 doi:10.20944/preprints201705.0067.v1

Technical Efficiency and Its Determinants on Maize Seed Production in Palpa District, Nepal

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Abstract

This paper aimed to assess the technical efficiency of maize seed production and the major factors contributing on technical efficiency. Maize is the second most important staple crop in Nepal, but the average yield of maize is very low as compared to other countries having similar agro-climatic requirements. Inefficient use of resources had led to low yield in maize crop. The software Raosoft was used to determine the required sample size and total of 182 samples were selected using simple random technique in June, 2016. Stochastic production frontier model and Tobit model were used to derive the results. The average technical efficiency of maize seed production ranged from 0.25-0.92 with an average of 0.71which revealed the scope of increasing technical efficiency by 29 percent. The majority of the farmers (29.1%) were at higher technical efficiency level of 0.8-0.9 followed by 28.6 percent at 0.7-0.8 and 23.1 percent at 0.6-0.7. Age and schooling of household head, experience on maize seed production, area shared by maize crop and dummies variables such as livestock holding, source of seed and access to extension service had found significantly affecting on the technical efficiency level. For the least developed country like Nepal it would be better to use the available resources wisely and improvement of existing technologies would be more cost effective than that of discovering new technologies. The study recommended that the concerned organizations should focus on mixed agricultural farming system, access to better quality seed and provide technical knowledge which would help in improving technical efficiency.

Keywords: Cost effective, stochastic frontier, maize, technical efficiency, tobit

1. Introduction

Agriculture sector contributes about 32.5% to Gross Domestic Product (GDP) and maize alone contributes 6.88% to AGDP (MoAD, 2015). Maize (*Zea mays* L.) is considered as second most important crop in terms of area and production in Nepal and it is mainly grown in summer season (Karki, KC, Shrestha & Yadav, 2015). The area, production and yield of maize crop in 2015/16 are 891,583 hectare (ha), 2,231,517 metric tonnes (Mt), 2.50 Mtha^{-1} respectively in Nepal showing deficit of 610,000 Mt (CDD, 2016). There is no any remarkable improvement in maize sector despite of many efforts, plans, policies and strategies implemented in the country (ABPSD, 2014). The demand of maize is found growing annually by 5% in last decade (Sapkota & Pokhrel, 2010). This shows that maize should be imported in a huge amount if its production is not increased. The low maize production might be due to weak management practice, decline in soil productivity and higher

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cost involved. Luque, Cirilo and Otegui (2006); Liu, Tollenaar and Smith (2004); Vega, Andrade, Sadras, Uhart and Valentinuz (2001) reported that yield of maize is highly affected by plant density. The optimum maize plant population is crucial as it do not have tillering nature to manage variation in plant stand. Shortage of labor in maize production is detrimental for yield (Joshi, Conry & Witcombe, 2012). Seed is considered as important basis for food security and biodiversity conservation (Gauchan, 2015) and is an inexpensive input which governs yield (Langyintuo, 2005). There is very less supply of breeder and foundation seed for its multiplication due to lack of research and production in seed sector. The supply of maize improved seeds is very limited in Nepal (Pullabhotla, Shreedhar, Kumar & Gulati, 2011) which has hindered the better production and yield of maize. Improved better quality seeds contributes about 20-30% increase in yield (SQCC, 2013). Improved seeds of maize (90.78%) covers 614,221 hectares of land in the Hills with the yield 2.477 Mt/ha, the total production is 1,521,311 Mt in contrast use of local seeds (9.22%) covers 62,350 hectares of land, 96,600 Mt of production and yield is 1.549 Mt/ha (ABPSD, 2014). About 40 to 45% of maize is imported annually in the country from India (Bhattarai, 2011). The available data on maize production shows the increase in production due to the increase in cropped area rather than increase in yield (MoAD, 2015). Maize has yielded more with the adoption of new technology which has increased the maize production of small holder farmers (Kibaara, 2005). The yield of winter maize is more as there is less risk of pests and diseases and including maize under rice-wheat system could be the new intervention to increase maize production in Nepal. Therefore, there is a need to improve efficiency and increase the yields of staple foods like maize to overcome the problems through efficient use of available resources. The study on efficiency helps to find the possibility of increasing yield by improving efficiency without increasing the resource (Kibaara, 2005). It is found relevant to the country like Nepal where there is narrower scope of increasing production through horizontal expansion. Poor and resource farmers use more inputs neglecting efficiency due to subsidy on inputs in developing countries (Jayaram, Chandrasekhar & Lalith, 1992). In this context, improved in technical efficiency might be the appropriate means to increase the yield. Efforts made to improve the existing technologies would be more cost effective than that of discovering the new technology for the increment of production and yield in developing countries (Bravo-ureta & Evenson, 1994). Those farmers who are technically efficient, they are able to produce maximum outputs from a given level of inputs (Chiona, 2011).

2. Research Methodology

2.1 Selection of the study area

The district with highest production of maize seed was selected for this study. The maize seed production was better and highest in Palpa district among other districts of Nepal (DADO, Palpa, 2014). The district is located at $27^0 52'$ north latitude and $83^0 33'$ east longitude. The list of total of 260 maize seed farmers of Palpa district were collected from DADO, Palpa, cooperatives and farmer groups. Total of 182 sample size was determined using Raosoft software (http://www.raosoft.com/samplesize.html) at 95% confidence level. The sample size was 70% representative of the whole population. Simple random sampling technique provides an equal chance for a selection of the element from the sampling frame (Scheaffer, 1979). Pretesting was done among 10 respondents in Modanpokhara VDC of Palpa district. The necessary correction and modification was done before administering to actual respondents in June 2016. Focus Group Discussion (FGD) and Key Informant Interview (KII) was done to collect and verify the responses collected from field survey. District profile, annual report of DADO, report from NARC, MoAD, CBS, research articles were the sources of secondary data. Data entry, data cleaning, management of missing data and descriptive analysis was done using SPSS software and assessment of technical efficiency was done using Stata software.

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2.2 Technical efficiency assessment

2.2.1 Stochastic production frontier model

Stochastic frontier model was used to predict technical efficiency with Cobb-Douglas production function described below.

$$Y = aX_1^{b_1}X_2^{b_2}X_3^{b_3}X_4^{b_4}X_5^{b_5}X_6^{b_6}$$

$\ln Y = \ln a + b_1\ln X_1 + b_2\ln X_2 + b_3\ln X_3 + b_4\ln X_4 + b_5\ln X_5 + b_6\ln X6$

Where,

Y = Yield ($kgha^{-1}$)

X_1 = Amount of seed sown (kg) in hectare

X_2 = Amount of FYM used (kg) in hectare

X_3 = Amount of chemical fertilizer used (kg) in hectare

X_4 = Number of labor used (man-days) in hectare

X_5 = Tillage by tractor (hour) in hectare

X_6 = Tillage by bullock (days) in hectare

a = Intercept

ln = Natural logarithm

2.2.2 Estimation of technical efficiency (TE)

The methodology to assess technical efficiency was studied from the book by Coelli, Rao, O'Donnell and Battese (2005). Aigner and Chu (1968) considered a Cobb-Douglas production frontier to estimate the stochastic production frontier of the form:

$\text{Ln } q_i = x_i b - u_i$ .... (1)

Where,

q_i represents the output; x_i is K*1 vector which contains logarithms of inputs; b is a vector of unknown parameters and u_i is non-negative random variable which is associated with technical inefficiency. Aigner, Lovell and Schmidt (1977); Meeusem and van den Broeck (1977) proposed the stochastic frontier production function model independently, which was,

$\text{Ln } q_i = x_i b + v_i - u_i$ .... (2)

This equation 2 is identical to the equation 1 except v_i. Here v_i (symmetric random error) was added to account for statistical noise[1]. The model defined in equation 2 is called as a stochastic frontier production method[2]. Battese (1992) and Rahman (2003) applied the stochastic production frontier method to estimate the technical efficiency. Most of the stochastic frontier analysis was directed towards the prediction of the inefficiency effects. Most common output-oriented measure of TE is the ratio as shown below:

$$TE_i = \frac{q_i}{\exp(x_i'\beta + v_i)} = \frac{\exp(x_i'\beta + v_i - u_i)}{\exp(x_i'\beta + v_i)} = \exp(-u_i)$$

The ratio of observed output to the corresponding stochastic frontier output. The measure of technical efficiency takes a value between zero and one. It measures the output of the firm relative to output that could be produced by a fully efficient firm using the same input vector.

$Y = f(X_i; b_i) + 1$

The error term is composite (Chavas et al., 2005; Rahman, 2003; Sharma & Leung, 2000; Bravo-Ureta & Pinheiro 1993; Ali & Flinn, 1989).

Thus,

$L = v - u$

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[1] Statistical noise arises from the inadvertent omission of relevant variables

[2] Because output values were bounded by the stochastic (random) variable $\exp(x_i b + v_i)$

Where v is a two-sided ($-\infty < v < \infty$) normally distributed random error [V≈ N (0, sd^2_v] that captures the stochastic effects outside the farmer's control (e.g., weather, natural disasters and luck), measurement errors, and other statistical noise. The term *u* is a one-sided ($u \geq 0$) efficiency component that captures the technical inefficiency of the farmer. It measures the shortfall in output from its maximum value given by the stochastic frontier. The study assumed *u* has an exponential distribution [U≈ N (0, sd^2_u)]. The two components *v* and *u* are also assumed to be independent of each other. This method was used by Bravo-Ureta and Pinheiro (1993); Bi (2004) by estimating the maximum likelihood method. Technical efficiency levels were predicted from the stochastic frontier production function estimation. The technical efficiency score was obtained and categorized in an interval of 10.

2.3 Tobit model analysis

The Tobit model was used to determine the factors affecting technical efficiency. This is the case of a limited dependent variable because the value of efficiency ranges from 0 to 1 and was a continuous variable. Generally, the Logit and Probit model are used when there is the binary response of dependent variable. Tobit model has been widely used to find the factor affecting technical efficiency (Nyagaka, Obare & Nguyo, 2010; Obare, Nyagaka, Nguyo & Mwakubo, 2010). Various socio-economic and demographic variables were regressed to determine the factors affecting technical efficiency. The equation of the Tobit model used was;

$$Y_i^* = X_i b_i + e_i$$

Where,

Y_i^* is latent variable for the i^{th} maize seed producer farmers and the values was censored at 0 and 100. X_i were the explanatory variables used in models, b_i were the estimated coefficient and e_i was the distributed error term which was assumed to be normally distributed at zero mean and constant variance.

In this study, the Tobit model was used as.

$Y = b_0 + \sum_{n=1}^{15} b_n X_n + e_i$

Where,

X_1 = Gender of the household head (Male = 1 otherwise 0)

X_2 = Age of the household head (Years)

X_3 = Schooling of the household head (Years)

X_4 = Occupation of the household head (Agriculture = 1 otherwise 0)

X_5 = Family type (Joint = 1 otherwise 0)

X_6 = Experience on maize seed production (Years)

X_7 = Number of educated members in household

X_8 = Livestock holding (Yes = 1 otherwise 0)

X_9 = Migration of the household member (Yes = 1 otherwise 0)

X_{10} = Share of maize area out of total cultivated land (%)

X_{11} = Seed produced (Foundation seed = 1 otherwise 0)

X_{12} = Seed source (NMRP = 1 otherwise 0)

X_{13} = Extension service (Yes = 1 otherwise 0)

X_{14} = Credit access (Easy = 1otherwise 0)

X_{15} = Membership on social groups (Cooperative = 1 otherwise 0)

b_0 = constant

e_i = Error term

Y = Technical efficiency scores (in %)

Estimating the model using OLS would produce inconsistent and biased estimates in such limited dependent variable (Gujarati, 2015). This was because OLS underestimates the true effect of the explanatory variables by reducing the slope. Therefore, the maximum likelihood estimation was used for Tobit analysis.

3. Results

3.1 Socio-economic and demographic characteristics of the sampled households

The information on age and year of schooling was of the household head. In context of Nepal, household head is supposed to be the major decision maker in the family. Maize for grain purpose is common in the hilly regions. Shifting their cultivation towards maize seed production cannot be decided without the agreement from the household head. Thus, household head plays a major role in decision-making in the family.

With respect to age, it was found that the average age of the household head was 56.77 years ranging from 23 to 93 years (Table 1). Similarly, the average year of schooling of household head was 5.51 years (range zero to 17 years) in the study area. The experience on growing maize seed production was found 5.51 years (range: 1 to 16 years). The average household size ranged from single to 16 members with an average of 5.4 in the study area. The average male and female members in the household were 2.81 and 2.60.

The economically active members[3] of the household determine the economic status of the family. The average economically active members were 3.59 with a range of zero to 14 members. The dependency ratio[4] was found 0.62, this indicates that 100 economically active members had to fulfill the basic necessities of 62 dependent members in the study area. The average educated members in the household were 4.80 ranging from zero to 15 members. The average landholding[5] of the household was 0.91 hectare (ha) which was higher than the national average (0.68 ha). Similarly, the average area on lowland and upland of the household was 0.17 ha and 0.43 ha respectively. Out of total land, only 0.49 ha was under the cultivation[6]. The average area under maize seed cultivation was found 0.32 ha in the study area. Livestock Standard Unit (LSU)[7] was calculated to study the livestock holding of household by a common unit. The LSU obtained was 3.05 and it ranged from 0 to 56 in the study area.

"Table 1 approx here"

Out of 182 sampled household, 74.2% were male headed household and 25.8% were the female headed household (Table 2). It is evident that Brahmin/Chhetri (68.7%) was the dominating groups in the study area followed by Janajati (20.9%) and Dalit (10.4%). The major occupation of household was agriculture (92.3%) followed by government service (4.4%), private service (2.7%) and wages (0.5%). There were 50.5% and 49.5% joint and nuclear family household respectively. Labor is considered as an active factor in the factors of production (Chopra, 2011). The migration of household member to abroad might lead to the decrease in manpower in agricultural activities. About 42.31% of household responded that they had migrated member from their household. Farmers having more than 0.32 ha (6.202 ropani[8]) were categorized as large scale whereas those having less than 0.32 ha (6.202 ropani) were categorized as small scale.The result revealed that there were about 39.01% household under large scale and 60.99% household under small scale in the study area.

"Table 2 approx here"

3.2 Technical efficiency assessment

3.2.1 Stochastic production frontier model

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[3] Economically active members referred to those who falls at a range of 15-60 years of age group.
[4] Dependency ratio = Dependent members/Economically active members (CBS, 2014).
[5] Total land holding = Summation of lowland, upland and khoriya
[6] Khoriya land was not considered as cultivated land.
[7] LSU: 1 cattle/buffalo = 10 goats = 4 pigs = 143 chickens/ducks (Kattel, 2015).
[8] 19.657 ropani = 1 hectare (CBS, 2013).

The Wald Chi-square value was found highly significant which indicates that the selection of explanatory variables in the model was enough to describe the variation in the dependent variable (Table 3). Increase in labor and seed by 1% increases the yield of maize seed by 0.38% and 0.29% respectively and were significant at 1% level. Increase in FYM quantity by 1% increases the yield of maize seed by 0.04% and found significant at 5% level.

"Table 3 approx here"

3.2.2 Technical efficiency of maize seed production

The prediction of technical efficiency revealed that the majority of the farmers (29.10%) were operating at efficiency level of 0.8-0.9 followed by 28.60% at 0.7-0.8; 23.10% at 0.6-0.7; 8.80% at 0.5-0.6; 6% at 0.4-0.5; 1.6% each at 0.3-0.4 and 0.9-1.0 and 1.10% at 0.2-0.3 in the study area (Figure 1). The value of Pearson Chi-square (14.783) showed statistically significant at 5% level.

"Figure 1 approx here"

The average technical efficiency level of maize seed production was found as 0.71 (71%) and the value ranged from 0.25 to 0.92 (Table 4). The overall technical efficiency score indicated that majority of the farmers in the study area were moderately technically efficient. The value of technical efficiency (71%) indicated that there is still scope for increasing the production by about 29% using the existing technology and available resources (inputs) in the study area. The farmers in the study area should focus on the wise use of the existing resources and technology so that the farmers could generate higher income and profit from maize seed production. The better allocation of the resources helps in increasing production and yield and ultimately the higher profit.

"Table 4 approx here"

3.3 Factors affecting technical efficiency of maize seed production (Tobit model)

It is difficult task to make conclusion and recommend some better policy based on the prediction of technical efficiency. So, it is necessary to identify the sources of variation in technical efficiency and their marginal effects. The predicted technical efficiency score (in percent) of each individual was used as dependent variable. The model correctly predicted and the value of likelihood ratio (40.61) was statistically significant at 1% level which revealed that the explanatory variables included in the model had good explanation power (Table 5).All the significant variables had positive effect on technical efficiency. With respect to age, keeping all other factor constant, one year increase in age of the household head would increase the technical efficiency by 0.19% and it was found statistically significant at 5% level. This might be due to the fact that increase in the year would increase maturity level so that they can operate better and make the wise allocation of resources and increase the efficiency level. Illukpitiya (2005) reported similar results in Srilanka that elderly farmers had a wealth of experience and therefore they were more technically efficient in production than their younger counterparts. The year of schooling of household head was found affecting positively on technical efficiency. Similarly, one year increase in the schooling of the household head significantly increase technical efficiency by 0.70%. Increase in one year of experience on maize seed production would increase technical efficiency by 0.49% which was significant at 5% level. Farmers having more year of experience on maize seed production can manage the field effectively and can allocate the resources wisely. The result revealed that farmers who held livestock showed higher technical efficiency by 9.01% as compared to those who did not have livestock and was statistically significant at 5% level. The share of maize area (in percent) with respect to the total cultivated land by 1% would increase the technical efficiency by 0.29% and was statistically significant at 5% level. With respect to seed source, those farmers who used the seed from NMRP would increase their technical efficiency by 4.76% as compared to those who used the seed from DADO and LAC and was found statistically significant at 5% level. Similarly, it is evident that the farmers who were accessed to extension service showed higher technical efficiency by 6.62% as

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compared to those who were not accessed to extension service and was found statistically significant at 5% level.

"Table 5 approx here"

4. Discussion

4.1 Stochastic frontier model

The coefficients of respective inputs used in maize seed production obtained using the stochastic frontier model such as seed amount (kg), FYM used (kg), labor (man-days) were found affecting positively and significantly whereas chemical fertilizer (kg), tillage by tractor (hour) found affecting positively but were non-significant.

Adinku (2013); Ahmadu and Alufohai (2012) also observed fertilizer as positive coefficient but non-significant on the estimation of technical efficiency under irrigated rice condition in Niger state. Adinku (2013) also observed amount of seed affecting technical efficiency positively.

4.2 Technical efficiency of maize seed production

In an average, farmers were 71% technically efficient in the study area. The majority of the farmers (29.10%) were operating at 0.8-0.9 efficiency level. Wabomba (2015) stated that average technical efficiency among the soybean farmers in Bungoma County, Kenya was 75.25% and found that 40.47% of the farmers had technical efficiency measure of 90% and above whereas 19.64% had an efficiency level of below 50%. Olarinde (2011) stated the average technical efficiency among the maize farmers in Nigeria was found only 0.56 and 0.58 in Oyo and Kebbi states respectively. Oluwatayo, Sekumade and Adesoji (2008) found the average technical efficiency of maize farmers to be 68% in rural Nigeria. Amos (2007) found the smallholder cocoa farmers of Nigeria were 72% technically efficient which was very close to the result obtained from this study. Chirwa (2007) found that average technical efficiency level of maize farmers was 46%, the main determinants for inefficiency was inappropriate use of fertilizer. Kibaara (2005) stated that the maize production was technically efficient at 49% in Kenya. Abdulai and Eberlin (2001) stated that average technical efficiency level of maize and beans in Nicaragua was found 69.8% and 74.2% respectively by using the translog stochastic frontier model.

4.3 Factors affecting technical efficiency

Increase in the age of household head by one year, the technical efficiency of maize seed production would increase by 0.2% and was statistically significant at 5% level in the study area. Sibiko (2012) found that age has positive influence on technical efficiency of common bean. Msuya, Hisano and Nariv (2008); Amos (2007) also found that the age of household head had positive influence on technical efficiency. They explained that as farmers grew old then they collect more experience in farming hence leading to more efficient but the findings was contrary to Chepng'etich (2013) and Amaza et al. (2006) and stated that younger farmers were likely to be more energetic and adopt new technologies rapidly hence lead to higher efficiency in production. Shafiq and Rehman (2000) stated that older farmers (more age) were found operating the farm efficiently due to experience in doing farm activities.

Household head with more years of schooling were more technically efficient than their counterpartsby 0.7% and was statistically significant at 1% level in the study area. The results obtained were similar to the findings of Nyagaka et al. (2011); Mussa et al. (2011); Shehu et al. (2010); Njeru (2010); Assadullah and Rahman (2009); Ajewole and Folayan (2008); Msuya, Hisano and Nariv (2008); Chirwa (2007); Idiong (2007); Amaza et al. (2006); Alene and Hassan (2003); Manthijs and Vraken (2001); Seyoum, Battese and Fleming (1998). All these studies agreed that the more year of schooling of household head reduces inefficiency. Those who are educated are better placed to receive, analyze, interpret and show quick respond to new information. As household head is the major decision maker in the family and more educated household head actively adopt the new improved technologies such as adoption of improved seeds, mechanization, soil conservation technologies and agronomic practices (inspection, rouging, thinning, spacing, weeding, etc.) which could positively influence the technical efficiency of maize seed production. Wakili (2012) and Njeru (2010) found that farmers with low level of education were reluctant to adopt the improved farming techniques. Further explained that such farmers provide poor supervision to their farm and are often very slow in responding to the emergencies such as outbreak of crop diseases or pests.

Experience in maize seed production found to be positive and was statistically significant at 5% level in the study area. Experience on farming tends to increase farmer's capacity to do better, hence they influence technical efficiency positively and significantly. This finding was in line with Olarinde (2011); Gul et al. (2009); Padilla-Fernandez and Nuthall (2009) but contrary to the result of Ajewole and Folayan (2008). Farmers having more year of experience are better placed to acquire knowledge and skills necessary for choosing appropriate new farm technologies over time.

Increase in maize share area by 1%, the technical efficiency would be increased by 0.25% which was positively and statistically significant at 5% level. Such positive relationship between farm size and technical efficiency were also identified by Chiona (2011); Gul et al. (2009); Msuya, Hisano and Nariv (2008); and Chirwa (2007), but on the contrary Chimai (2011) and Javed et al. (2010) stated that increase in size of sorghum farm would affect technical efficiency negatively. Similarly the findings from Tchale (2009); Padilla-Fernandez et al. (2009); Croppenstedt (2005) also stated the negative relationship between farm size and technical efficiency and further explained that as farm size increases, it takes more time to manage it and the efficiency level decreases. The positive relationship of technical efficiency might be good access to extension services.

Farmer's access to extension service would increase the technical efficiency by 6.62% and it was found statistically significant at 5% level in the study area. Sibiko (2012); Olarinde (2011); Obwona (2000); Seyoum, Battese and Fleming (1998) also found extension service would influence positively on technical efficiency. Idiong (2007) also observed that farmers who received extension service showed higher level of efficiency and further explained that the informal sources of teaching and learning process helped farmers in updating their farming ways, hence positively influenced efficiency level. Those farmers accessed with extension service receive better knowledge about the use of resources (inputs), get technical knowledge about the maize seed production and receive information about the market, which might lead to better technical efficiency.

Easy access to credit has positive effect (2.67%) on technical efficiency however it was non-significant in the study area. Chepng'etich (2013) also found the positive effect of credit use but non-significant but Olarinde (2011) and Idiong (2007) found it significantly affecting on technical efficiency. Nchare (2007) and Amaza et al. (2006) explained that access to credit and its use reduce the financial difficulty at the initial stage of production process. Credit help the farmers to purchase the required inputs and gather the required resources to prepare their land on time before planting. Credit access to farmers might act as an instrumental motivation to produce more efficiently apart from being able to purchase the required inputs for production.

5. Conclusion

Maize is staple crop for the majority of the farmers at Hilly area. Better and improved quality seed helps to increase production and yield of maize. Farmers involved in maize seed production in the district were better access to extension services as well as had received proper training and had collected better experience in seed production. The overall technical efficiency of maize seed production was predicted from stochastic frontier model and was found 0.71 (71%) which showed the scope of improving the efficiency by 29%. The majority of the farmers (29.10%) were operating at higher level of efficiency (0.8 – 0.9 level) in the study area. The Tobit model analysis revealed that technical efficiency scores were determined positively and statistically significant by age of household head, year of schooling of household head, experience on maize seed production, livestock holding (dummy), share of maize area, seed source (dummy) and access to extension service (dummy). There was increase in technical efficiency who owned livestock and those who were access to extension services. For least developed country like Nepal, it would be better to have mixed farming system which would also increase the technical efficiency of maize seed production. The better allocation and wise use of existing resources (inputs) and technology should be prioritized to maximize the profit from maize seed production. Wise use of existing resources and improvement of existing technologies would be more cost effecting rather than discovering new technology. Government should focus on improving efficiency of existing resources. Farmers with better technical efficiency would be able to use the inputs efficiently and maximize the production indicating profitable enterprise and ultimately improvement in the economic condition and livelihood of farmers.

6. Recommendations

Production of maize seed requires good marketing conditions. A study to assess marketing efficiency level could be the area for future research. This study has not cover the supply side of maize seed production and farmers are supposed to economically efficient when they are technically and allocatively efficient so further research covering these efficiencies could help in accurate policy recommendation.

8. Reference

Abdulai, A. & Eberlin, R. (2001). Technical efficiency during economic reform in Nicaragua: Evidence from farm household survey data. *Economic systems*, 25(2): 113-125.

ABPSD (2014). Statistical Information on Nepalese Agriculture. Agri-Business Promotion and Statistics Division, Statistics Section. Government of Nepal, Ministry of Agricultural Development, Singha Durbar, Kathmandu, Nepal.

Adinku, E. O. (2013). *Production Risk and Technical Efficiency of Irrigated Rice Farms in the Greater Accra and Volta Regions of Ghana*. Master of Philosophy degree submitted to Department of Agricultural Economics and Agri-business College of agriculture and consumer sciences, University of Ghana, Legon.

Ahmadu, J. & Alufohai, G. O. (2012). Estimation of Technical Efficiency of Irrigated Rice Farmers in Niger State. *American-Eurasian Journal of Agriculture & Environmental Sciences*, 12(12): 1610-1616.

Aigner, D. J., & Chu, S. F. (1968). On estimating the industry production function. *The American Economic Review*, 58(4), 826-839.

Aigner, D. J., Lovell, C. A. K., & Schmidt, P. (1977). Formulation and estimation of stochastic frontier production function models. *Journal of Econometrics*, 6(1), 21-37.

Ajewole, O.C. & Folayan, J. A. (2008). Stochastic frontier analysis of technical efficiency in dry season leaf vegetable production among smallholders in Ekiti State, Nigeria. *Agricultural Journal*, 3(4): 252-257.

Alene, A. D. & Hassan, R. M. (2003). The determinants of farm-level technical efficiency among adopters of improved maize production technologu in Western Ethiopia. *Agrekon*, 42(1).

Ali, M., & Flinn, J. C. (1989). Profit efficiency among Basmati rice producers in Pakistan Punjab. *American Journal of Agricultural Economics*, 71(2), 303-310.

Amaza, P. S., Bila, Y., & Iheanacho, A. C. (2006). Identification of factors that influence technical efficiency of food crop production in West Africa: Empirical evidence from Borno State, Nigeria. *Journal of Agriculture and Rural Development in the Tropics and Subtropics (JARTS)*, 107(2), 139-147.

Amos, T. T. (2007). An analysis of productivity and technical efficiency of smallholder cocoa farmers in Nigeria. *Journal of Social Sciences*, 15(2), 127-133.

Asadullah, M. & Rahman, S. (2009). Farm productivity and efficiency in rural Bangladesh: The role of education revisited. *Applied Economics*, 41(1): 17-33.

Battese, G. E. (1992). Frontier production functions and technical efficiency: a survey of empirical applications in agricultural economics. *Agricultural economics*, 7(3), 185-208.

Battese, G. & Coelli, T. J. (1995). A model of technical efficiency effects in a stochastic frontier function for panel data. *Empirical Economics*, 20: 325-332.

Bhattarai, T. C. (2011). Recent demand and supply situation of raw materials for the feed industries in Nepal, paper presented in mission TST training in Chitwan, 2068.

Bravo-Ureta, B. E., & Evenson, R. E. (1994). Efficiency in agricultural production: the case of peasant farmers in eastern Paraguay. *Agricultural economics*, 10(1), 27-37.

Bravo-Ureta, B. E., & Pinheiro, A. E. (1993). Efficiency analysis of developing country agriculture: A review of the frontier function literature. *Agriculture and resource economics review*, 22(1): 88-101.

CDD (2016). Annual report 2015/16. Crop Development Directorate, Department of Agriculture, Ministry of Agricultural Development, Kathmandu, Nepal.

Chavas, J. P., Petrie, R. & Roth, M. (2005). Farm household production efficiency: Evidence from the Gambia. *American Journal of Agricultural Economics,* 87(1): 160-179.

Chepng'etich, E. (2013). *Analysis of Technical Efficiency of Smallholder Sorghum Producers in Machakos and Makindu Districts in Kenya*. M. Sc. Thesis submitted to the school of Agriculture and Enterprise Development of Kenyatta University

Chimai, B. C. (2011). *Determinants of Technical Efficiency in Smallholder Sorghum Farming in Zambia.* M. Sc. Thesis, Ohio State University, Ohio, USA.

Chiona, S. (2011). Technical and Allocative Efficiency of Smallholder Maize Farmers in Zambia. A master thesis submitted to the University of Zambia, Lusaka.

Chirwa, E. W. (2007). *Sources of technical efficiency among smallholder maize farmers in Southern Malawi* (No. RP_172 Key words: smallholder maize farmers, technical efficiency, southern malawi). Nairobi: African Economic Research Consortium.

Coelli, T. J., Rao, D. S. P., O'Donnell, C. J., & Battese, G. E. (2005). *An introduction to efficiency and productivity analysis*. Springer Science & Business Media.

Croppenstedt, A. (2005). Measuring technical efficiency of wheat farmers in Egypt. *The Agricultural Development Economics Division (ESA) is the focal point for FAO's economic research and policy analysis for food security and sustainable development, Egypt*.

DADO, Palpa (2014). Annual report 2013/14. District Agriculture Development Office, Department of Agriculture, Ministry of Agricultural Development.

Finch, H., & Lewis, J. (2003). Focus groups. *Qualitative research practice: A guide for social science students and researchers*, 170-198.

Gujarati, D. (2015). Econometrics by example (2nd ed.). PALGRAVE. ISBN: 978-1-137-60734-8, pp. 181-184

Gul, M., Koc, B., Dagistan, E., Akpinar, M. G., & Parlakay, O. (2009). Determination of technical efficiency in cotton growing farms in Turkey: A case study of Cukurova region. *African journal of Agricultural research*, 4(10), 944-949.

Idiong, I. C. (2007). Estimation of farm level technical efficiency in small scale swamp rice production in cross river state of Nigeria: A stochastic frontier approach. *World Journal of Agricultural Sciences*, 3(5): 653-658.

Illukpitiya, P. (2005). Technical efficiency in agriculture and dependency on forest resources: An economic analysis of rural households and the conservation of natural forests in Sri Lanka. *University of Hawaii*.

Javed, M. I., Adil, S. A., Ali, A., & Raza, M. A. (2010). Measurement of technical efficiency of rice-wheat system in Punjab, Pakistan using DEA technique. *J. Agric. Res*, 48(2), 227-238.

Jayaram, H., Chandrashekar, G. S., & Achoth, L. (1992). An economic analysis of technical efficiency in rice cultivation in Mandya: Some issues in resource pricing. *Indian Journal of Agricultural Economics*, 47(4), 677.

Joshi, K. D., Conry, C., & Witcombe, J. R. (2012). Agriculture, seed, and innovation in Nepal: Industry and policy issues for the future. Project Paper. International Food Policy Research Institute. www.ifpri.org.

Karki, T. B., KC, G., Shrestha, J., & Yadav, J. P. (2015). Tillage and planting density affect the performance of maize hybrids in Chitwan, Nepal. 1(1): 10-20

Kattel, R. R. (2015). Rainwater harvesting and rural livelihoods in Nepal. South Asian Network for Development and Environmental Economics (SANDEE). SANDEE Working Papers, ISSN 1893 1891; WP 102–15.

Kibaara, B. W. (2005). *Technical Efficiency in Kenyan's Maize Production: An Application of the Stochastic Frontier Approach*. M. Sc. Thesis, Department of Agricultural and Resource Economics Colorado State University Fort Collins, Colorado: USA

Gauchan, D. (2015). Research and support services in seed production and supply in Nepal. *Final draft thematic paper for seed submit, 2015, Kathmandu, Nepal.*

Langyintuo, A. S. (2005). Maize production systems for Zimbabwe: Setting indicators for impact assessment and targeting. *Research Project on strengthening seed marketing incentives in southern Africa to increase impact of maize breeding. International Maize and wheat improvement centre (CIMMYT), Harare, Zimbabwe*.

Liu, W., Tollenaar, M. & Smith, G. (2004). Within row plant spacing variability does not affect corn yield. *Agron. J.,* 96: 275-280.

Luque, S. F., Cirilo, A. G., & Otegui, M. E. (2006). Genetic gains in grain yield and related physiological attributes in Argentine maize hybrids. *Field Crop Res*., 95: 383-397.

Manthijs, E. & Vranker, L. (2000). Farm restructuring and efficiency in transition from Hungary and Bulgaria. Selected paper, American Agricultural Economics Association Annual Meeting, 30 Jul – 2 August, Tampa, Florida.

Meeusen, W., & Van den Broeck, J. (1977). Efficiency estimation from Cobb-Douglas production functions with composed error. *International economic review*, 435-444.

MoAD (2015). A report on Prime Minister Agriculture modernization project to support agriculture development strategy, Kathmandu, Nepal.

MoAD (2015). Nepal Portfolio Performance Review (NPPR). Ministry of Agricultural Development.

Msuya, E. E., Hisano, S., & Nariv, T. (2008, July). Analysis of technical efficiency of maize farmers in Tanzania the globalization era. In *XII World Congress of Rural Sociology of the International Rural Sociology Association, Goyang, Korea*.

Mussaa, E. C., Obare, G. A., Bogale, A., & Simtowe, F. (2011). Resource use efficiency of smallholder crop production in the central highlands of Ethiopia.

Nchare, A. (2007). Analysis of Factors Affecting the Technical Efficiency of Arabica Coffee Producers in Cameroon. *African Economic Research Consortium*, AERC Research Paper163, AERC, Nairobi, Kenya.

Njeru, J. (2010). *Factors Influencing Technical Efficiencies among Selected Wheat Farmers in Uasin Gishu District, Kenya* (No. RP_206). African Economic Research Consortium.

Nyagaka, D. O., Obare, G. A., Omiti, J. M., & Nguyo, W. (2010). Technical efficiency in resource use: Evidence from smallholder Irish potato farmers in Nyandarua North District, Kenya. *African Journal of Agricultural Research*, 5(11), 1179-1186.

Obare, G. A., Nyagaka, D. O., Wilson, N. & Mwakubo, S. M. (2010). Are Kenyan smallholders allocatively efficient? Evidence from Irish potato producers in Nyandarua North District. *Journal of Development and Agricultural Economics,* 2(3); 78-85.

Obwona, M. (2000). Determinants of technical efficiency among small and medium scale farmers in Uganda: A Case Study of Tobacco Grower. In *A Final Report Presented at AERC Bi-annual Workshop at Nairobi, Kenya*.

Olarinde, L. O. (2011). Analysis of technical efficiency differentials among maize farmers in Nigeria. The African Economic Research Consortium. Ladoke Akintola University of Technology, Nigeria. ISBN: 978-9966-023-04-9

Oluwatayo, I. B., Sekumade, A. B., & Adesoji, S. A. (2008). Resource use efficiency of maize farmers in rural Nigeria: Evidence from Ekiti State. World Journal of Agricultural Sciences, 4(1), 91-99.

Padilla-Fernandez, M. D., & Nuthall, P. L. (2009). Technical efficiency in the production of sugar cane in central Negros area, Philippines: An application of data envelopment analysis. *J. Int. Soc. Se. Asian. Agric. Sci*, 15(1), 77-90.

Pullabhotla, H., Shreedhar, G., Kumar, A. G., & Gulati, A. (2011). A Review of Input and Output Policies for Cereal Production in Nepal. *Report prepared for the Cereals System Initiative for South Asia (CSISA), Discussion Paper*, *1114*.

Rahman, S. (2003). Profit efficiency among Bangladeshi rice farmers. Contributed paper for the 25th conference of the International Association of Agricultural Economists, Durban, South Africa, August, 2003.

Sapkota, D., & Pokhrel, S. (2010). Community based maize seed production in the hills and mountains of Nepal: A review. *Agronomy Journal of Nepal*, 1: 107

Scheaffer, R. (1979). Elementary Survey Sampling. Massachusetts, USA, Duxbury Press.

Seyoum, E. T., Battese, G. E., & Fleming, E. M. (1998). Technical efficiency and productivity of maize producers in eastern Ethiopia: a study of farmers within and outside the Sasakawa-Global 2000 project. *Agricultural economics*, 19(3), 341-348.

Shafiq, M. & Rehman, T. (2000). The extent of resource use inefficiencies in cotton production in Pakistan's Punjab: An application of data envelopment analysis. *Agricultural Economics*, 22: 321-330.

Sharma, KhemR. & Leung, P. S. (2000). Technical efficiency of carp production in India: a stochastic frontier production function analysis. *Aquaculture Research*, 31: 937-947.

Shehu, J. F., Iyortyer, J. T., Mshelia, S. I., & Jongur, A. A. U. (2010). Determinants of yam production and technical efficiency among yam farmers in Benue State, Nigeria. *Journal of social science*, 24(2), 143-148.

Sibiko, K. W. (2012). *Determinants of common bean productivity and efficiency: A case of smallholder farmers in eastern Uganda*. M. Sc. Thesis submitted in Agriculture and applied economics of Egerton University.

SQCC (2013). National seed vision 2013-2025, Seed Sector Development Strategy. Government of Nepal, Ministry of Agricultural Development, National Seed Board, Seed Quality Control Centre, Hariharbhawan, Lalitpur, Nepal.

 doi:10.20944/preprints201705.0067.v1

Tchale, H. (2009). The efficiency of smallholder agriculture in Malawi. *African Journal of Agricultural and Resource Economics*, 3(2), 101-121.

Vega, C. R. C., Andrade, F. H, Sadras, V. O., Uhart, S. A. & Valentinuz, O. R. (2001). Seed number as a function of growth. A comparative study in soy-bean, sunflower, and maize. *Crop Sci.,* 41: 748–754.

Wabomba, O. W. (2015). *Determinants of technical efficiency of soybean production among farmers in Bungoma County, Kenya*. M. Sc. Thesis submitted to department of agricultural economics and resource management, school of business and economics, MOI University.

Wakili, A. M. (2012). Technical efficiency of sorghum production in Hong local government area of Adamawa State, Nigeria. *Russian Journal of Agricultural and Socio-Economic Sciences*, 6(6), 10-15

Tables:

Table 1. Socio-economic and demographic characteristics (continuous variable) of the sampled household

Variables	Mean (± standard deviation)
Age of household head (Year)	56.77 (± 14.30)
Schooling (Year)	5.51 (± 4.69)
Experience on maize seed production (Year)	6.63 (± 3.91)
Household size	5.41 (± 2.72)
Male members of household	2.81 (± 1.71)
Female members of household	2.60 (± 1.46)
Economically active members	3.59 (± 2.21)
Dependency ratio	0.62 (± 0.62)
Educated members of household	4.80 (± 2.49)
Total landholding (ha)	0.91 (± 0.79)
Lowland (ha)	0.17 (± 0.27)
Upland (ha)	0.43 (± 0.30)
Khoriya (ha)	0.31 (± 0.49)
Land area under cultivation (ha)	0.49 (± 0.36)
Land area under maize seed cultivation (ha)	0.32 (± 0.17)
Livestock holding (LSU)	3.05 (± 5.63)

Table 2. Socio-economic and demographic characteristics (categorical variable) of the sampled household

Variables	Frequency	Percentage
Gender of household head		
Male	135	74.2
Female	47	25.8
Ethnicity		
Brahmin/chhetri	125	68.7
Janajati	38	20.9
Dalit	19	10.4
Occupation		
Agriculture	168	92.3

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Government service	8	4.4
Wages	1	0.5
Private service	5	2.7
Family Type		
Joint	92	50.5
Nuclear	90	49.5
Migration status		
Yes	77	42.3
No	105	57.7
Farm category		
Large scale	71	39.01
Small scale	111	60.99

Table 3. Stochastic production frontier of maize seed production

Variables	Coefficients	Standard error	z	P>z
Log Seed (kg)	0.286***	0.106	2.69	0.007
Log FYM (kg)	0.043**	0.018	2.40	0.016
Log Chemical fertilizer (kg)	0.011	0.008	1.45	0.146
Log Labor (man-days)	0.382***	0.077	4.93	0.000
Log Tillage tractor (hr)	0.008	0.008	0.95	0.341
Log Bullock (day)	-0.008	0.008	-0.92	0.357
Constant	4.409***	0.409	10.77	0.000
Sigma v	0.271	0.039		
Sigma u	0.481	0.073		
Sigma2	0.305	0.056		
Lambda	1.779	0.104		
Observations	182			
Wald Chi^2 (6)	76.49			
Prob>Chi^2	0.000			
Log likelihood	-87.456			

Note: *** and ** indicate significant at 1% and 5% levels respectively.

Table 4. Overall technical efficiency of maize seed production

Variable	Observation	Mean	Standard deviation	Minimum	Maximum
Technical efficiency	182	0.710	0.131	0.246	0.920

Table 5. Factors affecting technical efficiency using Tobit model

Variables	Coefficient	Standard error	t-value	p-value
Gender (#)	-0.832	2.260	-0.370	0.713
Age (year)	0.195**	0.080	2.420	0.017
Schooling (year)	0.696***	0.237	2.940	0.004
Occupation (#)	1.093	3.479	0.310	0.754
Family type (#)	0.453	2.211	0.210	0.838
Experience (year)	0.488**	0.248	1.970	0.050
Educated members	0.495	0.424	1.170	0.244
Livestock holding (#)	9.013**	3.702	2.430	0.016

 doi:10.20944/preprints201705.0067.v1

Migration (#)	-2.537	1.943	-1.310	0.193
Maize share (%)	0.258**	0.108	2.390	0.018
Seed produced (#)	2.516	3.148	0.800	0.425
Seed source (#)	4.759**	2.175	2.190	0.030
Extension (#)	6.618**	3.099	2.140	0.034
Credit (#)	2.672	2.415	1.110	0.270
Membership (#)	-3.090	2.164	-1.430	0.155
Constant	27.925***	9.324	3.000	0.003
Number of observation	182			
LR $chi^2(15)$	40.610			
Prob>chi^2	0.0004			
Pseudo R^2	0.028			
Log likelihood	-704.998			
Correctly predicted	70.974			

Notes: *** and ** indicate significant at 1% and 5% levels respectively. # indicate dummy variable

Figure:

Figure 1. Percentage of farmers operating at different technical efficiency level