Asian Journal of Agricultural Extension, Economics & Sociology

Volume 42, Issue 6, Page 62-74, 2024; Article no.AJAEES.108588
ISSN: 2320-7027

Determinants of Profit Efficiency among Rice Farmers in Kilombero Valley, Morogoro, Tanzania

Mariki, Anna [a*] and Philip, Damas [b]

[a] Department of Agricultural Economics and Agribusiness, College of Economics and Business Studies, Sokoine University of Agriculture, P.O. Box 3007, Chuo kikuu, Morogoro, Tanzania.
[b] Department of Trade and Investment, College of Economics and Business Studies, Sokoine University of Agriculture, P.O Box 3007, Chuo Kikuu, Morogoro, Tanzania.

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJAEES/2024/v42i62463

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/108588

Original Research Article

Received: 24/09/2023
Accepted: 28/11/2023
Published: 10/05/2024

ABSTRACT

Farmers in the Kilombero Valley are experiencing a growing trend towards commercialization seen through the expansion in the cultivated land area rather than agricultural intensification. There is a modicum of information on whether the observed increase in commercialization in the area is associated with an increase in profit. This study used the stochastic profit frontier function to estimate the profit efficiency of rice commercializing farmers and the respective determinants. The study used data collected from 377 rice farmers who were selected by using a multi-stage stratified sampling method. Results indicate that rice commercialising farmers' mean profit efficiency level was 75.65%. This indicates that rice farmers can improve their efficiency levels by 24.4% without increasing the level of inputs used. Maximum likelihood estimates indicated that wage, price of fertilizer, rice area in hectares, and production assets value were significant in determining the profit efficiency of rice commercializing farmers in Kilombero. The study concludes that commercializing

**Corresponding author: E-mail: marikiannaw@gmail.com;*

farmers in the study area was profit efficient. The study recommends that more emphasis on early formal education in farmers' society be emphasized for the literate group is more profit-efficient than the illiterate. With the present national educational policy to support education, farming households should strategically take advantage of it as education has exhibited a positive impact on their efficiency. Different services (marketplaces and inputs dealerships) in the area should be improved further to create more room for rice farmers to improve their productivity and profitability.

Keywords: Profit efficiency; rice farmers; commercialization; stochastic frontier.

1. INTRODUCTION

1.1 Background Information

Rice is a seed of a grass species named (*Oryza Sativa L*.) which contains, starch, protein, Zinc, and water used as human food. It is a common staple food crop depended on for subsistence by half of the world [1,2]. The crop is said to grow well in areas with flooded soil compared to dry soil and is adaptable to a wide range of climates [3]. Rice is generally a food crop but due to its growing demand and consumption in different parts of the world, it is also a cash crop. Globally, most of the rice produced and consumed is from Asia where China and India account for more than 50% of the rice produced and traded globally [3]. In Africa, the leading producers from different parts were Nigeria, Madagascar, and Tanzania in the year 2019 [4].

In East Africa, Tanzania produces most of the rice and is a net exporter compared to other nations in the region (JICA, 2021). The exhibited growth in rice production in Tanzania over time is explained by the growth in population and urbanization in different parts within and outside Tanzania. The latter results in the growth in food demand including the rice crop. This is an opportunity for rice producers in different parts to commercialize (Lazaro *et al.,* 2016; URT 2019). In Tanzania, rice is mostly produced and commercialized in various parts such as Mbeya, Morogoro, Shinyanga, Tabora, Mwanza, Kigoma, Rukwa, Arusha, Kilimanjaro, Manyara, Mara, Iringa, Tanga, and regions [5] (URT 2019). Morogoro and Mbeya are the largest rice producers compared to other remaining regions while Dar es Salaam has the highest consumption level [5].

Among areas that have had rice commercialization present over the longest time is the Kilombero area in the Morogoro region. Commercialization activities in the region date back to the 1980s when the establishment of the KOTACO (Korea Tanzania Company) and thereafter a change in managerial arrangements followed by a change of ownership. The events led to the emergence of Kilombero Plantation Limited (KPL). The presence of the company has had positive externalities on influencing commercialization among farmers of different ranks through the spillover of skills, technology, and agricultural practices [6].

The commercialization process is ongoing in the area. Generally, over time, there has been an increase in the production level (output) resulting from land area expansion rather than efficient use of inputs (land, labour, and other variable inputs) or intensification [6]. This implies that the commercialization process may be more lucrative for participants if and only if they utilize inputs optimally to produce outputs with a good quality enough to fetch a good price in the market. This is because it is key in any rice production enterprise regardless of its size. The level at which most farmers operate may not be optimal in terms of productivity and profit as well. Relating to the economic theory of firms' production, producers' existence in a market is determined by profit attained at the prevailing market conditions (prices). There is sufficient literature on rice output commercialization in the area [6,7,8] but there is less literature on the efficiency of farmers in attaining profit as they commercialize.

A recent study on profit efficiency in the respective area on paddy farmers using the warehouse receipt system in comparison with non-users found no significant difference in their profit efficiency scores as they all averaged 44.5% [9].

Other studies that involved rice crop from a commercial perspective in the same area was for comparisons between sugar cane and rice as they compete for land allocation guided by gains from each crop whereas rice was allocated more land compared to sugar cane [10].

With the knowledge of the authors, [6,8] previous studies on rice crop conducted in the area specifically on rice commercialisation following that it has been thriving over time in the area, was with the assumption that rice farmers were profitable but there is no evidence established through data. Hence, there is a need to understand te profit, profit efficiency distribution and, sources that determine rice farmers' ability to achieve their profit potential efficiently on commercializing, in the study area.

2. LITERATURE REVIEW

2.1 Theoretical Framework

The underlying theory for this study is the theory of the firm explaining the production of individual economic entities such as farmers and/or farms under the concept of efficiency. The profit function as was used in this study is an extension of the production function which entails the decision made by a farmer in their production process as modelled by Sadoulet and de Janvry, [11]. Farrell [12] then, constructed the definition for the frontier production function that presented the concept of maximality. Farrell's idea explained and differentiated the three types of efficiency, which are technical efficiency, allocative or price efficiency, and economic efficiency which is the combination of the first two. According to Farrell [12], Technical efficiency is defined as the ability to produce a greater amount of output or a specific amount of output at a given level of inputs. Allocative efficiency is the ability to produce a given level of output using the least cost for the input combinations employed. Allocative and technical efficiency combine to form economic efficiency [13,14,15,16] (Ngaga *et al.,* 2010).

After Farrell's [12] work, other studies were done in measuring efficiency in different fields. There was a proposition of measuring efficiency in the field of agriculture proposed by Aigner *et al.* (1977) which was later proved to be invaluable by Mccusen and Van den Broeck [17]. Battese [18] conducted a thorough review of the frontier literature that focused on farm-level efficiency in developing nations, and Brave-Ureta and Pinheiro (1993), Coelli [19], and Thiam *et al.* (2001) furthered this review. In general, these authors noted that there were several theoretical concerns about measuring efficiency using frontiers that questioned the best approach (between parametric and non-parametric approaches) to follow and the proper selection of variables (Oguniyi, 2011). Estimation of efficiency was done by estimating technical and allocative efficiency separately from a production frontier using farm data and a production function. It was further discussed that using a production function in estimating the economic efficiency of farms was insufficiently accurate due to farms facing different prices and also the differences in factor endowments. With that regard, farms may have diverse best practice functions and different optimum combination points [13].

Consequently, Yotopoulos and other authors claimed that in estimating efficiency, farmer-specific prices and fixed factor levels should be included in the analysis. This in turn led to the formation of the profit function which was also popularized by Yotopoulos and Lau [20]. [13,14]. There on, profit function led to the extension of technical efficiency to profit efficiency after the inclusion of farm-specific input and output prices in the production function. Profit efficiency is the capacity of a farm to maximize profit given the prices and levels of fixed factors for the specific enterprise [21,13].

Several functional forms are used usually in the profit frontier estimation depending on the input and output relationship. This is because the profit function arises from the production function such that the difference between the two is the presence of prices in the profit function while input and output quantities are production functions. The production forms that constitute the profit functions namely, the Cobb Douglas function, and other adaptable functional forms including generalized Leontief, normalized translog and normalized quadratic [21]. The translog function and the Cobb-Douglas function are two frequently employed functional forms. The normalized translog function is commonly used in profit efficiency estimation under the stochastic frontier analysis technique. The translog is known for its flexibility in adding in a variable that has interaction based on how they are related and also allows for flexibility in the returns to scale for the production function [13,21,16]. Apart from its popularity, the Translog production function has the risk of multicollinearity and inadequate degrees of freedom since there are interaction terms. Many times, some terms used in interactions do not always put forward a useful economic interpretation [22,23].

According to Kumbakar and Lovel (2000); and Murthy [24], the Cobb-Douglas production function is adaptable due to its mathematical characteristics; it can handle various numbers of inputs when expressed in a generalized manner, it allows estimate with minimal parameters and also permits the focus on error term estimation. However, the function also has weaknesses which include that it shows constant returns to scale concerning how it is specified for a given production entity which may not hold in realistic conditions.

In this study, the Cobb-Douglas production function is utilized because of its flexibility, economic interpretability of its terms, and assurance of enough degrees of freedom in the estimation process. According to [13,15,16,25] the stochastic function is specified as detailed in equation 1:

$$\pi_i = f(P_{in} Z_{in}).exp(\varepsilon_i)\ldots \quad (1)$$

Where; - π_i is identified as the normalized restricted profit of the ith farmer which is obtained by dividing the output price by the difference between revenue and variable costs per specific farm. P_{in} is identified as the price of the nth variable input faced by the ith farm/ farmer divided by the price of output. Z_{in} is identified as the level of nth fixed inputs on the ith farm and ε_i is the error term. i = 1, 2….n is the number of farmers present in the sample.

The assumption is that the error term will behave in a way that is compatible with the frontier concept [13,16] where it is specified in equation 2;

$$\varepsilon_i = V_i - U_i\ldots \quad (2)$$

The assumption is that V_i is independently and identically distributed $N = (0, (\sigma_v)^2)$ two-sided random errors, Independent of the errors due to inefficiency U_is. The U_i is a random variable that is not negative and explains production inefficiency. It is also assumed to be independently distributed as truncation at zero of the normal distribution with mean, $\mu_i = \delta_0 + \sum_{ni} \delta_{ni} w_{ni}$

And variance $\sigma_u^2(|N(\mu, \sigma_u^2)|)$, where w_{ni} are the nth explanatory variable accounting for inefficiencies on farm i_n and δ_0 and δ_n are unknown parameters.

2.2 Empirical Literature Review

Efficiency studies are a common area in understanding agriculture production over time. Efficiency studies comprise technical, allocative, economic, and profit efficiency studies. Technical and allocative efficiency studies were centered on the productivity aspects of various entities in different contexts and for different crops [26,27,28,29,30,31,32].

Profit efficiency studies were carried out centering on the output quality while taking into account farm-specific prices and fixed inputs for various crops and or production entities in various contexts over time [22,33,34,35,36,37] (Wognaa *et al.,* 2018; kaka *et al.,* 2020; Chang, 2016).

Regarding profit efficiency, Different agricultural entities have been studied such as maize [236] (Abu and Kristen, 2007; Wognaa *et al.,* 2018), groundnuts [38,33,35] Coffee [39] Milk and beef [40,41] and many other agricultural production entities. Social economic variables such as farmer-specific characteristics (age, education, sex, household size), institutional factors such as access to credit, extension services, the existence of memberships and or farmer associations, infrastructure, market facilities, and agricultural inputs dealers. All factors influenced farmers' profits positively and negatively in different contexts.

Profit efficiency studies on rice crops that have been conducted by different researchers in different parts of sub-Saharan African Economies indicated most studies being from West Africa than other parts of Africa. This is attributable to the fact that it is the leading region in rice production [15,16,42,43,44] (Tijani and Bakari, 2015). Among various studies on profit efficiency for the rice, crop stated previously and even from other areas even outside the African continent, social economic, and institutional factors had an influence on efficiency positively and negatively depending on the respective contexts. Studies on the rice crop efficiency in production centering on profit have been done for various causes such as unexploited commercial potentials [44], planting systems, and agro-ecological features differences [36,33,45], associated production costs [46,47,45], and also about financial facilitation present for farmers [48,9]. This implies that different production systems with different compositions are faced with different setbacks and/or opportunities for improving rice production processes. Hence researchers explore the possibilities of realizing greater profits on production given the different stated conditions in various contexts.

The stochastic frontier approach and data envelopment analysis approach (DEA) is by far the common techniques used by different researchers in analyzing profit efficiency where the Translog and Cobb Douglas functions are popularly incorporated in the analysis [46,36,33,42,49,22]. The stochastic frontier approach (SFA) is parametric, allows for hypothesis testing, and is used with a single crop case. The data envelopment approach (DEA) is non-parametric meaning it does not allow for hypothesis testing and is usually utilized for the case of multiple crops. Hence, the stochastic frontier approaches are useful for the present study as they focus on a single output and intend to test hypotheses.

3. METHODOLOGY

3.1 Study Area

The present study was done in the Morogoro region which is one of the leading areas in rice production in Tanzania [5] specifically, in the Kilombero valley, Mngeta district. The selected area has a high rice or paddy production and also appears along the SAGCOT corridor areas selected for fostering agricultural commercialization through linking small-scale farmers with large-scale farmers and/or agribusinesses. The villages surrounding Kilombero Plantation Limited (KPL) in the Mngeta division in the Kilombero district are where respondents for the present study were obtained. The villages from which the samples of farmers were drawn were from the Chita, Mngeta, and Mchombe districts in Mngeta division. The selection for the study area goes in line with the thinking of Poulton, [50] and Wiggins, [51] as they have argued about the existence of agricultural commercialization in that part of Morogoro region. According to them, the process can be present with the existence of external investment (private and or public investment), market specialization, farm consolidation, or a combination of all factors. In the study area, there was significant private investment in the form of Kilombero Plantation Limited (KPL).

3.2 Source of Data

The data used in this study was collected by the APRA African Policy Research in Africa Research Program as part of the program in six African countries, which included Tanzania as well. The study in Tanzania which was on rice commercialization was conducted in Mngeta division in the Kilombero valley. The study area was chosen following that it fit well with the government's objective to link small-scale farmers with large-scale farmers under the (SAGCOT) Sothern Agricultural Corridor of Tanzania [6].

3.3 Sampling Procedures

The sample was drawn from ten villages located within 30 kilometers of Kilombero Plantation Limited. At first, the list of all respondents in Kilombero rice farmers in Kilombero valley was obtained. Then stratified sampling was used to draw the desired sample from the sampling frame [6]. A sample of 377 commercializing farmers was obtained from the study area.

3.4 Data Analysis

Data for rice commercializing farmers were analyzed using descriptive statistics and the Cobb-Douglas profit function described in equation 3.

$$Ln\pi_i = \beta_0 + \sum_{n=1}^{4} \beta_n \ lnX_{ni} + \beta_m \mathrm{Ln}Z_m + V_i - U_i \quad (3)$$

Where;

Ln= natural log
π =Restricted normalized profit for the i^{th} farmer
X_1 = Normalized seed price
X_2= Normalized herbicide price
X_3= Normalized fertilizer price
X_4= Normalized labour price.
Z_1= Total livestock units
Z_2= Land area cultivated with rice
Z_3= Production assets value
$\beta_0, \beta_{1,......4}$ and β_m are parameters to be estimated
V_i = represents the statistical random error
U_i= profit inefficiency component for i^{th} farmer

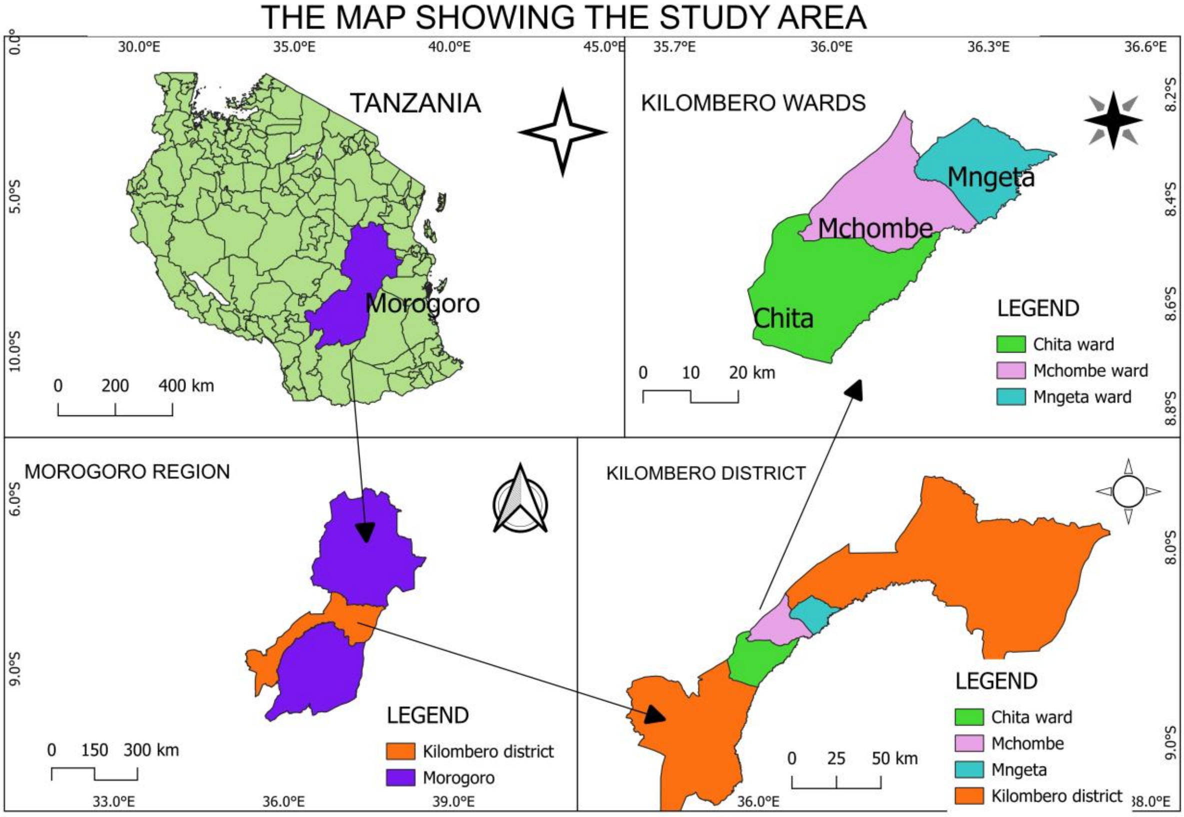

Fig. 1. Location of the study areas in Kilombero

The inefficiency component of the profit function is specified as detailed in equation 4;-

$$U_i = \Lambda_0 + \sum_{n=1}^{\infty} \Lambda_n \ w_n + e \ \ldots \quad (4)$$

Where;

U_i= profit inefficiency of the i_{th} farmer, Λ_0 and Λ_n are parameters to be estimated and w_n are variables explaining profit inefficiency effects,$i, n = 1,2,3 \ldots . n$.
e = truncated random variable.
w_1= age of the household head
w_2 = Education is the number of years of schooling
w_3= Sex of the Household head (1= male, 0= women)
w_4 = Use of Tillage services (1= yes, 0= No)
w_5 = Use of Artificial Fertilizer (1= yes, 0= No)
w_6= Use of purchased seed (1= yes, 0= No)
w_7= Use of extension services (1= yes, 0= No)
w_8= Household size
w_9= Non-Farm Income
w_{10}= Access to established market (1= yes, 0= No)
w_{11}= Access to tillage services (tractor) (1= yes, 0= No)

4. RESULTS AND DISCUSSION

4.1 Social-economic Characteristics of Respondents

The average age for the rice farmers in the area was 49 years which indicates that the farmers are in the working force age range. The youth group (24-35 years) constitutes 17.5 percent of the sample size with that regard, youth are in agriculture but with minimal participation. Rice farmers were literate according to the findings, they have an average of 6 years of schooling which indicates acquisition of the primary level education. This reflects farmers' ability to make sound production decisions. The mean household size for rice farmers in the study area was 6 members which indicates a count of individuals that can provide labour for a small farm-size area. Following that most farmers are in the small-scale farm range given the area under rice mean value of 2.5 hectares of land as it was defined in the report by [5].

Table 1. Social-economic characteristics of farmers

Variable	Mean	Median	Std Dev.
Years of Schooling	6	7	2.628
Age	49	47	14.021
Household size	6	5	2.66
Area under rice	2.552	1.214	6.169
Output price per kg	689	666	201.8
Total Livestock Unit	2.493	0.08	8.547

Table 2. cost incurred in rice production in Kilombero valley

Variable	Mean	Median	Std Dev.
Seed costs per hectare	63 826	64 400	17 935
Labour Costs per hectare	154 364	108 062	165 566
Fertilizer costs per hectare	5 379	00	21 762
Herbicide cost per hectare	37 469	32 933	36 060

4.1.1 Cost of production

Among all costs incurred by rice farmers at a per hectare level, Labour costs were greater compared to other costs indicated by its mean value compared to the mean values of other costs. This is attributable to the fact that the rice crop cultivation process is labour intensive. This is similar to the study by [52] where labour costs constituted up to 30 percent of production costs.

4.1.2 Parameter estimation of the stochastic profit frontier function

Sigma square (δ^2) was significant at 1% indicating the goodness of fit and the correctness of the specified distribution assumptions of the composite error terms. Gamma (γ) was statistically significant at 1% and was estimated at 0.97 which is similar to the findings of [47,52]. Gamma indicates that 97.4% of the total variation in farm profit is due to profit inefficiency rather than random variation. The frontier model revealed that the price of fertilizer, wage per man-day (price of labour), area under rice crop and product asset value were significant at 1% and 10%.

The estimated coefficient for the price of fertilizer was positive and statistically significant at 1%. The positive coefficient indicates the direct relationship between the price of fertilizer and profit. With a 1% increase in the price of fertilizer, the profit efficiency of rice commercializing farmers increases by 2.93%. This is because higher-priced fertilizer types are associated with greater solubility and nutrient supply during the phase in rice production. The use of fertilizer highly depends on the soil conditions of a farm. With that regard a commercializing farmer can produce higher quality output. High-quality rice can be easily differentiated in the market and farmers have the opportunity to charge premium prices. Hence, the increase in the use of fertilizer with a higher solubility level enhances the maximization of profit for rice commercializing farmers. The results are similar to those of studies done by [53,47] on cassava and rice respectively, where fertilizer price increase was significant and had a positive influence on profit efficiency attainment.

The estimated coefficient for the price of labour was negative and statistically significant at 10%. The negative coefficient indicates that with a 1% increase in the price of labour, the profit efficiency of rice commercializing farmers decreases by 0.017%. This is attributed to the fact that in commercialization farmers reduce the number of labour while increasing labour productivity. Therefore, the process involves labour with high skills and expertise and that are paid higher wages in the labour market. The result is similar to the study by [49,47,25] on rice and maize crops

The estimated coefficient for rice cropped area was positive and statistically significant at 1%. The positive coefficient indicates that with a 1% increase in the rice-cropped area, profit efficiency increases by 0.64%. This indicates that rice farmers can increase their level of profit by producing more rice even an increase in the land area for production. Also, the farmers attain economies of scale when increasing the size of land used for rice production. In this case, rice commercializing farmers may attain the cost advantages (decrease in unit cost) with an expansion of farm size. The result is similar to

[47,25,53,13] studies on rice crop profit efficiency.

The estimated coefficient for production assets value was positive and statistically significant at 1%. The positive coefficient indicates that with a 1% increase in production, asset value will increase the level of profit efficiency by 0.045%. The production assets increase the productive capacity of the farmers and most of the time rice commercializing farmers tend to accumulate a substantial amount of assets. The result indicates proper utilization of the assets since they increased the level of profit efficiency [54-58].

4.1.3 Profit efficiency scores estimates

The result indicated that rice farmers in Kilombero valley had an average efficiency level of 0.7565 equivalent to 75.6%. This indicates that rice farmers are efficient in attaining profit by 75.65% since it is greater than 50%. Although rice farmers are efficient, but are operating below the efficient frontier. This indicates that there is still room for improvement to reach the efficient frontier. They can increase profit efficiency levels by 24.4% by improving the technical allocation of resources with the same set of inputs.

Profit efficiency levels ranged between 0.144 (14.4%) and 0.945 (94.5%) following the frontier estimation. There is greater variation in the profit efficiency levels among rice farmers in the study area. This may be attributed to differences in planting techniques and practices, types, levels of input use, and levels of technology (mechanization).

Table 3. Parameter estimation of the maximum-likelihood stochastic profit function

Variable	Coefficient	Std. Error	t- Value
Constant	7.3244	0.2655	27.581 ***
Ln Price of Seed	0.0495	0.0433	1.1429
Ln Price of Fertilizer	0.0690	0.0235	2.9369 ***
Ln Price of Herbicide	0.0136	0.0116	1.1700
Ln Price of Labour	-0.0172	0.0104	-1.6635 *
Ln TLU	0.0146	0.0147	0.9965
Ln Rice area (Ha)	0.6378	0.0515	12.3616 ***
Ln Production Assets Value	0.0450	0.0163	2.7547 ***
Variance Parameters			
Sigma squared	3.3530	0.3161	10.606
Gamma	0.9745	0.0288	338.25
Log Likelihood	-213.949		

*Notes: * is significant at 10% **, is significant at 5% and *** is significant at 1% **

Table 3. Distribution of the efficiency scores

Efficiency Scores	Frequency	Percentage
1 – 0.91	7	1.8567
0.9-0.81	138	36.60
0.8 – 0.71	129	33.952
0.7 – 0.61	60	15.915
0.6 – 0.51	24	6.366
0.5 – 0.41	10	2.652
0.4 – 0.31	6	1.5915
0.3 -0.21	2	0.5305
0.2 -0.11	1	0.2652
Total	377	
Mean	0.7565	
Maximum	0.945	
Minimum	0.144	
Standard Deviation	0.121922	

4.1.4 Determinants of profit efficiency

From the inefficiency model, the coefficient for education, sex, use of tillage services, use of purchased seeds, access to extension services and access to seed dealers were significant at 10%, 5%, and 1% respectively.

The estimated coefficient for educational level in years was negative and statistically significant at 1%. The negative coefficient implies as years of schooling for rice commercialized farmer increase, the profit efficiency increase by 0.17%, holding other factors unchanged. The educational level influences the thinking process, decision-making, and management of resources. This implies that educated farmers are more flexible in investing in new technologies and the application of better agricultural practices than non-educated farmers. Similar results were obtained by Ali and Flin [13]; Ogunniyi, [23] production.

The parameter education had a negative effect on the inefficiency of a rice farmer in rice production. It was negative and statistically significant at 1%. This indicates that an increase in the education level for farmers by a year of schooling increases the efficiency level of farmers in attaining maximum profit possible and or suppressing inefficiency by 17.3% holding other factors unchanged. Literacy levels impact rice farmers' ease of uptake and utilization of information in different contexts and forms, implying a higher likelihood of well-informed decision-making in both production and market participation.

The coefficient parameter for sex was negative and statistically significant at 5%. The negative sign indicates that male-headed households are higher in attaining profit as compared to female-headed households by 0.12%. This may be attributable to the fact that males often participate in the production and commercial activities of the farm more than females. Most often females need to divide time between domestic activities and other production activities such as farming and others, hence the difference in participation and the level of profit respectively. This is similar to the findings in studies by [23,22].

The coefficient for the use of tillage services in rice production processes was positive and statistically significant at 1%. The positive coefficient indicates that farmers using tillage servicers have higher profit efficiency levels by 3.29% than their counterparts. Many rice commercialization farmers tend to shift from cultivating using hand hoes to the use of tillage services of different kinds when conversant. This is because farmers who use tillage services have the possibility of cultivating a larger land area properly at a low cost and time hence timeliness. This in turn may imply attaining more rice output compared to non-users.

The estimated coefficient for the use of purchased seed was positive and statistically significant at 1%. The positive coefficient indicates that farmers using purchased seeds were found to have lower profit efficiency levels than their counterparts by 4.2 %. This can be explained by the previous findings in this study that most farmers did not use purchased seed (improved varieties) in their production process but rather used and/or bought retained seeds from the previous harvests from fellow farmers. With that regard, the profit estimation process reflects gains associated with the use of local seeds for the specific time in which data was collected. However, using improved purchased seeds still guarantees good yields for a rice farmer, only that they should cultivate the crop under recommended input requirements and at a lower cost. This is so that the output produced is of good quality, sufficient to fetch a good price on sale in the market to offset the cost of purchasing the seeds.

Further, the results indicated that the coefficient for the use of extension services was positive and statistically significant at 1%. This indicates that rice commercializing farmers using extension services have a lower profit efficiency level than those who do not use it by 2.66%. This might be attributed to the fact that extension officers' visits to farms inform farmers on best agricultural practices including proper use of inputs for better yields. The results are similar to those of Saysay *et al.* [16] on rice farmers' profit efficiency levels in Ghana where the use of extension services had a positive influence on their ability to realize more profit in their production process.

The estimated coefficient for access to an established marketplace was positive and statistically significant at 1%. The positive sign for the coefficient indicates that farmers having an access to the established marketplace have a greater likelihood of attaining the maximum profit possible in their production process. This can be attributable to the fact that they incur less to negligible costs (transport costs, and other transaction costs) on accessing the market, than

Table 4. Parameter estimation of maximum-likelihood profit inefficiency equation

Variable	Coefficient	Std. Error	t-Value
Constant	-0.1000	0.2029	-0.4943
Age	0.0247	0.0165	1.5011
Education	-0.1733	0.0795	2.1786 ***
Sex	-0.1181	0.8293	-2.1850 **
Use of Tillage services	3.2996	1.2268	2.6895 ***
Use of artificial fertilizer	0.4340	0.9856	0.4403
Use of purchased seeds	4.2711	1.0644	4.0123 ***
Use of extension services	2.6592	0.7937	3.3502 ***
Household size	-0.0510	0.0661	-0.7716
Non-farm Income	-0.8548	0.6155	-1.3887
Access to Established Market	1.6887	0.5982	2.8226 ***
Access to tillage services (tractor)	3.0868	0.8505	3.6291 ***

*Notes: * is significant at 10% **, is significant at 5% and *** is significant at 1%*

rice farmers who have no access to the market. Hence on ease of trading output, the greater the likelihood of fetching a variety of prices for the output.

The estimated coefficient for the access to tillage services (tractors) was positive and statistically significant at 1%. The positive coefficient indicates that farmers with access to tillage services (tractors) are more inefficient in attaining profit than farmers who do not access and possibly do not use the services. This may be due to greater rental costs associated with tractor services in comparison to hired labour.

3.7 CONCLUSION AND RECOMMENDATIONS

The profit efficiency levels of rice farmers ranged between 14.4% and 94.5%. The study concluded that rice farmers in Morogoro are efficient. The farmers are operating efficiently but they have room to increase profit efficiency by 24.4% without changing the resources. The stochastic frontier revealed the price of fertilizer, price of labour, rice cropped area, and production assets value have effect on the profit efficiency levels of farmers. Further, the inefficiency model discovered educational level, sex, use of tillage services, use of agro-dealers, use of extension services, and access to established markets had influence on the inefficiency levels of rice farmers in the study area on average. The study concludes that commercializing rice farmers in the study area are profit efficient and the use of inorganic fertilizer can contribute to improving productivity and profitability. The study recommends policies at the lower levels, (local government level) that will encourage and emphasize to farmers to continue educating their generation by ensuring that young people attend education from primary up to secondary level. Education has been made free in public schools through the national “free education“ policy although with minor contributions, planning and strategizing with respect to the specific societies. This is following the fact that being educated is highly associated with better decision-making. In turn, this should foster intensification in agricultural production on the side of farmers utilizing, resources efficiently and so is better/ informed market participation. Different services (marketplaces and outlets for inputs) in the area should be improved further to create more room for rice farmers to improve their productivity and profitability. Further on, male-headed households showed more performance profit-wise than female-headed households. This calls for means to empower women and social-cultural initiatives to enable women to improve in managing on-farm activities and market participation as well.

ACKNOWLEDGEMENTS

African Economic Research Consortium (AERC) through the Collaborative Masters in Applied Agricultural Economics (CMAAE) Scholarship Programme and The Agricultural Policy Research in Africa for the data used to produce this study which was collected in the 2020 wave in Morogoro region, Kilombero district, and Mngeta division.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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