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Viengpasith, Vanisaveth
Laboratory of Environmental Economics, Department of Agricultural and Resource Economics

Yabe, Mitsuyasu
Laboratory of Environmental Economics, Department of Agricultural and Resource Economics, Faculty of Agriculture, Kyushu University, Graduate School of Bioresource and Bioenvironmental Sciences

Sato, Goshi
Laboratory of Environmental Economics, Department of Agricultural and Resource Economics, Faculty of Agriculture, Kyushu University, Graduate School of Bioresource and Bioenvironmental Sciences

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Analysis of Technical Efficiency of Smallholder Maize Farmers in Northern Lao PDR: Case Study of Paklay District, Sayaboury Province

Vanisaveth VIENGPASITH[1], Mitsuyasu YABE[2]* and Goshi SATO[2]

Laboratory of Environmental Economics, Department of Agricultural and Resource Economics,
Faculty of Agriculture, Kyushu University, Fukuoka 812–8581, Japan
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This study estimated the level of technical efficiency of smallholder maize farmers in Paklay district, Sayaboury province, Lao People's Democratic Republic. Primary data for the study was collected through the use of a set of structured questionnaires administered to 178 smallholder maize farmers in three villages in the study area. A stochastic frontier production function was used to estimate technical efficiency and to identify socioeconomic characteristics influencing technical efficiency in maize production. The key finding was that the mean technical efficiency of smallholder maize farmers was 85%. Major contributing factors to technical efficiency were educational levels, experience, farm size, agricultural group membership, and credit access.

Key words: Stochastic frontier analysis, technical efficiency, smallholder maize farmers

INTRODUCTION

The Lao People's Democratic Republic (Lao PDR) has an agricultural farming–based national economy. Nearly 80% of its population of 6 million live in rural areas and their main income derives from agricultural farming and exploiting their surrounding natural resources. Particularly, agriculture has played the most important role in the national economy. In 2010, the agricultural sector accounted for 29% of gross domestic product (GDP).

Promotion of cash crop cultivation is one of the government's priorities to create jobs and increase income for local communities. In addition, to fulfil the government's goal to eradicate poverty and remove Lao PDR from the UN list of Least Developed Countries by 2020, the Lao Government has instigated a policy to transform subsistence farming into market–oriented agricultural production, as well as to improve productivity in rural areas and promote commodity production for export. One of the key actions is introducing new technology applications.

In northern Lao PDR, rice, maize, beans, starchy roots, peanuts, soy beans, sugarcane, and other commercial crops are commonly seen. Maize is the second most productive commercial crop after rice. Between 1995 and 2009, annual maize production in Lao PDR increased from 48,000 tonnes to approximately 1,134,000 tonnes Lao maize production for export also rose from approximately 9000 to some 315,000 tonnes over the same period. This was due to high demand for maize products as food for raising poultry and pigs in both Lao PDR and neighbouring countries to meet higher demand for meat concurrent with demographic change. Hence, maize products are used not only as supplemental feed for livestock in domestic markets but also in external markets, especially in neighbouring countries such as Thailand, Vietnam, and China.

In Lao PDR, low productivity in agriculture is a serious problem because subsistence farming is widely practiced, resulting in low income for farmers. According to one report (Sayaboury Provincial Office of Agriculture and Forestry, 2009), although technology application has been a key solution in increasing productivity, it was found that farmers incurred additional farming expenses when using such technology. Some farmers were therefore not satisfied with their yields because they caused no change in their production. In addition, farmers experienced a limitation of cultivatable lands, mostly slope land, and had inadequate knowledge to use recommended technology for land preparation, causing a decline in maize production.

Various studies have tried to justify why efficiency is important in developing countries' agriculture. Bravo–Ureta and Pinheiro (1997) suggested that attention to productivity gains arising from more efficient use of existing technology is justified. Thus, productivity increases do not depend on adoption of new technologies but effective use of available technologies. Although new technologies have partially succeeded in improving productivity in developing countries (Xu and Jeffrey, 1998), the benefits from new technologies may not be realized in the short run (Feder *et al*., 1985). Efficiency is an important factor for productivity growth. Agricultural productivity is defined as a measure of the efficiency of an agricultural production system employing land, labour, capital, and other resources (Oluwatayo *et al*., 2008). Moreover, several factors, including socioeconomic and demographic factors, farm characteristics, environmental factors, and non–physical factors were likely to affect the efficiency of smallholder farmers

[1] Laboratory of Environmental Economics, Department of Agricultural and Resource Economics

[2] Laboratory of Environmental Economics, Department of Agricultural and Resource Economics, Faculty of Agriculture, Kyushu University, Graduate School of Bioresource and Bioenvironmental Sciences, Fukuoka 812–8581, Japan

* Corresponding author (E–mail: yabe@agr.kyushu–u.ac.jp)

(Kumbhakar and Bhattachary, 1992; Ali and Chaundry, 1990).

Study Objectives

The main objectives of this study were to:

i. Estimate technical efficiency levels in smallholder farms producing maize;
ii. Examine farming inputs such as seed, pesticide, and material application and their effects on technical efficiency of maize farmers; and
iii. Identify socioeconomic characteristics that influence technical efficiency in maize production including level of education, role of gender, off–farm income, farmers' experience, agricultural association membership, and credit access.

Theoretical Framework

Technical Efficiency – A formal definition of technical efficiency, used by Koopmans (1951) and Debreu (1951), is given as follows: a producer is technically efficient if, and only if, it is impossible to produce more of any output without producing less of some other output or using more of some input. The efficiency measurement was begun by Farrell (1957), who drew upon the work of Koopmans and Debreu to define a simple measure of firm efficiency that could account for multiple inputs. Farrell proposed that the efficiency of a firm consists of two components: technical efficiency (TE), which reflects the ability of a firm to obtain maximal output from a given set of inputs; and allocative efficiency (AE), which reflects the ability of a firm to use the inputs in optimal proportions, given their respective price and the production technology. These two measures are then combined to provide a measure of total economic efficiency (EE).

Stochastic Frontier Production Function – Since Ferrell's proposition, a great deal of effort has been directed towards the estimation of frontier models of a production technology and obtaining production efficiency measures. Many frontier models have been developed based on Farrell's work. Aigner *et al.* (1977) and Meeusen and Van den Broeck (1977) independently proposed the estimation of a stochastic frontier production function, where noise is accounted for by adding a symmetric error term (ui) to the non–negative term to provide. It has the general form:

$$Y_i = f\,(\,x_i\,;\,\beta\,) + exp(\varepsilon_i) \quad (1)$$

$$\varepsilon_i = v_i - u_i \quad (2)$$

$$i = 1,2,3\ldots, N$$

where Y_i denotes production output level, x_i is input level, and β is a vector of unknown parameter to be estimated. ε_i is the composed error term $(v_i - u_i)$. v_i is assumed independently and identically distributed as $N(0, \sigma_v^2)$. u_i is a set of non–negative random variables that are independently and identically distributed as $N(0, \sigma_u^2)$. The parameters to be estimated include β, σ_v^2, and a variance parameter σ_u^2 associated with u_i. Either distributional assumption on u_i implies that the composed error is negatively skewed; statistical efficiency requires that the model be estimated by maximum likelihood.

Battese and Coelli (1995) have adopted a single–stage approach in which explanatory variables are incorporated directly into the error component. In this approach either the mean or the variance of the inefficiency error component is hypothesized to be a function of the explanatory variables. Technical inefficiency effects are defined by

$$u_i = z_i\;\delta + w_i \quad (3)$$

where z_i is a vector of explanatory variables associated with the technical inefficiency effects, δ is a vector of unknown parameter to be estimated, and w_i is a set of unobservable random variables that are assumed identically distributed, obtained by truncation of the normal distribution with mean *zero* and unknown variance σ^2 such that u_i is non–negative.

Following Battese and Coelli (1995), Kumbhakar and Lovell (2000) and Coelli *et al.* (2005), much of stochastic frontier analysis is directed towards the prediction of the inefficiency effect. The most common output–oriented measure of technical efficiency is the ratio of observed output to the corresponding stochastic frontier output. The technical efficiency of an individual farm is:

$$TE_i = \frac{Y_i}{Y^*_i}$$

$$= \frac{f\,(\,x_i\,;\,\beta\,) + exp(v_i - u_i)}{f\,(\,x_i\,;\,\beta\,) + exp(v_i)}$$

$$TE_i = exp(-u_i) \quad (4)$$

where Y_i denotes production output level and Y^*_i is the frontier output. This measure of technical efficiency takes a value between *zero* and one. The stochastic frontier production function model is established using the maximum likelihood estimation procedure.

MATERIALS AND METHODS

Study Area – The study was carried out in Paklay district, Sayaboury province, Lao PDR. Sayaboury province is located in the northwestern part of the country and borders with Bokeo and Oudomxay provinces on the north, Vientiane and Luang Prabang Province on the east, and Thailand on the west and south. The provincial population was approximately 367,000 as of 2010 census, occupying an area 16,389 km^2, with 455 villages, 63,682 households, and 33 ethnic groups. The climate of the area is highly favourable for growing agricultural crops, industrial trees, and fruit trees. The annual rainfall is 1010.2–1515.9 mm. Daytime temperature ranges from 19.9 to 30.6°C. The major economic activities in the province are the growing of agricultural products including rice, maize, bean, tobacco, sesame, Job's tears, sugarcane, starchy roots, and vegetables. The province is the largest maize–producing province in the country.

Data collection – The data for this study were primary data collected from a random sample of 178 smallholder maize farmers in three villages in Paklay district, Sayaboury province, in September 2010. Data collection was conducted through face–to–face interviewing of a sample of farmers using a structured questionnaire for collecting information on production inputs, outputs, and some important socioeconomic variables.

Data analysis – The survey data were used to estimate technical efficiency of smallholder maize farmers. Using the stochastic frontier production model to determine relations between the dependent variable (maize output in the 2009–10 farming season) and independent variables (maize input), as well as to analyse socioeconomic characteristic variables influencing the estimated technical efficiency in maize production.

Empirical Model Specification – Production technology of smallholder maize farmers in the study area is assumed specified by Cobb–Douglas stochastic frontier model taking the form:

$$
\begin{aligned}
ln\ (Yield_i) = \ & \beta_0 + \beta_1\ ln\ Labour_i + \beta_2\ ln\ Seed_i \\
& + \beta_3\ ln\ Pesticide_i + \beta_4\ ln\ Other\ expenditures_i \\
& + v_i - u_i \qquad (5)
\end{aligned}
$$

where

ln : Natural logarithms

$Yield_i$: Maize output (yield) of the *i–th* farmer in ton per hectare

$Labour_i$: Labour use in person–days per hectare

$Seed_i$: Seed use in kilograms per hectare

$Pesticide_i$: Pesticide use in litres per hectare

$Other\ expenditures_i$: Expenditure on materials and services in kip per hectare.

The technical inefficiency effects are:

$$
\begin{aligned}
u_i = \ & \delta_0 + \delta_1\ Age_i + \delta_2\ Education_i + \delta_3\ Experience_i \\
& + \delta_4\ Household\ size_i + \delta_5\ Farm\ size_i \\
& + \delta_6\ Gender_i + \delta_7\ Off\text{–}farm\ income_i \\
& + \delta_8\ Tractor_i + \delta_9\ Pesticide_i + \delta_{10}\ Grain\ drill_i \\
& + \delta_{11}\ Membership_i + \delta_{12}\ Credit_i + \delta_{13}\ Soil\ fertility_i \qquad (6)
\end{aligned}
$$

where

Age_i : Age of the *i–th* farmer

$Education_i$: Level of education (no. school years)

$Experience_i$: Years of farming experience

$Household\ size_i$: Household size (no. people living together in household)

$Farm\ size_i$: Farm size under maize cultivation in the 2009–10 season expressed in hectares

$Gender_i$: Value of 1 if the farmer is male, 0 if female

$Off\text{–}farm\ income_i$: Value of 1 if off–farm income earning activities, 0 if otherwise

$Tractor_i$: Value of 1 if the farmer uses tractor, 0 if otherwise

$Pesticide_i$: Value of 1 if the farmer uses pesticide, 0 if otherwise

$Grain\ drill_i$: Value of 1 if the farmer uses grain drill machine, 0 if otherwise

$Membership_i$: Value of 1 if the household is a member to any farming organization/ association/group, 0 if otherwise.

$Credit_i$: Value of 1 if the household has access to credit, 0 if otherwise

$Soil\ fertility_i$: Value of 1 if the soil fertility is good as demonstrated by farmers, 0 otherwise

The parameters of both the stochastic frontier model and the inefficiency effects model can be consistently estimated by the maximum likelihood method. In the process, the β and δ coefficients are estimated together; variance parameters σ_u^2 and σ_v^2 are expressed in terms of:

$$\sigma^2 = \sigma u^2 + \sigma v^2 \qquad (7)$$

$$\text{and} \quad \gamma = \sigma_u^2 / \sigma^2 \qquad (8)$$

The value of γ ranges from *zero* to *one*. If γ is equal to *zero*, all deviations from the frontier are due to noise. If γ is close to *one*, all deviations are due to technical inefficiency (Coelli *et al*., 2005).

The maximum likelihood estimates for the parameters of the stochastic frontier model and the predicted technical efficiency are obtained using the computer FRONTIER 4.1 (Coelli, 1996). The computer program automatically calculates the maximum likelihood method. The technical efficiency takes a value between *zero* and *one*. If the technical efficiency is equal to *one*, maize production of farmers is *full technical efficiency*, while if it is less than *one*, there is *technical inefficiency* in farmers' maize cultivation.

RESULTS AND DISCUSSION

Statistics for the Variables

Table 1 presents descriptive statistics for variables in equations (5) and (6) including names of variables, units, means, standard deviations, and minimum and maximum values. It shows that the average yield per hectare is around 5 tonnes using 64 person–days of labour, 20 kg of seed, 3 l of pesticide, and 1,300,000 kip of other expenditure on materials and services. In addition, 93% of the total observed households use tractor, 86% of pesticide, and only 17% of grain drill machine. This high use could be related to the number of available services such as hiring tractors for land preparation, particularly ploughing and planting, as well as using pesticide–spraying machines.

The farm and household characteristic variables were employed in the technical efficiency analysis. The farm-

Table 1. Descriptive statistics for variables used in the stochastic frontier production function

Variables	Unit	Mean	Standard Deviation	Min	Max
Production function model					
Yield	Tonnes/ha	5.22	0.76	2.10	7.12
Labour	Person–days/ha	64.04	16.84	19.00	106.00
Seed	Kg/ha	19.68	3.73	14.00	30.33
Pesticide	Lit/ha	3.19	1.44	0.00	6.07
Other expenditures	Thousand kip/ha	1,302.00	414.00	240.00	2,760.00
Inefficiency model					
Age	Years	42.96	9.67	17.00	58.00
Education	Years	5.86	1.42	3.00	11.00
Experience	Year	8.86	3.48	1.00	18.00
Household size	Persons	5.23	1.93	2.00	11.00
Farm size	Ha	3.20	2.30	0.60	15.00
Gender	1=Yes; 0=No	0.67	0.47	0.00	1.00
Off– farm income	1=Yes; 0=No	0.17	0.38	0.00	1.00
Tractor	1=Yes; 0=No	0.93	0.25	0.00	1.00
Pesticide	1=Yes; 0=No	0.86	0.34	0.00	1.00
Grain drill	1=Yes; 0=No	0.17	0.37	0.00	1.00
Membership	1=Yes; 0=No	0.40	0.49	0.00	1.00
Credit	1=Yes; 0=No	0.48	0.50	0.00	1.00
Soil fertility	1=Yes; 0=No	0.86	0.34	0.00	1.00

Source: Field observation in Paklay district, Sayaboury province in 2010

ers' average age was 43 years. They were able to make informed decisions about their farm operations. The average length of education was only 6 years, indicating that the farmers have low educational level because they received only primary school education. The mean length of maize cultivation experience was relatively higher at approximately 9 years, indicating that the farmers had long–term farming experience. The average household size was 5 persons. Mean farm size under maize cultivation in 2009–10 was around 3 hectares. In addition, 67% of households had a male head. Only 17% of the households were engaged in off–farm income–earning activity, showing that most households spent the majority of their time engaged in agriculture. Meanwhile, household membership in agricultural groups or associations and access to credit were only approximately 40% and 48%, respectively, showing that less than half the maize farmers had access to agricultural groups and credit. Soil fertility was rated as good in approximately 86% of farms, as demonstrated by farmers in the study area.

Estimates of Stochastic Frontier Function

Table 2 shows the estimates of parameters of the stochastic frontier function. All the estimated maximum likelihood coefficients had expected positive signs and statistical significance at 1% level, which show direct relations with output.

Importantly, the coefficient of labour had a positive value of 0.18 and was the most significant. This implies that increment of labour by 1% will increase the yield of maize by 0.18%. This could be explained in that labour is intensive in farming practice, and also the availability of labour is important for timely operations especially during planting and harvesting.

The coefficient of seed had a positive value of 0.16, indicating that increment of seed by 1% will increase maize yield by 0.16%. This could be explained in that many farmers using more seed gives higher output. However, some farmers lack sufficient financial support. They received credit from middle trader or investors to support production inputs including seeds. In addition, although most farmers used hybrid seeds for maize cultivation, the cost of seed was relatively high due to hybrid seeds imported from neighbouring countries. Because of uncertain price demanded by these countries, the higher price of these seeds may severely affect maize producers.

The coefficient for pesticide had a positive value of 0.14, implying that increment of pesticide by 1% will increase output by 0.14%. This could be explained by the observation that most smallholder farmers did not have enough labour to clear weeds/grass from maize fields. Thus pesticide application was increased. However, if farmers use wrong ratios and inappropriate pesticides, it would unintentionally affect their productivity in the short run, as well as have environmental adverse effects in the long run.

The coefficient for other expenditures had a positive value of 0.11, indicating that increment of other expenditures by 1% will increase output by 0.11%. This could be explained in that other expenditures included technology application such as tractor and grain drill machine

Table 2. Maximum likelihood estimates of the production frontier

Variables	Parameters	Maximum Likelihood Estimates	
		Coefficients	t–ratios
Stochastic frontier			
Constant	β_0	5.644***	18.750
Labour	β_1	0.186***	8.382
Seed	β_2	0.163***	4.453
Pesticide	β_3	0.140***	9.873
Other expenditures	β_4	0.118***	4.987
Variance parameters			
Sigma–squared	$\sigma^2 = \sigma^2_u + \sigma^2_v$	0.011***	4.980
Gamma	$\gamma = \sigma^2_u / \sigma^2$	0.958***	25.494

Log likelihood function = 202.646
LR test of one–sided error = 149.737
No. observations = 178
*** Statistically significant at 1% level

Source: Analysis results from field observation in Paklay district, Sayaboury province, 2010.

application. Hence to obtain better production, technological innovation is necessary. This is reasonable given that the use of these technologies ensures land preparation on time especially for ploughing and planting. However, this may not work with some smallholders who have small land, as a result of higher input cost.

The results also suggest that the gamma (γ) parameter was 0.96 in the study area, indicating that 96% of the total variation in maize output was due to technical inefficiency.

Determinants of Technical Efficiency

The determinants of technical efficiency were examined using the parameter estimates of the inefficiency effects. The estimated maximum likelihood coefficients in the inefficiency model are depicted in Table 3. It is interesting to note that a negative sign on an inefficiency parameter implies that the associated variable reduces technical inefficiency or an increase in efficiency and a positive effect on productivity, while a positive sign on inefficiency parameters means the associated variable increases technical inefficiency.

The results suggest that the education coefficient had a negative sign and was statistically significant at the 1% level, indicating that better educated farmers tend to have higher technical efficiency. Education is likely to enhance a farmer's ability to have better access to information on production inputs and markets, as well as farming practice especially the use of hybrid seeds, machinery, and pesticides in the study area.

The coefficient of farming experience was negative and statistically significant at 1% level, implying that farmers with more experience of maize cultivation were more technically efficient than those with less experience. This can be explained in that farmers are more confident when they are experienced in production techniques because they have a positive attitude to adopt inputs of production such as hybrid seeds. Moreover, many farmers not only learn to farm by their own long experiences but also from their parents' experiences.

The coefficient of farm size had a positive sign and was statistically significant at 1% level of probability, implying positive correlation with technical inefficiency. This could be explained in that farmers with large farm size of maize cultivation have many field plots. Thus each plot needs careful management. Small farm size tends to be more efficient in production than larger farm size.

The coefficient of the dummy variable for membership in an agricultural association or group was negative as expected and significant at 5% level, indicating that farmers with access to membership in associations or groups tend to be more technically efficient than those who are not members. This is reasonable given that farming groups facilitate access to markets, information on farming practices, and provide some technical assistance; moreover, membership also confers better opportunities to credit access. Hence membership in an agricultural group is a crucial factor for their accessing agricultural information and enhancing their ability to apply agricultural technology.

The dummy variable for credit access was negative and significant at 10% level, implying that access to credit is likely to have more technical efficiency in the study area. This could be explained in that although there are few farmers with access to bank credit, many farmers received credit from traders or investors by supporting the inputs and services such as hybrid seeds, pesticides,

Table 3. Maximum likelihood estimates of inefficiency effects

Variables	Parameters	Maximum likelihood Estimates	
		Coefficients	t–ratios
Constant	δ_0	0.589***	5.789
Age	δ_1	0.001	0.734
Education	δ_2	– 0.044***	– 2.988
Experience	δ_3	– 0.021***	– 4.026
Household size	δ_4	0.004	0.628
Farm size	δ_5	0.022***	2.938
Gender	δ_6	0.032	0.926
Off–farm income	δ_7	0.029	0.599
Tractor	δ_8	– 0.082	– 1.644
Pesticide	δ_9	– 0.031	– 0.572
Grain drill	δ_{10}	0.016	0.394
Membership	δ_{11}	– 0.085**	– 1.984
Credit	δ_{12}	– 0.052*	– 1.774
Soil fertility	δ_{13}	– 0.026	– 0.621

***, **, * are statistically significant level at 1%, 5%, and 10% respectively
Source: Analysis results from field observation in Paklay district, Sayaboury province in 2010

and land preparation. Thereafter, when maize production is harvested and sold several months later, the farmers return money to investors. Thus credit access is a significant factor to increase ability of poorer households to acquire agricultural inputs.

Technical Efficiency Estimates

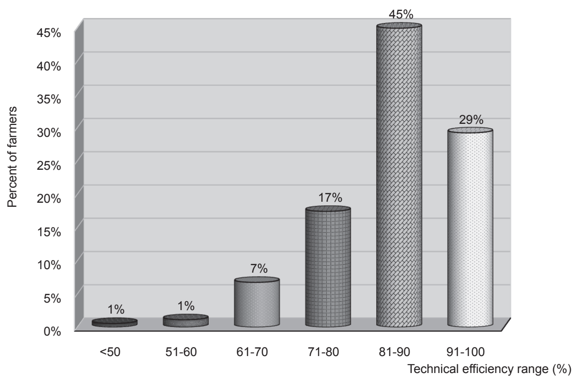
The mean technical efficiency for smallholder maize farmers is 85%; minimum was 49% and maximum 98% (Table 4). This implies that the output could be increased by 15% if all maize farmers could achieve technical efficiency at the same level of the best farmer in the study area.

Frequency distribution of technical efficiency is presented in Figure 1. The figure reveals that approximately 45% of the maize farmers have technical efficiency ranging at 81–90%. This suggests that there is widely distributed technical efficiency among the smallholder maize farmers in the study area. Approximately 29% of farmers achieved the high level of technical efficiency ranging at 91–100%. In addition, 17% of maize farmers had technical efficiency ranging at 71–80%, while the proportion who had technical efficiency ranging at 61–70%, 51–60%, and <50% was 7%, 1%, and 1%, respectively.

The results of technical efficiency in this study were also used as base comparison with the study of Latt *et al*. (2011) and Oyewo *et al*. (2009) as shown in Table 5: the average technical efficiency from various studies using stochastic frontier production function indicated that the results of these two studies, at 85% and 84%, respectively, were similar to ours.

Table 4. Summary statistics of technical efficiency

Statistic	Technical efficiency score
Mean	0.85
Minimum	0.49
Maximum	0.98



Source: Analysis results from field observation in Paklay district, Sayaboury province in 2010.

Figure 1. Frequency distribution of technical efficiency

CONCLUSION AND RECOMMENDATION

Conclusions

The present study estimated levels of technical efficiency of smallholder maize farmers in Paklay district, Sayaboury province, Lao PDR and identifies socioeconomic characteristics influencing technical efficiency in maize production. The detailed survey data were obtained from 178 smallholder maize farmers in three villages throughout the 2009–10 growing season. A stochastic frontier approach was used to examine technical efficiency using the computer software FRONTIER 4.1.

The key findings were that the estimated coefficients for labour, seed, pesticide, and other expenditure were positive and significant to maize output, indicating that if any of these factors were improved there could be an increase in the maize yield. Therefore, households with sufficient labourers play crucial roles for farming. Technological innovation is also necessary to obtain better production.

The mean technical efficiency of smallholder maize farmers in the study area was 85%. The implication is that technical efficiency in maize production in the study area could be improved by 15% through better use of available resources as well as presently available technology or new techniques.

Also significantly related to technical efficiency were educational levels, experience, farm size, membership in an agricultural group, and credit access. Better educated farmers with more experience were more likely to apply higher technical efficiency. Thus farmers with good education and experience were the key innovation enhancing agricultural product development as well as

Table 5. Average technical efficiency in this study and other researchers

Author	Country	Crop	Mean TE (%)
This study	Lao PDR	Maize	85
Basnayake and Gunaratne (2002)	Sri–Lanka	Tea	63
Kai *et al*. (2008)	Viet Nam	Soybean	74
Oyewo *et al*. (2009)	Nigeria	Maize	84
Latt *et al*. (2011)	Myanmar	Sesame	85
Seyoum *et al*. (1998)	Ethiopia	Maize (farmers inside and outside the project)	94 and 79
Okoye *et al*. (2008)	Nigeria	Cocoyam	95

decisions to improve productivity. Farmers with small farm size tend to be more efficient than those with larger farm size. In addition, households with membership in agricultural associations or groups and with better credit access were more likely to be technically efficient than those who did not. It could be said that farmers' associations and better credit access played critical roles in farming productivity.

Recommendations

Based on the findings of this study, it is recommended that:

First, more training on the use of pesticides and machinery for land preparation and planting in mountainous areas should be organized to ensure that local farmers have sufficient knowledge on technology application.

Second, the introduction of local hybrid seeds produced by Lao researchers should be made widely available to maize farmers to stop them from importing costly seeds from neighbouring countries, which has direct impacts on maize production.

Third, harvesting technology should be introduced so as to tackle labour problems during the harvesting season and allow farmers effectively to produce higher yields.

Fourth, better education, at least compulsory education, should be implemented so that farmers can be better trained in agricultural knowledge as well as technology application.

Fifth, agricultural associations or groups should be set up to help farmers exchange knowledge and skills related to maize productivity.

Sixth, providing all farmers with equal opportunity to access credit is essential because it can stimulate maize production.

Finally, soil quality analysis should be made so that farmers may be aware of the use of certain fertilizers (organic fertilizers) to reap optimal benefits from these resources.

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