was used to analyze other research objectives.

The *technical efficiency effect model* was applied to determine the effect of production factors in mung bean farming in the form of *transcendental logarithmic* (trans-log) production function with the following model:

$$\ln Y = \beta_0 + \sum_{j=1}^5 \beta_j \ln X_{ij} + 0,5 \sum_{j=1}^5 \sum_{s=1}^5 \beta_{js} \ln X_{ij} \ln X_{is} + V_i + U_i \quad (1)$$

Where, Y: total production (kg), X1: total land area, X2: number of seeds (kg). X3: number of family labor (HOK), X4: number of non-family workers (HOK), X5: numbers of total workers (HOK), V – U: confounding error (where V is the effect of external factors or the effect of inefficiency in the model), i: sample farming (i = 1,2,...,N), j and s: type of input (j = 1,2,3),  $\beta_j$ : parameters to be estimated.

The method of using unbiased parameters is to use the maximum likelihood estimator (MLE) method [3]–[5]. Signs and magnitudes of the expected coefficient values were  $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5 > 0$ . The positive coefficient value means that with the increasing use of these production factors, mung bean production is expected to increase as well. Meanwhile, the negative coefficient will apply the opposite if there is an additional use of these inputs in the production process. It will reduce the production of mung beans. Meanwhile in capability (non-technical factors), it is done by using the following equation model:

$$u_{ik} = \delta_0 + \sum_{l=1}^5 \delta_l z_{il} + \omega_m D_m \quad \dots\dots\dots (2)$$

Where,  $u_i$ : technical efficiency value automatically obtained from the frontier program, Z1: age of farmer (years), Z2: number of farmer family members (people), Z3: formal farmer education (years), Z4: farming training (scoring), Z5: mung bean farming experience (years), D1: other sources of income (1 for other sources of income, 0 if not), D2: membership of farmer groups (1 for group members, 0 if not),  $i$ : sample of farming ( $i = 1, 2, \dots, N$ ),  $1$ : type of factor/source of inefficiency ( $1 = 1, 2, 3$ ),  $m$ : number of dummy variables ( $m = 1, 2$ ),  $\delta$  &  $\omega$ : estimated parameter.

Efficiency and inefficiency variables are estimated using the MLE method [6] simultaneously (between Formulas 1 and 2) with the frontier 4.1.c program tested with the criteria used is a *one-sided generalized likelihood ratio* (LR-test) test [7], [8] with the following equation:

$$LR = -2 \left\{ \ln \left[ \frac{L(H_0)}{L(H_1)} \right] \right\} = -2 \{ \ln[L(H_0)] - \ln[L(H_1)] \} \dots\dots\dots (3)$$

Where  $L(H_0)$  and  $L(H_1)$  are the values of the likelihood function of the null hypothesis and the alternative hypothesis. Reject  $H_0$  if  $LR > \chi^2$  and vice versa,  $H_0$  accepted if  $LR < \chi^2$ . If the result of  $H_0$ :  $\gamma = \delta_1 = \delta_2 = \dots\dots\dots = \delta_7 = 0$  is accepted, it proves that the effect of technical inefficiency does not exist in the trans-log production function model.

The elasticity of production from the trans-log function is not obtained automatically from the coefficient of the estimation results as is the case with the Cobb-Douglass function. Therefore, it is necessary to do a separate analysis. The calculation of the partial elasticity of production (each factor of production) on the geometric mean of the use of the production factors follows the guidelines [9], [10] (Equation 4). Meanwhile, the amount of the elasticity of each production factor determines the business scale or return to scale of mung bean farming. Thus, if the total elasticity  $> 1$  is said to be increasing return to scale; if  $= 1$  constant return to scale and if  $< 1$  decreasing return to scale.

$$E_{X_k} = \frac{\partial \ln Y}{\partial \ln X_k} = \beta_k + \beta_{kk} \overline{\ln X_k} + \sum_{j \neq k}^5 \beta_{kj} \overline{\ln X_j} \dots\dots\dots (4)$$

Where,  $E_{X_k}$ : elasticity of the input  $X_k$ ,  $\beta_k$ : the estimated coefficients of the inputs  $X_k$  and  $X_j$ : the average number of uses of the input types  $k$  and  $j$ .

### 3. Results and discussion

Most of the farmers interviewed (64.85%) were around 35-55 years old, with an average age of 42.87 years. Thus, most of the farmer respondents were in the productive age. Judging from the level of formal education, most of the farmers (79.44%) have a primary school level of education. Some of the respondent farmers have attended training on mung bean farming and some have not. The number of farmers who have participated in mung bean farming training is an average level of 0.50 times. Meanwhile, the experience of farmers in mung bean farming is 8.02 years with an experience span of 1 – 30 years. Most respondent farmers (51%) had 3-5 family members per household, with an average of 4 family members per household. The number of respondents who have made contact with field agricultural extension officers (PPL) is 53%. Most of the respondent farmers (86%) are members of the farmer group.

#### 3.1. Technical factors of mung bean farming

Farming activities are a way for how someone to allocate his existing resources intending to obtain high production yields, so, that they can meet market demand and increase farmers' income. In doing business several important factors must be known by farmers which can affect the production results of the farming itself. However, farmers often pay less attention to these production factors in carrying out their production activities. In general, there are several production factors that can affect technically the production of agricultural products,

namely production, total land owned, seeds, family labor, non-family labor, total labor, age, family members, formal education, mung bean farming training, mung bean farming experience, membership of farmer group and other sources of income which are listed in the following table.

Table 1. Summary statistics of the variables used in the mung bean farming production frontier model

No.	Characteristics	Average	Max	Min
1	Production (kg)	1420	2000	100
2	Land (ha)	2.70	8.00	1.00
3	Seed (kg)	30	64	12.8
4	Family labor (man-days)	58.8	240	7.8
5	Hired labor (man-days)	95.9	900.3	0
6	Total labor (man-days)	154.7	1132	23.5
7	Age (year)	42.87	65.50	24.00
8	Family members (man)	4.34	7.00	1.00
9	Education (year)	7.49	16.50	3.00
10	Experience (year)	0.50	2.00	0.00
11	Training (score)	8.02	30.00	1.50
12	Farmer group (%)	85.88	1.00	0.00
13	Other income sources (%)	69.72	1.00	0.00

The land area has an influence on agricultural production. Without land, agriculture cannot be implemented. The more land owned by the farmer, the greater opportunity will be provided for the farmers' planting. Therefore, the land area has a positive effect on farming efficiency. The use of superior seeds can improve the product quality and efficiency of mung bean farming and affect the income of the farmers. The use of other production factors will also affect the production process carried out. If the use is not in accordance with the recommended composition, it will result low low-quality mung bean production even lead to failure. The use of fertilizers in the study area is still far from the standard amount that has been determined. So, it is not included in the analysis of the results of this study. Similar to the use of fertilizers, the use of pesticides must also be in accordance with the recommended composition. However, most of mung bean farmers (98.9 %) do not use pesticides. Labor has an influence on production activities from land preparation to post-harvesting. The size of labor can be expressed in working people days (HOK). Labor can have a positive and negative effect on the efficiency of mung bean farming. Therefore, to answer this goal, the analysis of multiple linear regression functions can be used by applying the trans-logged function model. The analysis is carried out using the Frontier Version 4.1.c program, so, that the technical efficiency level of the use of these production factors will be identified.

Apart from the technical and non-technical production factors listed in Table 1, the farmer's cropping pattern also contributes to the productivity of mung bean farming. Mung bean farmers usually start farming in the rainy season. The planting method used by the farmers is to use a one-hole method, planting 2-3 mung bean seeds. The spacing of mung bean seeds at the research location is 20 cm x 40 cm. There are even farmers who do not use the spacing in planting the mung beans. Most mung bean farmers (78%) do not apply row cropping patterns.

### 3.2. Productivity and technical efficiency of mung bean farming

The conditions for using technical and non-technical production inputs from sample farmers are listed in the previous Table 1. The average area of mung bean farming for the sample farmers was 0.53 ha, with an average farmers' income level of IDR 3,367,517.79 per ha with a harvest age of 56 days with an R / C ratio of 2.6. The income gap between farmers is very high, namely between the minimum income of IDR 839,622.64 to the highest of IDR 9,969,002.7 per ha per farmer. The opportunity to increase farmer's income is still very high at 89% of their potential income. The low income of farmers is caused by low land productivity (1,420 kg per ha)

as a result of high technical inefficiency of production and very low capital use, which is only 24% with low family workforce capabilities.

The average productivity of mung beans in the study area is still low, namely 1.42 t / ha. As a result, the balance between the demand and supply of mung beans in the study area is almost unheard of. This has led to a high process of mung beans during the non-harvest season. To answer the purpose of this study about factors that influence the productivity of mung bean farming technically in Reok and West Reok sub-district, Manggarai regency, the frontier production function in the form of trans-log has been estimated. In this study, there are several production factors. They are total land area (X1), seeds (X2) family labor (X3), wage labor (X4), and total labor (X5). These five production factors are independent variables that affect the production of mung beans (Y) or the dependent variable. The results of the regression analysis of the trans-logged production function are listed in Table 2.

Table 2. Estimated parameters and t-ratio of the trans-log production function, production elasticity, and variance parameters of dry land area mung bean farming

Variable (Parameter)	Coefficient	Standard error	t-ratio
Stochastic frontier translog production function model			
Intercept ( $\beta_0$ )	3.856	3.512	1.098
$\beta_1$ (X <sub>1</sub> ) land (ha)	-1.135	0.298	-3.811*
$\beta_2$ (X <sub>2</sub> ) seed (kg)	2.247	0.849	2.647*
$\beta_3$ (X <sub>3</sub> ) family labor (man-days)	2.045	0.192	10.651*
$\beta_4$ (X <sub>4</sub> ) hired labor (man-days)	0.050	0.132	0.380
$\beta_5$ (X <sub>5</sub> ) total labor (man-days)	-1.680	0.493	-3.407*
$\beta_6$ (0.5*X <sub>1</sub> *X <sub>1</sub> )	0.140	0.225	0.623
$\beta_7$ (0.5*X <sub>2</sub> *X <sub>2</sub> )	-0.150	0.646	-0.232
$\beta_8$ (0.5*X <sub>3</sub> *X <sub>3</sub> )	-0.326	0.148	-2.202**
$\beta_9$ (0.5*X <sub>4</sub> *X <sub>4</sub> )	-0.010	0.016	-0.633
$\beta_{10}$ (0.5*X <sub>5</sub> *X <sub>5</sub> )	0.421	0.116	3.629*
$\beta_{11}$ (X <sub>1</sub> *X <sub>2</sub> )	0.110	0.275	0.400
$\beta_{12}$ (X <sub>1</sub> *X <sub>3</sub> )	-0.315	0.122	-2.591**
$\beta_{13}$ (X <sub>1</sub> *X <sub>4</sub> )	0.000	0.021	0.000
$\beta_{14}$ (X <sub>1</sub> *X <sub>5</sub> )	0.220	0.244	0.902
$\beta_{15}$ (X <sub>2</sub> *X <sub>3</sub> )	-0.240	0.241	-0.996
$\beta_{16}$ (X <sub>2</sub> *X <sub>4</sub> )	-0.010	0.026	-0.389
$\beta_{17}$ (X <sub>2</sub> *X <sub>5</sub> )	0.190	0.247	0.768
$\beta_{18}$ (X <sub>3</sub> *X <sub>4</sub> )	-0.020	0.018	-1.107
Production elasticity			
$\beta_1$ (X <sub>1</sub> ) land (ha)	-1.05	Elastic	
$\beta_2$ (X <sub>2</sub> ) seed (kg)	0.13		
$\beta_3$ (X <sub>3</sub> ) family labor (man-days)	2.52	Elastic	
$\beta_4$ (X <sub>4</sub> ) hired labor (man-days)	-0.96		
$\beta_5$ (X <sub>5</sub> ) total labor (man-days)	1.90	Elastic	
Return to Scale	2.54	Increasing return	
Parameter Variance			
$\sigma^2$	0.695	0.214	3.251*
$\gamma$	0.716	0.237	3.021*
Log-Likelihood	-24.03332		
LR	28.388631		$\chi^2 = 12,5916^*$

Note: \* = significant at  $\alpha = 1\%$  dan \*\* significant at  $\alpha = 5\%$

Some important factors that need attention in increasing the productivity of mung beans in dry land are the total land area owned by the sample farmers, both family labor and total labor, and the interaction factor between land area and labor.

Increasing the amount of land owned by the farmers will reduce the amount of mung bean production. This is very significant at the real level of 1%. The reality in the research field shows that the more land area for other crops, apart from mung bean farming, the more the concentration of farmers in managing will be disturbed. As a result, the maintenance of mung bean farming is less intensive, and this has an impact on decreasing production yields. The results showed that the majority (81%) of the respondent farmers only cared for mung beans (weeds) one time during the growing season. In theory, are shows that maintenance more than twice a season will provide high productivity [11].

Increasing the number of seeds will increase the amount of mung bean production. Mung bean seeds with recommended spacing and number of seeds per hole are predetermined, but in practice, the farmers do not apply this. For example, seeds must be planted one seed per planting hole in a row planting pattern. In fact, 86% of mung bean farmers do not apply it. Irregular planting patterns with the use of  $\geq 3$  seeds per planting hole still dominate the cropping patterns of mung bean farmers. So, modern seeds are treated traditionally. However, the seed variable is not important for the fluctuation of mung bean production in the research area. It proves that statistically the seed variable has no significant effect on the production of mung beans in the research location.

The addition of total labor (family labor and outside the family) will reduce the production of mung beans, with a production elasticity greater than 1 or elastic. In terms of numbers, farmers already have a large family workforce, but in terms of quality, it is still categorized as low. It can be seen from the level of education. They are dominated by elementary school graduates. Therefore, periodic training activities or fields on farms during the stages of mung bean agribusiness management (starting from planning, production, process, harvesting, post-harvest, and marketing) need to be implemented.

The interaction between land and family labor is negative and has a significant effect on mung bean production of 5%. The relatively low education level of the family workforce with a relatively large area of land (2.7 ha per farmer), has caused a significant negative impact on mung bean production in the study area. This requires increasing the capability of farmers, so, that they will be able to prioritize the exploitation of plants that they are able to provide high economic value. Thus, it will increase intensive land management.

Table 2 shows the results of the estimation that the likelihood-generalized ratio (LR) of the production function model *stochastic frontier* is higher than the value of distribution table  $\chi^2$  [12]. The ratio value is real in statistics at  $\alpha = 5\%$ . This means that the production function of the *stochastic frontier* of the research area states the existence of technical efficiency and inefficiency of farmers in the production process of mung beans. It is also found that there is significant disruption in dry land mung bean farming more specifically in the research area. It is shown by the values of gamma. Parameter  $\gamma$  estimation is the ratio from technical efficiency variants ( $u_i$ ) to total variants ( $\varepsilon_i$ ) gains value of 0.72. In statistics, the obtained value is different from the real zero at  $\alpha=1\%$ . This figure shows that 72% of the variation in yields among respondent farmers is due to stochastic effects (external factors) such as climate, pest attacks, and modeling errors.

The distribution of technical efficiency of the model used is shown in Table 3. The results of previous studies [13], [14] show that the efficiency index value of the analysis results is categorized as quite efficient if it is greater than 0.70. By tracing the distribution of technical efficiency values per individual respondent farmer, it is found that on average there are 59% of the total respondent farmers are not efficient or have not reached an efficiency level greater than 70%. The number of efficient farmers in the study area was 41%. Of this amount, only 9% of respondents had a high level of efficiency. Based on the average value of technical efficiency in the frontier production function model which is only 66%, it can be argued that on average the respondent farmers still have the opportunity to obtain higher potential yields to achieve maximum results as obtained by the most

technically efficient farmers. In the short term, on average, green bean farmers in the study area have the opportunity to increase production by 34%.

Table 3. Distribution of mung bean farming technical efficiency

Efficiency level	Respondent	(%) Respondent
$0 < ET < 70$	59	59
$70 \leq ET < 80$	25	25
$80 \leq ET < 90$	7	7
$ET \geq 90$	9	9
Total	100	100
% Efficient ( $TE \geq 70$ )	41	41
Mean TE : 0,66		

### 3.3. Sources of mung bean farming technical inefficiency

The amount of inefficiency in green bean farming can be caused by other factors, namely, at the research location, crop failure occurred due to lack of rainfall during the growing season, so only a few mung beans could be harvested [15], [16]. Apart from lack of rainfall, several factors influence such as farmers' age, education, number of family members and members of farmers groups, and several other farmer factors that affect the farmer's capability.

The factors that influence the efficiency level of green bean farming are implemented simultaneously by using the technical inefficiency effect model of the stochastic frontier production function while analyzing the sources of the technical inefficiency or farmer capability is carried out using the model in Equation 3. The results are listed in Table 4.

Table 4. Estimation of parameters of parameters and t-ratio of the stochastic frontier production function model

Variable	Coefficient	Standard error	t-ratio
$d_0 (\delta_0)$ Constanta	0.310	0.543	0.575
$Z_1 (\delta_1)$ age	0.000	0.003	0.619
$Z_2 (\delta_2)$ family members	0.010	0.024	0.606
$Z_3 (\delta_3)$ experience	-0.010	0.003	-2.370**
$Z_4 (\delta_4)$ education	0.010	0.010	0.826
$Z_5 (\delta_5)$ training	-0.280	0.053	-5.173**
$D_1 (\delta_6)$ farmer group	-0.030	0.099	-0.283
$D_2 (\delta_7)$ other income sources	0.310	0.543	0.575

Note: \* = significant at  $\alpha = 1\%$  and \*\*Significant at  $\alpha = 5\%$

Based on the results of the coefficient values listed in Table 3, the coefficient that shows negative results will have a positive impact on technical efficiency, and vice versa; the positive coefficient results will have a negative impact on technical efficiency.

The addition of the use of factors that have a negative coefficient will increase technical efficiency in farming at the research location, such as the number of family members ( $Z_2$ ), farming experience ( $Z_3$ ), and members of farmer groups ( $D_1$ ). Based on this analysis, it is concluded that these factors have a significant effect on technical efficiency.

In addition to the negative factors in this technical inefficiency analysis, some factors are positive, indicating that age has a significant effect on the efficiency of green bean farming at the research location and can add to the value of technical inefficiency even though the average age of the respondent farmers is 43 years. The

theoretical age if it is at the productive age will increase the productivity of green beans, but in fact, it does not have a significant impact on technical efficiency. Thus, empowering the workforce with training and supporting resources needs to be taken seriously.

### 3.4. Strategy for increasing productivity and technical efficiency of mung bean farming

Based on the results of the calculation of the technical efficiency level for each production factor, the production factor of seed, labor, and urea fertilizer is a production factor that is technically efficient in conducting green bean farming in Toe, Rura, Watu Baur, and Robek villages while fertilizer NPK is a production factor that has not been efficiently used in green bean farming, it is very necessary to pay attention to the factor that influences technical green bean farming.

The use of seeds in conducting mung bean farming greatly affects the efficiency level of mung bean farming. The use of superior seeds suitable for cultivation on dry land is one way to increase the efficiency of green bean farming [16]. The use of superior seeds will increase the yield of green beans and reduce the risk of crop failure.

Labor in green bean farming activities also has a significant effect. The use of labor in farming activities in NTT usually uses labor in the family or cooperation. Even though farming activities still use human labor, from land preparation to marketing, this green bean farming activity is carried out in the rainy season so that the use of labor is efficient, but it can also be carried out in the dry season provided that certain technology is used so that workforce remains efficient in the green bean farming activities [17]–[19].

Urea fertilizer is also commonly used in green bean farming activities, although not all farmers use it. The use of urea fertilizer as well as the use of NPK fertilizer is also used by farmers in conducting green bean farming activities, although not all farmers use it. The use of fertilizers in farming activities can increase the yield of green beans if their use is in accordance with predetermined usage rules.

In summary, the strategies for improving productivity and technical efficiency in green bean farming in dryland areas in Manggarai Regency are as follows:

1. Select varieties that have a short life, dry resistance, storage resistance, and low cost but high productivity.
2. Fertilization. More emphasis on the use of organic fertilizers without neglecting inorganic fertilizers with a balanced use or according to the needs of the environment.
3. Mechanization. Its main focus is on rural or agro-industry for input development, especially organic fertilizers. In addition, the rural industry outputs to produce flour (maize, cassava, sweet potato, banana, taro, potato).
4. Livestock development. Apart from the purposes of making money, livestock in dryland areas can also be used to support the production of inputs (organic fertilizers) and the utilization of dry land farming by-products.
5. Increasing the capability of farmers' resources by doing:
  - a. On-farm training with a focus on dry land farming patterns including post-harvest and marketing.
  - b. Participatory research with farmers (on-farm participatory research). It should be focused on rural youth with formal education for more than nine years.

Empowerment of farmer groups by increasing the frequency of member cooperation and transparency in the management of group activities as well as facilitating partnerships between farmers, business people, and academics.

## 4. Conclusions

Most of the mung bean farming production systems in the study area (59%) were not technically efficient; with an average of technical efficiency of 0.66. The important production factors that affect the technically efficient production of mung beans are land, seeds, and labor. Meanwhile, other production factors are inefficient because the coefficient value is negative. Sources of technical efficiency in mung bean production are farming

experience, training, and farmer group membership. Thus, improving the productivity and technical efficiency of mung bean farming must be carried out with a focus on these four factors for the realization of food security in the mung bean farming community.

Increasing productivity and technical efficiency can be done by improving technology for mung bean farmers, so, as to minimize the risk of crop failure if the rainfall is irregular. In addition, the government needs to be faster in providing production inputs such as fertilizers, superior seeds, integrated livestock, mechanization, and improvement of farmers' capabilities. This last activity can be done by increasing training activities, participatory research, and empowering farmer groups. It is also suggested that the results and recommendations of this study still require implementation activities for the effective productivity and technical efficiency improvements.

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The authors declare that they have no known financial or non-financial competing interests in any material discussed in this paper.

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### **Author contribution**

Damianus Adar: Writing – Original draft, Funding acquisition, Investigation, Project administration.  
Aleksius Madu: Methodology, Validation, Data curation, Visualization, Reviewing, Editing.

### **Ethical approval statement**

Ethical approval is not applicable to this research.

### **Informed consent**

Informed consent for the publication of personal data in this article was obtained from the participant(s).

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