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Research Article

Technical Efficiency in Maize Production among Small-Scale Farmers in Batticaloa, Sri Lanka

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Maize is largely a subsistence food under promotion for ensuring food security and it is also the source of income for small-scale farmers in rural areas. The study of technical efficiency directs small-scale farmers, especially small-scale farmers in Koralaipattu North Division who tend to underutilise or over utilise some of the factors of production, to compare the expected potential yield with the actual yield. Therefore, 100 maize farmers were randomly selected as respondents from among 150 farmers for the study to estimate the technical efficiency of maize and its determinants in Koralaipattu North, DS division from December to March 2022. Cobb Douglas, Stochastic frontier production function was applied to identify the impact of each input on maize production and the findings revealed that log forms of the inputs such as land size, labour hours and fertiliser significantly affected the maize production in this study area. Further, the findings indicated that the mean value of technical efficiency was 78%. The inefficiency effect model indicated that the coefficient for farmers' experience, education, farm income and credit assistance were statistically significant and negative which reduced the technical inefficiency. The findings of the study suggest that government should initiate programs to exchange the farm experience among the community and promote farmers' education which encourages the adoption of new farming techniques and management. Further, providing additional income and credit facilities improves the efficiency of maize farming and their income in the future.

Keywords
Technical efficiency, maize farmers, stochastic frontier production function, technical inefficiency

INTRODUCTION

Maize *(Zea mays* L.) is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions. It is one of the world's most important crops for food security, domesticated for human utilisation as well as animal farming (Lana et al., 2017). Maize plays a key role in assuring food security as it provides about 15%–19% of the world's protein and calories respectively (Rena, 2004; Surinder, 2011). However, despite the increase in maize production, food insecurity is still a major problem worldwide. In 2014 over 1,022 million tons of maize was produced by more than 170 countries in about 181 million ha of land (Food and Agriculture Organization of the United Nations, 2016). Due to higher demand from the livestock and poultry feed industries, the Asian countries are increasing its production significantly.

Agriculture is an important sector in the economy of Sri Lanka. It contributes about 7.3% of the GDP and creates employment for about 23.73% of Sri Lanka's population (Central Bank Report, 2020). Among the agricultural sector, cereals except rice recorded a sharp positive growth of 12.9% in the first quarter of 2020 compared to the first quarter of 2019 which reported a negative growth of 19.8%. The major proportion of this positive growth is shared by 'Maize production' which is reported to show a production increase of 43.7% among other cereals and a price increase of 21% within the first quarter of 2020 when compared to the first quarter of 2019 (Sri Lanka Customs, 2019).

The domestic shortfalls of maize production are covered by imports due to the consumption of maize based food items like locally produced ready mix cereals, popcorns and boiled maize cobs which have increased during the past few years. According to Livestock Statistical Bulletin (2012), imports have significantly dropped in 2011, and only 8244 metric tons were imported as against 83195 metric tons imported in 2008.

However, FAO (2021) indicates that Maize production in Sri Lanka increased from 29,000 tons in the year 2000 to 351,000 tons in 2019, growing at an average annual rate of 16.73%. Yet the overall productivity of maize is not adequate enough to meet the increasing local demand, and consequently maize imports is taking place. The production gap clearly depicts that demand for maize is drastically increasing and the gap is being covered with the importation. According to the Sri Lanka Customs report 2018/2019, it is further observed that in Sri Lanka, 119,086 Tons of maize was imported in 2018 whereas 102,461 Tons was imported in 2019 and similarly, 1482 Tons of maize seeds was imported for cultivation in 2018 and 1076 Tons in 2019. Therefore, it is confirmed that local requirement has been met with importation.

According to the Resource Profile (2020), six Divisional Secretariat Divisions in Koralai Pattu North are major contributors to the maize production and most of the farmers fully depend on rain fed irrigation. In this context, Vaharai has been selected for the research study where higher yield of maize is contributed to the Batticaloa District annually. Variations in productivity due to efficiency disparities among small-scale farmers may be influenced by a variety of regional and farm-specific socio-economic factors. In order to discover these elements, a method of monitoring farmer performance must be developed. Improved efficiency of maize production is found to contribute to overcoming the problems of lower yield. Further, it helps to find the possibility of increasing yield by improving efficiency without increasing the resource.

Natesan & Jogaratnam (1997) & Rena (2007) found that low quality is the biggest constraint to the utilisation of locally produced maize both in feed and food industry, and this is mainly because of the involvement of a large number of small-scale poor farmers who do not have the basic facilities for processing maize in the country. Inadequate education with adequate inputs in agriculture development is another hindrance to small scale farmers (Belete et al., 1991). Also, small scale farmers have a tendency of underutilising or over utilising some of the factors of production. Therefore, there may be a knowledge gap in the technical efficiency of maize farmers in Sri Lanka.

Considering, food insecurity and poverty, the study of technical efficiency directs farmers to use the optimum combination of productive resources to achieve food sustainability (Rena, 2005, 2007). Koralaippattu North, Vaharai is one of the poorest DS Divisions in Batticaloa in terms of poverty with 28% living below the poverty line (Dung, 2013). Small-scale farmers in the research area cultivate maize as their source of income. Farmers are able to harvest approximately, 5000 kg per acreage (Resource Profile, KPN, 2020). To combat hunger, food insecurity, and poverty, agriculture must increase at a steady pace. Thus, this study intends to examine the technical efficiency of maize production in Koralaippattu North Division and factors affecting the technical efficiency of maize farmers in this research area.

LITERATURE REVIEW

The measurement of efficiency (technical, allocative and economic) has been carried out by various researchers for different crops all over the world. It is vital to developing countries, where resources are meagre and opportunities for adopting better technologies are dwindling. Therefore, this section tries to analyse the previous studies to understand the determinants of the technical efficiency of a product and determine the extent to which it is possible to raise productivity by improving the efficiency, with the existing resource base and available technology.

Factors Influencing the Technical Efficiency

Age

A study by Battese & Coelli (1995) on the paddy farms of Aurepalle India used panel data for 10 years and concluded that older farmers were less efficient than the younger ones. Farmers with more years of schooling were also found to be more efficient but this declined over the time period. But Battese et al. (1996) used a single stage stochastic frontier model to estimate technical efficiencies in the production of wheat farmers in four districts of Pakistan and confirmed that the older farmers had lesser technical inefficiencies.

To measure the technical efficiency of maize producers in Eastern Ethiopia, Seyoum et al. (1998) used a translog stochastic production frontier and a Cobb–Douglas production function. The key conclusion of the study was that younger farmers are more technically efficient than the older farmers. Further, older farmers are more experienced in farming activities and better able to assess the risks involved in farming than younger farmers, who contribute to the improvement of technical efficiency. However, the possible truth could be that older farmers who has not received a better education may be more technically inefficient than the younger ones (Tchale, 2009).

Education and efficiency

Using Tamil Nadu maize farmers, Kalirajan (1985) conducted a quantitative analysis of various types of education in relation to productivity in order to determine whether schooling of farmers has a greater influence on maximising yield, or not. The findings revealed that schooling of farmers had an independent effect on yield, but it was not significant. On the other hand, a farmer's non-formal education was found to have a significant and greater influence on yield. Kalirajan (1985) concluded that farmers' schooling and productive capacity need not be significantly related under all circumstances.

Daramola & Aturamu (2000) found out that acquisition of formal education exposes farmers to availability and technical-know-how of innovations and increases their desirability for acquiring them because increased level of education of farmers leads to increased knowledge input and their application. Similarly, the study of Rudra et al. (2016) examined the determinants of inefficiency in vegetable farms for improving rural household income in Nepal and its results revealed that vegetable farms can be improved to higher levels with farmers' education, and increased number of trainings to the farmers in Nepal. Therefore, this study tries to estimate farmers' education and its effect on the yield of maize in the study area.

Farm size and efficiency

The majority of maize farmers are small-scale farmers, farming on less than 3 acres. But many small-scale farmers along with subsistence producers follow low input cultivation practices. Gautam & Jeffrey (2003) used stochastic cost function to measure efficiency among smallholder tobacco cultivators in Malawi. Their study revealed that larger tobacco farms are less cost inefficient. The paper uncovered evidence that access to credit retards the gain in cost efficiency from an increase in tobacco acreage. This suggested that the method of credit disbursement was faulty. However, farm size will be examined with yield level in this study.

According to Nieuwoudt (1990) & Rena (2005), small-scale farmers may use land much more intensively than large farmers and their study revealed that farms with less than one hectare applied inputs much more intensively than farms with more than one hectare, thus, suggesting that smaller farms may maximise returns to land while larger farms maximise returns to labour and capital. In this line, Hasnain et al. (2015) analysed the technical efficiency of rice farms in Bangladesh. He found that farm size significantly and positively affects the technical efficiency of rice production.

However, the effect of farm size on efficiency is a controversial issue, small-scale farms may be more efficient in terms of transaction costs than large ones. On the other hand, large farms have the advantage of attaining economies of scale by spreading fixed costs over more land and output, getting volume discount for purchased inputs (Ogolla & Mugabe, 1996; Rena, 2004). Other studies on productivity of crops in Sri Lanka such as rice (Shantha et al., 2012), tea (Basnayake & Gunaratne, 2002) and Potato (Amarasinghe & Weerahewa, 2001) has revealed that land is a significant factor in production. Therefore, farm size is also a crucial factor to be analysed the productivity of the study area.

Gender issues and efficiency

Informal sector activities have become increasingly important in rural areas. For some women, formal employment outside the home is not a feasible income generating strategy for reasons which include lack of access to transport, domestic responsibilities, inadequate job training or lack of previous work experience, and other barriers pertaining to entering the workforce (Orberhauser, 1993).

A study done by Yiadom-Boakye et al. (2013), on rice farmers in the Ashanti Region, Ghana, has found out that female headed farms recorded a mean technical efficiency of 16.5% with a range of between 2% and 66%. The male headed farms, on the other hand, showed a mean technical efficiency of 30.8%, and a range between 2% and 85%. The results imply that on an average, the female rice farmers are relatively technically inefficient than their male counterparts. Hence, this study will be examined while dealing with productivity in connection to gender.

Labour source and efficiency

The greater efficiency of family labour on small-scale farms may be due to two factors; first, as the ratio of hired labour to family labour rises, supervision becomes more time-consuming and less effective. Second, as the social distance between the supervisors and the hired labour increases, the effectiveness of supervision will decrease (Boyce, 1987; Rena, 2004).

Carter & Wiebe (1990), argue that small-scale hyper productivity is eventually overwhelmed by capital constraints as farm size increases; it becomes less easy to substitute family labour with hired labour and other purchased inputs. Since credit markets in many less-developed countries are characterised by undeveloped financial institutions the cost of and access to credit is inversely related to farm size (Cornia, 1985).

However, another study done by Michael (2011) in Nigeria among yam farmers has detected that labour from family sources was mostly used in yam production and Labour for land preparation and maintenance with farm distance showed a negative decreasing function to the factors and reduced yam output. Labour resource is a crucial factor to be analysed in connection with the productivity of the area under study.

Hybrid seed and efficiency

Considering the level of technology generally used by smallholder farmers in producing maize, the farmers tend to depend on family and community, cooperation labour (Kimenyi, 2002). Using improved seeds in crop production is one way of increasing productivity in terms of quantity and quality (Kiplangat, 2003).

Despite the low level of production technology used by smallholder farmers in developing countries, the use of improved seeds is said to be on the increase (Kiplangat, 2003). The availability of these seeds is usually in the markets. Thus, farmers with more access to the market may have increased potential of using them appropriately, and subsequently improve crop productivity.

Chemical fertiliser and efficiency

The use of chemical fertiliser is known to be a commonly used method in improving productivity. In the intensification of agricultural production as a whole chemical fertiliser plays a big role in regions where the scarcity of farm land is a big problem and traditional fallow periods are either very short or no longer in existence. However, the appropriate use of these fertilisers is very important in achieving the desired results. Disproportionate use of fertilisers is usually common among farmers with little knowledge about them, or with little access to extension agents. In such a case, productivity may be affected negatively (Hopper, 1965).

Further, Dominic Tasila Konjal et al. (2019) studied the technical and resource use efficiency among smallholder rice farmers in Northern Ghana. The Translog production frontier was analysed to estimate the efficiency scores and the results show that the quantity of weedicide used has positive effects on output of rice. Therefore, fertiliser is also to be analysed for the technical efficiency of maize production in the area under study.

Access to extension service and efficiency

In contrast, Awoniyi & Bolarin (2007) & Kibirige (2013) expressed in their study that increase in farmers' access to extension services would increase their efficiency in maize production, but results in the model indicate that increase in farmers' access to input use of training leads to a decrease in technical efficiency. The negative relationship between access to extension services and technical efficiency may be a result of poor-quality extension services rendered to farmers due to technically unqualified extension staff or farmers, who do not put into practice what is being taught by extension officers.

Further, a study by Getachew (2018) was to estimate technical efficiency of barley production in the case of smallholder farmers in market district in Ethiopia. He indicated that extension contacts significantly and negatively affected technical inefficiency score in the study.

However, a study mentions the promotion of technical change through the generation of agricultural technologies by research and their dissemination to end users play a critical role in boosting agricultural productivity in developing countries (Mapila, 2011). Thus extension service also plays an important role in productivity.

Uses of tractor and efficiency

Farmers currently use some form of mechanisation in cultivation. Abramov & Malek (2012) found in their study that use of tractors in land preparation reduces the technical efficiency through timely land preparation and planting. By contrast, Ali & Khan (2014) mentioned in their study that tractor plow significantly increases the wheat productivity. Hence, the use of tractor is an input to be analysed in connection with technical efficiency.

Farm income and efficiency

The study by Goyal et al. (2006) on paddy farming is significant at 1% level and it revealed that as the farm income increases, it is possible to reduce the technical inefficiency by spending more expenditure on paddy to buy necessary inputs and improving the production in the next season.

Similarly, Obwona (2006) estimated a Trans-log production function to determine technical efficiency of tobacco farmers in Uganda using a stochastic frontier approach. The estimated efficiencies were explained by socioeconomic and demographic factors. The results showed that farm assets contribute positively towards the improvement of efficiency. Another study mentioned that farm income influences the technical efficiency of farm household agricultural production in Pakistan (Mehmood, 2017). Hence, farm income or asset is an important factor to be analysed while studying efficiency of production in the area under study.

Credit assistance and efficiency

Binam et al. (2004) examined factors influencing technical efficiency of groundnut and maize farmers in Cameroon and the study concluded that access to credit, social capital, and distance from the road were important factors explaining the variations in technical efficiencies. Similarly, another study was done by Addai & Owusu (2014) on technical efficiency of maize farmers across various Agro Ecological Zones of Ghana. The results showed that credit assistance positively influenced the productivity of maize.

Further evidences from Sri Lanka show that smallholder farmers can benefit from contract farming arrangements with private sector companies (Esham et al., 2005). Further, they mentioned in their study that government should provide incentives to the private sector to enhance their role as partners in contract farming schemes involving smallholder farmers. Hence, credit assistance must be examined in order to analyse the efficiency of maize production.

As shown in Figure 1, KPN Division has recorded the highest yield compared to the other DS Divisions in Batticaloa District except for the Maha season in 2020/21.

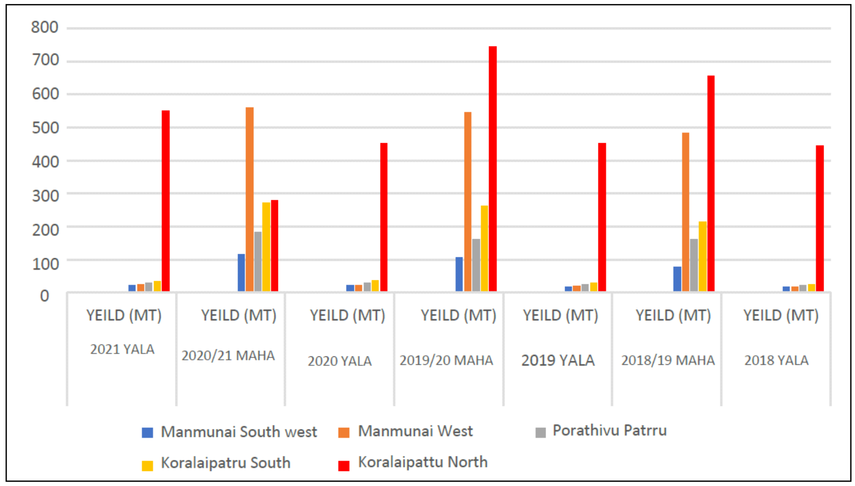

Figure 1: Trend in maize cultivated season and the yield in Batticaloa District
Source: Resource Profile, District Secretariat, Batticaloa, 2020

Conceptual Framework

Figure 2 indicates the possible underlying factors influencing maize production among small scale farmers in the study area. Conceptual frame work was formulated based on the production theory where Y is the output (yield) and X are production factors (Cobb & Douglas, 1928). It was organised in terms of influence and feedback mechanisms of farm level production efficiency. Production factors (seed, land size, fertiliser, labour, etc.) were used as inputs for maize production process. It was anticipated that as more inputs were used by the farmer, yields would increase on one hand but this may have a negative effect in cases of overuse. Therefore, optimality was crucial in deciding the level of inputs to be applied. Yield levels were affected by efficiency of production of a farmer.

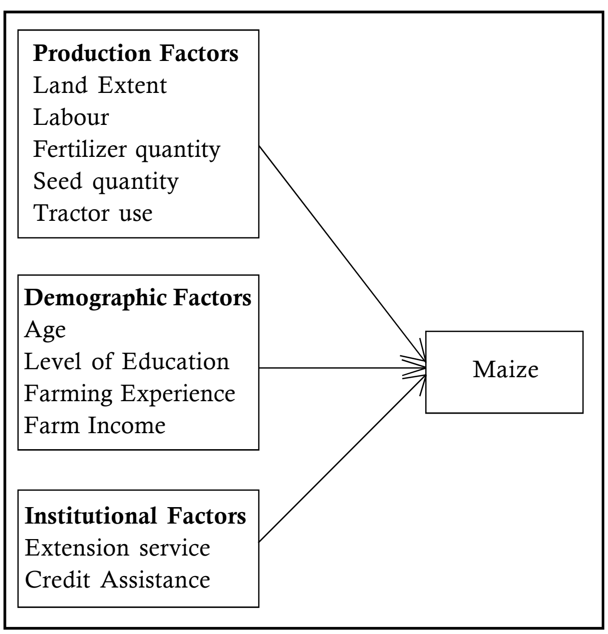

Figure 2: Conceptual Framework
Source: Extracted from Esham (2009); Sibiko (2012); Sapkota & Joshi (2021)

Socioeconomic and institutional factors were expected to influence farmers' efficiency. Socio-economic factors that were anticipated to influence technical efficiency included age of the decision maker, farming experience, education level, farm income and institutional factors such as amount of credit used and extension service contact were hypothesised to influence TE.

Theoretical Framework

Technical efficiency (TE) relates the rate of the maximum output from given inputs, or the minimum amount of inputs to produce a given output. This technical efficiency led to output-oriented and input-oriented efficiency measures. These two measures of technical efficiency will coincide when the technology displays constant returns to scale (Coelli et al., 2005; Rena, 2005). Therefore, technical efficiency is an important factor that has to be analysed along with other factors affecting any production. Different methods for measuring TE have been developed and currently, two approaches namely the Stochastic Frontier Analysis (SFA) and the Data Envelopment Analysis (DEA) are mostly used in measuring TE.

These approaches are qualified as a primary model in the analysis of technical efficiency (Coelli, 1996; Thiam et al., 2001).

Cobb–Douglas Production Function

The Cobb–Douglas production function widely used to represent the technological relationship between two or more inputs and the output that can be produced by those inputs. Also, this form of stochastic frontier model was used in this study.

A linear relationship Cobb–Douglas production was established for the study as follows.

$$\text{In}(Y) = \alpha_0 + S_i \alpha_i \text{ In } (I_i)$$

where, Y = Output
I_i = Inputs
α_i = Model coefficients

RESEARCH METHODOLOGY

The present study was conducted in Kallarippu village, Koralaippattu North Divisional Secretariat, Vaharai. Here farmers engage in Maize cultivation during rainy seasons. There are around 150 farmers residing in this village. They are involved in persistent maize cultivation for their source of livelihood and the lands are cultivated once in every three months annually by pumping water from Verugal river basin and consequently they could be contributed to the Batticaloa District as a leading and main contributor in the line of maize production (Resource Profile, KPN, 2020). Primary data was collected using structured questionnaires with randomly selected 100 farmers among 150 maize farmers in this study area.

Analytical Tools and Techniques

As the Cobb–Douglas (C–D) production function is commonly used in Stochastic Frontier Analysis (SFA), the following methods of techniques were applied to analyse the data in the study. Further, the variables of this study were shown in Table 1.

Stochastic Frontier Production Function

This is a measure of the efficiency scores of individual famers. Cobb–Douglas production function of the stochastic frontier production function was used in the study where the maize production was taken as output and five inputs such as land size, labour hours, quantity of seed, quantity of fertiliser and duration of tractor are defined as production inputs. The empirical model of the Cobb–Douglas production function takes the maize production as dependent variable and its major inputs are taken as independent variables in the model as below:

Table 1: Variables description of the model

Variable		Definition
Yield		Yield of maize in kilogram per acre
Land		Area under maize cultivation in acres
Labour		Labour used per hectare (number)
Tractor		Duration of tractor use per acre (hours)
Seed		Seed used per acre (kg)
Fertiliser		Chemical/Organic fertilisers used per acre (kg)
Farming Experience		How many years of experience do respondent have
Resource accessibility	Age	Age of farmer in years
	Education	Household heads' education in number of years of schooling
	Farm Income	How much earn from the farm per cultivation
	Family Size	How many members in the family
	Credit Assistance	How much credit assistance receive per cultivation
	Extension service	How many times an extension agent visit
Number of observations	n = 100	

Source: Modified from Esham (2009); Sibiko (2012); Sapkota & Joshi (2021)

$$\ln Y_i = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \varepsilon_i \quad \ldots (1)$$

Where, ln Yi = Yield of maize production (kg)
$\ln X_1$ = Size of cultivated land (Acres)
$\ln X_2$ = Labour (Hours)
$\ln X_3$ = Quantity of seed (kg)
$\ln X_4$ = Quantity of fertiliser (kg)
$\ln X_5$ = Duration of tractor (Hours)
β_0 = Constant term
β_1, β_2, β_3, β_4 and β_5 are the coefficients of each independent variable respectively.
ε_i = Error term

Inefficiency Effect Model

After estimating the technical scores using production, the inefficiency effect model is also employed to identify the impact of farmers' demographic and farming characters on technical inefficiency. For this purpose, variables related to demographic characteristics and farming characteristics among the stakeholder agricultural farmers were collected from the respondents in the area chosen for study. Thus, the determinants of technical efficiency were modelled in terms of those characters which is specified by the following efficiency model.

$$| \mu_i | = \alpha_0 + \alpha_1 Z_1 + \alpha_2 Z_2 + \alpha_3 Z_3 + \alpha_4 Z_4 + \alpha_5 Z_5 + \alpha_6 Z_6 + \alpha_7 Z_7 + \epsilon \quad \ldots (2)$$

Where, μ_i: Inefficiency
α_0: Intercept term
Z_1: Education level of farmer (Years)
Z_2: Experience of farmer (Years)
Z_3: Credit Assistance (Amount)
Z_4: Age of farmer (Years)
Z_5: Family size (Number)
Z_6: Family income (Amount)
Z_7: Extension Service (Number)
ϵ: Random error

Data Analysis

The collected data was first entered into Microsoft Excel. For the Maximum Likelihood Estimation (MLE), the data was imported and analysed using STATA. The unknown parameters of the stochastic frontier production and the inefficiency effects were estimated simultaneously.

From the estimation of the stochastic frontier production function, the effects of the production inputs on maize output were obtained and statistical tests at this level revealed the significant determinants. The stochastic frontier production function and the inefficiency model defined by equations (1) and (2) are simultaneously estimated by using STATA. The variance parameters are expressed in terms of $\gamma = (\sigma^2_u / \sigma^2_u + \sigma^2_v)$ and the γ parameter lies between zero and one.

Hypotheses Test of the Study

The hypotheses to be tested were:

1. There are no inefficiency effects in the specified stochastic production function and the value of gamma $[\gamma = (\sigma^2_u / \sigma^2_v + \sigma^2_u)]$ equals zero: $H_o: \gamma = 0$.
2. There are no inefficiency joint effects of the considered socio-demographic and institutional factors on technical efficiency in the study area. This null hypothesis is then written as $H_0: \sigma_1 = \sigma_2 =\ldots= \sigma_7 = 0$, where σ represents the parameters of the considered factors.

RESULTS AND DISCUSSION

Democratic Information of Respondents

Small-scale farmers are distinguished based on the physical parameters of farms (utilised agricultural area, inputs used e.g. labour, fertiliser, seed), the economic size of farms in terms of standard output, and the ratio of market participation (Davidova et al., 2010). In this study concerned farmers' socio-economic parameters are related to production in order to identify the technical efficiency which is directly interconnected to farm productivity.

Table 2 depicts the number of sampled farmers by gender and marital status from the study area. Among the sample, 86% were male while only 14% were female and 87% of respondents were married while only 13% of them were single. Generally, in Vaharai Division, men are more engaged in agricultural activities especially in maize cultivation for their livelihood.

Table 2: Democratic information of respondents

Variables	Percentage
Gender	
Male	86
Female	14
Civil Status	
Married	87
Single	13
Education level	
Grades 1–5	56
Grades 6–10	34
O/L	5
A/L	4
Degree	1
Extension service	
One time	25
Two times	11
Three times	20
Four times	38
Five times	6
Experience (years)	
Less than 5	9
6–10	24
11–15	30
16–20	12
21–25	9
25–30	4
Total Sample	100

Source: Researchers' calculation

As the results presented in Table 2, majority of the maize farmers did not complete the compulsory education as mentioned by the Ministry of Education of GOSL. Among the respondents, 56% completed Grade 1 to Grade 5 and 34% of respondents completed grade 6 to grade 10 while a few of them completed O/L, A/L and degree. This indicates that many unskilled householders are engaged in maize farming and majority of the respondents depend on maize farming as their livelihood.

Further, 38% of the respondents are recipients of extension services from the Ministry of Agriculture of GOSL four times during the maize farming period. The extension agent visited 25% of the respondents at one time and another 11% was visited twice. It may be due to the difficult access from the town to the farm that the extension officers are not be able to reach the farmers quite often.

Majority of the respondents have been involved in maize farming for more than ten years. Only, 9% of respondents had less than five years of experience. Only 4% of the respondents had more than 25 years of experience. All the maize farmers had some prior experience regarding the maize farming management and practices.

The mean age in the study sample was found to be 47.2 and the mean number of persons per household was 3.93 as given in Table 2. Majority of the respondents were young and were able to produce higher yields since they were physically healthy enough and strong. However, Bhavan & Maheswaranathan (2012) have found that farmers' age does not have any significant effect on the yield in Batticaloa. According to Table 3, the smallest household had one member while the largest had 7 members among the respondents.

Table 3: Mean age and household size

Variable	Mean	Std. Dev.	Min	Max
Age	47.2	12.97784	28	74
House Hold Size	3.93	1.281216	1	7

Source: Researchers' calculation

Maize Farming Inputs

The main farming inputs considered for this study are explained by Table 4. According to this table, respondents utilised different amount of human labour hours, land, seed, fertiliser and tractor as inputs per acre. As shown in Table 4 an average of 3169.5 kg per acre of maize was yielded from an average of 1.7-acre land with 31.5 hours of work force, 2.64 hours of tractor duration, 8.5 kg of seed and 71.5 kg of fertiliser. Further, all farmers made use of hybrid maize seeds for their cultivation.

Empirical Results from the Stochastic Frontier Analysis

It elaborates on the results obtained from the econometric analysis of the stochastic production frontier of the Cobb–Douglas functional form. It

Table 4: Production inputs for maize farming

Variable	Mean	Min	Max
Yield (kg/acre)	3169.5	600	12000
Land (acre)	1.7	1	5
Labour (hours)	31.5	23.7	69.6
Duration of tractor (hours)	2.64	1.5	10.5
Quantity of seed (kg/acre)	8.5	5	25
Fertiliser (kg/acre)	71.5	50	250

Source: Authors' calculation using STATA, 10

initially explains the results from the estimation of the production frontier function on the significant parameters with effect of maize yield. Secondly, it further analyses the results from the technical efficiency prediction to improve the maize yield.

The stochastic frontier production function was used to determine the factors which influence the maize production among farmers in the study area. In the given model, according to among the five variables, the log of labour hours, the log of land size and the log of fertiliser are significant while remaining variables such as the log of seed quantity and the log of tractor hours are insignificant.

The coefficients of each variable represent the elasticity of maize yield with respective inputs which means percentage changes that occur in output as a result of 1% change in input. In this line, coefficient of labour hours 0.63 reflects that as the labour hours is increased by 1%, it will lead to production of 0.63% of more output of maize while the remaining inputs remain constant. Similarly, coefficient of land size 0.65 shows that as the cultivated land size is increased by 1%, it will increase the output by 0.65% while other inputs remain constant.

These findings reveal that farmers are currently cultivating below the optimal land scale in maize production in this area, and an increase in area would increase the maize production. However, land resource management must be considered carefully since arable land scarcity greatly affects the next generation.

The relationship between land size and maize production in this study is similar to the study made by Khan et al. (2010) on maize farming in Bangladesh; and Baruwa & Oke (2012) in their study on cocoa yam in Nigeria. In contrast, a study by Chirwa et al. (2008) mentions that land size negatively influences the maize yield in Malawi in Table 5.

Moreover, the coefficient of fertiliser was 0.07 which is also statistically significant and positively influences the maize production. The remaining variables including the use of tractors for maize farming and the use of high quality seeds were insignificant. However, a study by Kibaara (2005) indicated that agricultural mechanisation was statistically significant in a study of the technical efficiency of maize production in Kenya where households that used tractors for land preparation increased their technical efficiency by 26%.

Estimation of Variance Parameters Using Stochastic Production Frontier

It is indeed necessary to identify the variant parameters that are useful to measure both efficiency and inefficiency among maize farmers in the area chosen for study in order to identify the determinants of the production factor in the area. These findings would be useful to enhance the maize production in the future.

Table 5: Estimated inputs results using stochastic frontier production function

Variables	Coefficient	Standard Error	P > Z
Constant	5.215747	.7703958	0.00
Ln land (size)	.6597102	.3518519	0.031
Ln labour (hours)	.6379482	.2538963	0.012
Ln seed (quantity)	.0417357	.2692137	0.808
Ln Fertiliser (quantity)	.0767906	.0590471	0.003
Ln Tractor (hours)	–.2222446	.2692137	0.409

Source: Authors' calculation using STATA, 10

Table 6: Estimation of variance parameters

Variables	Coefficient	Standard Error
Sigma-v	.0572715	.0125919
Sigma-u	.2736035	.0316474
Sigma square (σ^2)	.0781389	.0170352
Lambda	4.777308	.0367173
Log likelihood	11.173286	
Wald chi squared	1568.27	
Chi bar squared	50.3	

Source: Researchers' calculation

Table 6 represents the estimation of variance of parameters produced stochastic production frontier using exponential distribution method. Moreover, value of sigma u is higher than the sigma v which shows the presence of the inefficiency and the value of lambda is equalled to 4.77 which also shows the presence of technical inefficiency among maize farmers in the study area. The value of log likelihood ratio test of chi bar squared distribution is equalled to 50.33 which is significant at 5% level and confirms the presence of the inefficiency effects.

Hypotheses Testing

Two hypotheses such as (1) the absence of inefficiency effects in maize production in the study area and (2) absence of joint effect of the considered socio-demographic, economic and institutional factors on the inefficiency component were formulated and statistically tested for this study.

According to Coelli et al. (2005) for the half-normal and the exponential models, the null hypothesis that the absence of inefficiency effects involves one parameter often noted as sigma ($\sigma\mu$). The parameter represents the variance related to the inefficient effects in the stochastic frontier model. As the variance inefficiency effects is concerned, Battese & Coelli (1995) specified another parameter gamma (γ) which is associated with two error terms of the stochastic frontier functions.

The parameter γ measures the output deviation from the frontier caused by inefficiency effects and it equals to $\sigma^2\mu$ / ($\sigma^2\mu$ + $\sigma^2\mu$) where $\sigma^2\mu$ and σ^2v respectively stand for the variances related to inefficiency and statistical noise.

The first hypothesis testing was conducted to check if these effects were statistically significant. Findings in Table 7 showed that the calculated chi-squared values (χ^2) for the estimated model exceeded the critical values from the statistical table which lead to the rejection of the first null hypothesis. Hence, there is an inefficiency effect in maize production in the study area.

The second hypothesis stated that there is no joint effect of age, household size, maize farming experience, education level, use of credit in maize farming, farm income and visit of extension agent were not significant. Table 7 showed that this hypothesis was rejected based on the value of chi-statistics which exceeded the critical values. This leads to the conclusion that the joint effect of the seven variables was significant.

Technical Efficiency Levels among Maize Farmers

As per the results shown in Table 8, the mean value of TE was estimated to 78% with a range from 25% to 98%. About 42% of respondents recorded a technical efficiency of 61%–90% and 37% of respondents showed 91%–100% of technical efficiency; 21% of respondents recorded a technical inefficiency of below 40% which means still farmers in the study area utilised the resources inefficiently in the production process though many of the farmers have improved their technical efficiency.

Determinants of Technical Inefficiency

Technical inefficiency was calculated using farmer's experience, farmer's education, family size,

Table 8: Frequency distribution of technical efficiency values

Technical Efficiency (%)	Frequency	% of Total
0–30	1	1
31–60	20	20
61–90	42	42
91–100	37	37
Total	100	
Mean TE	.7881593	
Minimum TE	.25561	
Maximum TE	.9828878	

Source: Researchers' calculation

Table 7: Tests of hypotheses in the estimated models

Hypotheses	Null hypotheses	Log Likelihood	Chi-Square statistics	Critical Value	Decision
Hypothesis 1	H0 = 0	11.17	50.33	0.00491	Reject H0
Hypothesis 2	H0 = 0	31.3	64.91	3.9×10^{-18}	Reject H0

Source: Estimated using Kodde & Palm (1986) age, extension services, farm income and credit assistance and error term (u). The results from Table 9 suggests that coefficient of all variables such as farmer's experience, farmer's education, family size, age, extension services, farm income and credit assistance are found statistically significant in the inefficiency model of maize farmers, whereas the coefficient for farmer's experience, farmer's education, farm income and credit assistance in the inefficiency model were negative and they may either reduce the technical inefficiency or increase technical efficiency of the production.

The coefficient for experience of farmers is negative and it reflects that by adopting new techniques, knowledge and skills, efficiency level would improve. However, age is in a negative relation with productivity. Old farmers are unable to adopt better techniques as their technical efficiency is low. An increase in experience in maize seed production will increase TE by 0.02%, which is significant at 5% level of significance. Farmers having more years of experience are better placed to acquire the knowledge and skills necessary for choosing appropriate new farm technologies over time. They can manage the field efiectively and allocate the resources wisely. Experience in farming tends to increase farmers' capacity to do better. Hence, they infiuence TE positively and significantly.

The negative sign of farmer's education indicates minimal number of years of schooling, and it will reduce the technical inefficiency. Education would help to understand the maize farming techniques and management which would eventually lead to increase in efficiency. Similar findings made by Awudu & Richard (2001) in their study on technical efficiency during economic reform in Nicaragua found that education increases efficiency. A study by Seyoum et al. (2000) on technical efficiency among maize farmers in Ethiopia has found that educated farmers adopt new technology and it increases efficiency.

Though family size is statistically significant in this model, they are negative in affecting productivity in this study. The positive relationship between the technical inefficiency and extension contacts could lead to negative relation in productivity. Similar findings were made in the study of Tijani (2006) & Ezeth et al. (2012). In contrast, Nchare (2007) and Muhammad-Lawal, Omotesho & Falola (2009) found out a positive relation between productivity and technical efficiency of youth participation in agriculture, in their studies on coffee production in Cameroon.

Further, the coefficient of farm income and credit assistance in the inefficiency model reveal that these may be used to purchase additional farming inputs and helps to improve the risk tolerance capacity of the maize farmers in the study area thereby increasing the efficiency of maize production. However, extension service is negatively correlated with maize productivity.

Empirical findings of TE indicated that the farmers achieved 78% of technical efficiency in maize production on an average and it suggests that maize farmers in the study area still have to improve their farming efficiency by 22% from its present level and this variation has arisen from differences in production

Table 9: Inefficiency effect model

Variables	Coefficient	Standard Error	P > Z
Constant	6.416642	.0002625	0.000
Experience (years)	–.0205691	3.75e-06	0.000
Education (years)	–.0369951	3.65e-06	0.000
Family size (numbers)	.013609	3.54e-06	0.000
Age (years)	.0485412	6.16e-06	0.000
Extension services visit (numbers)	.0029684	1.98e-06	0.000
Farm income (amount)	–.0166489	.0000179	0.000
Credit assistance (amount)	–.042454	9.02e-06	0.000

Source: Researcher's calculation

factors, demographic characteristics and institutional factors rather than random error. Of them, 37% operate with more than 91% of technical efficiency.

The stochastic frontier production function is applied to identify the impact of each input on maize production and its results show that log forms of the inputs such as land size, labour hours and fertiliser significantly affect the maize production in the model. Hence, it is important for the government and farmer organisations to work collectively to ensure proper planning of land use, and optimal usage of fertiliser and labour.

CONCLUSION

In conclusion, the results of inefficiency model in this study reveal that farmer's experience, farmer's education, farm income and credit assistance negatively influence technical inefficiency. Therefore, efficiency improvement can be ensured firstly, by motivating the experienced farmers to be involved in maize farming and then secondly, by capacity development of farmers which can be improved by conducting training, and sharing experience among maize farmers.

Moreover, greater efforts must be taken by the financial institutions and banks that focus on credit accessibilities for small scale farmers, to stimulate the current levels of efficiency and productivity of maize farmers in the future. Additional farm income from the maize farming makes higher efficiency in production and increases risk tolerance.

Recommendations

The findings of this research study indeed bring some benefits for maize farmers to increase the TE in their production in future. Therefore, the following implications are recommended based on the findings of the study to uplift the maize production in KPN.

- Focus on pioneering effective institutional arrangements with collaboration of GOSL and NGOs that would enhance the positive influence of access to credit through which maize farmers are able to raise the required funds.
- Based on the findings, both formal and informal education are deemed to have a huge impact on attaining higher efficiency levels in maize production in the study area. This can be attained through farmer forums and on farm practical demonstrations. Provision of non-formal agricultural education could be a supplement to formal education.
- More Focus on comprehensive land consolidation plan may help to increase maize production and hence improve efficiencies in the study area. Fertiliser subsidy programme for maize farmers will also enable to increase production in the study area.
- This study only evaluated the technical aspects of production efficiency of maize production. This study identified only optimal use of farming inputs. Therefore, the study recommends an assessment of allocative efficiency and economic efficiency of maize production which would be a comprehensive study to specify the inputs in the maize production in the study area.
- It is vital to streamline local hybrid seed production program to ensure the availability of high-quality seeds to farmers at an affordable price.

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