ISSN (Online): 2091-2609
DOI Prefix: 10.3126/ijasbt
International Journal of Applied Sciences and Biotechnology (IJASBT)

**Research Article**

# Resource Use Efficiency and Profitability of Maize Farming in Sindhuli, Nepal: Cobb-Douglas Production Function Analysis

**Bhishma Raj Dahal[1*], Swodesh Rijal[1]**

[1]Agriculture and Forestry University, Rampur, Chitwan, Nepal

## Abstract
The study was conducted to determine the resource use efficiency, profitability and demography of maize farming in Sindhuli district. This study was conducted among 120 maize producers, 60 from Kamalamai Municipality (KMC) and 60 from Marin rural municipality. Pretested semi-structured questionnaire was administered to randomly selected farmers. Maize producers were interviewed using face to face interview method in the month of October 2018. All the data were entered into SPSS and Microsoft excel and analysis was done by using Microsoft excel and SPSS. Cobb- Douglas production function was used to determine the resource use efficiency of maize production. Benefit cost ratio in the research area was 1.20 which indicated that maize production was profitable and farmers of Sindhuli got additional 20 paisa with investment of one rupee in maize farming. Productivity, cost and income per hectare of maize farming in Sindhuli was 1.98 tons, Rs 42423.3 and Rs 50805 respectively. 10% increase in chemical fertilizer, FYM and seed cost resulted in increase in income by 7.21%, 2.43% and 0.6% respectively. 10% increase in labor and animal power resulted into 0.2% and 0.07% decrease in output. For optimal allocation of resource expenditure on seed and chemical fertilizer were need to be increased by 89.93% each. Labor, animal power and FYM were over utilized resources for maize farming. The sum of coefficients was 0.983 which implied decreasing return to scale, 100% increase in all the factor of production included in the model would result in 98.30% increase in maize production.

**Keywords**: Cobb-Douglas; B/C, productivity, factors of production

## Introduction

Maize is one of the major crops of Nepal and is cultivated in both irrigated as well as non-irrigated field across the different agro-climatic conditions of the country (Paudyal and Poudel, 2001). It is used as subsistence staple food crops in remote hills and mostly used as animal feed in terai and inner terai (Dhakal *et al*., 2015). It is grown under rain fed conditions during summer as a single or relay crop with millet. In terai it is also grown during winter and spring if irrigation is available (Paudyal *et al*,. 2001). Among cereals it contributes about 26.8% of total food requirements in hills and mountains of country (Sapkota and Pokhrel, 2010). Maize is used as multipurpose grain, *chayakhla*, *roti*, *Dhido* are typical food products made from it. Maize flour is used in bakery and fermentation industries. It is an important source of starch as it contains 70% of starch by weight. It is source of caretonoids such as, beta-carotene, zeaxanthin, lucin and cytoxanthin. Maize is source of oil which can also be used for human consumption. Efforts have been made to make fortified maize rich in iron, zinc and provitamin A

**Cite this article as:**

B.R. Dahal and S. Rijal (2019) Int. J. Appl. Sci. Biotechnol. Vol 7(2): 257-263. DOI: 10.3126/ijasbt.v7i2.24648

***Corresponding author**
Bhishma Raj Dahal,
Agriculture and Forestry University, Rampur, Chitwan, Nepal
Email: dahalbhishmaraj@gmail.com

Peer reviewed under authority of IJASBT

(Chaudhary *et al*., 2013). Maize is deficit in two proteins lycin and tryptophan but Quality protein maize (QPM) has double amount of proteins which has reduced protein malnutrition in hills of Nepal (Upadhaya *et al.*, 2009). Maize demand has been growing constantly by about 5% in the last ten decades (Sapkota and Pokhrel, 2010). Quantity of maize required for food per year is around 2.9 million metric ton and there is need of about 6.46 million metric ton feed to run the existing poultry industries in our country (KC *et al*., 2015). Production of maize during 2017 was 2.30 million tons (MoAD, 2017) thus there is huge deficit in demand and maize production in our country. This gap can be maintained by increasing efficient maize production for this resource must be used at optimum level. Seed, labor, animal power, chemical fertilizers and FYM are resources used in maize production. Resources used in production process are regarded as an input that runs production activity. Resources are said to be efficiently utilized when it is used in best possible way by minimizing cost of production (Dhakal *et al*,. 2015). It is very crucial to figure out whether the farmers are making rational use of available resources or not. They might use resources irrationally or rational use not at economic optima level. The major goal of farmers is to maximize profit by increasing production and minimizing cost, therefore analysis of resource use must be done for sustainable maize production. Keeping these points in view the study was undertaken to determine resource use efficiency and profitability of maize production in Sindhuli district.

## Materials and Methods

The research was conducted in Sindhuli district, a central mid-hills of Nepal. The district was purposefully selected because it is one of the major maize producing districts with identifiable maize growing farmers. It is a part of province no 3 of Federal Republic of Nepal. The district, with Sindhulimadhi Kamalamai (KMC) as its district headquarters and covers an area of 2,491 km². In 2001, it had a population of 279,821 and in 2011 the population was 296,192. It lies in Janakpur zone with coordinates of $27.25^0$ N and $85.97^0$E. Climate here ranges from tropical, subtropical, temperate, sub-alpine and alpine but subtropical is dominant. 120 respondents were selected using Simple random sampling among the farmers cultivating maize since last five years. 60 respondents from Kamalamai municipality (KMC) and 60 respondents from Marin rural municipality were selected. Face to face interview method was used to collect primary data using pretested semi-structured questionnaire in the month of October 2018. Data about socio-economic and demographic information, variable cost incurred for maize production and income were collected during survey. Focus group discussion (FGD) and key informant interview (KII) were conducted to validate information obtained from respondents. Data analysis and comparisons were made to obtain results. The data were entered in Microsoft excel and SPSS. Analysis was done by using SPSS and Microsoft excel.

***Econometric Models***

Cobb-Douglas production function was accessed to calculate economics of maize production. This model is widely used to represent the relationship of an output to inputs and it gives good approximation to actual production (Yuan, 2011). It is use to determine the resource use efficiency of production of agricultural commodity (Dahal and Rijal, 2019).

$$Y=aX_1^{b1}X_2^{b2}X_3^{b3}X_4^{b4}X_5^{b5}e^u$$

Y is income of maize production in hectare (Nrs), $X_1$ is cost of maize seed per hectare, $X_2$ is cost of animal power per hectare, $X_3$ is cost of labor per hectare, $X_4$ is cost of chemical fertilizer per hectare, $X_5$ is cost of FYM (Farm Yard Manure) per hectare. e is error term and b1 to b5 is coefficient to be estimated. The above mentioned equation is linearized in logarithmic function.

$$\ln Y= \ln a+ b1\ln X1+ b2\ln X2+ b3\ln X3+b4\ln X4+b5\ln X5+u$$

Where, ln= natural logarithm, a= constant and u is random disturbance

The efficiency ratio (r) was computed using the formula

$$r = \frac{MVP}{MFC}$$

where,

MFC= Marginal factor cost

MVP= Marginal value product, the marginal value product was computed by using formula:

$$MVP_i = b_i \times \frac{Y}{XI}$$

Where, $b_i$ = Estimated regression coefficients

Y and $X_i$ are the values from geometric mean.

Efficiency estimation

r = 1 indicate the efficient use of resource

r < 1 indicate overused of resource

r > 1 indicate underuse of resource

The relative percentage change in MVP of each resource was estimated by using following formula

$$D= (1- MFC/MVP) \times 100$$

Or, $D= (1-1/r) \times 100$

Where, D= Absolute value of percentage change in MVP of each resource

***Return to Scale***

Return to scale is used to determine the relationship among inputs, outputs and costs. It is more concerned about profit function analysis (McClelland *et al*., 1986). If output increases by the same proportional change, there is constant return to scale. If output increases by less than that of proportional change, there is decreasing return to scale. If output increases by more than that of proportional change then it is referred as increasing return to scale (Bao Hong, 2008).

***Benefit Cost Analysis***

Benefit cost analysis was calculated by using following formula

$$B/C=\frac{Gross\ return}{Total\ variable\ cost}$$

## Result and Discussion

Majority of household head in the research area was male. 80% of household of Marin had male as household head whereas 86.7% of household of KMC had male as household head. Marin was dominated by Janajati and KMC was dominated by Brahmin/Chhetri. Most of the farmers of the research area were Hindu and very few farmers of Marin follow Buddhism. Majority of farmers (88.3%) of Marin live in joint type of family, only 18.3% of farmers of KMC live in joint family system as shown in Table 1.

Farmers of Marin had greater land holding than farmers of KMC. In KMC agricultural land has been fragmented due to rapid urbanization. Average land holding of farmers of Marin was 12.04 hectare and that of KMC was 8.11 hectare. The difference was statistically highly significant at 1% level of significance whereas no significant difference was observed in maize cultivated area. Farmers of Marin left school earlier than farmers of KMC, generally farmers of KMC left school after completing grade eight. Average active members of family in Marin is higher than KMC but the result was statistically non significant. Number of active member is decreasing at alarming rate due to migration to Arabian nations for employment. Livestock standard unit (LSU) of Marin was 4.19 and that of KMC was 1.89, the difference is statistically highly significant as shown in Table 2.

Maize producer of KMC apply higher seed rate than Marin but the difference was statistically non significant. Farmers of KMC apply higher dose of NPK than Marin but the dose was far below recommended practice. This is due to timely unavailability of chemical fertilizers (Dahal and Bhandari, 2019; Pyakurel *et al.*, 2019). Recommended dose of NPK for maize cultivation in Nepal is 105 kg, 65kg and 50 kg/ha (MoAD, 2018). 10.9 pairs of oxen were required for carrying out tillage operation in Marin whereas 11.03 pairs of oxen were required in KMC. Farmers of Marin apply higher amount of FYM for maize cultivation than farmers of KMC because farmers of Marin have higher no of livestock. The difference was statistically highly significant at 1% level of significance. Farmers of Marin apply 300 *doko* FYM whereas farmers of KMC apply 256.83 *doko*. Labor employed for maize production in Marin was higher than that of KMC and the difference was statically significant at 1% level of significance. 25.73 men and 21.88 men were required to produce maize in Marin and KMC respectively as shown in Table 3.

**Table 1.** Demographic characteristics of maize growing farmers

| | Maize Grown Area | | | |
|---|---|---|---|---|
| **Variables** | **Marin** | **KMC** | **Chi-square** | **p-value** |
| Gender of HHH (male) | 48(80.0) | 52(86.7) | 0.96$^{ns}$ | 0.327 |
| Ethnicity | | | | |
| Brahmin/Chhetri | 29(48.3) | 33(55.0) | 19.68$^{***}$ | 0.000 |
| Janajati | 31(51.7) | 14(23.3) | | |
| other | 0 | 13(21.7) | | |
| Religion(Hindu) | 53(88.3) | 60(100) | 7.434$^{**}$ | 0.013 |
| Family type (joint) | 25(41.7) | 11(18.3) | 7.778$^{***}$ | 0.005 |

Figures in parenthesis indicate percent. *, ** and *** indicate 10%, 5% and 1% level of significance

**Table 2:** Demographic characteristics of maize growing farmers

| | Maize Grown Area | | | |
|---|---|---|---|---|
| **Variables** | **Marin** | **KMC** | **t-value** | **p-value** |
| Total Land | 12.04 | 8.11 | 3.375$^{***}$ | 0.001 |
| Maize grown area | 8.34 | 7.57 | 1.204$^{ns}$ | 0.231 |
| Schooling | 6.13 | 8.57 | -4.616$^{***}$ | 0.000 |
| Active members | 4.35 | 3.9 | 1.33$^{ns}$ | 0.186 |
| LSU | 4.19 | 1.89 | 6.659$^{***}$ | 0.000 |

*, ** and ** indicate 10%, 5% and 1% level of significance. ns indicate non-significant.

**Table 3:** Amount of inputs required in maize farming

| | | Maize grown Area | | | |
|---|---|---|---|---|---|
| **Variables** | **Overall** | **Marin** | **KMC** | **t-value** | **p-value** |
| Seed rate | 8.83 | 8.55 | 9.116 | -1.616^ns | 0.109 |
| Urea | 50.71 | 49.5 | 51.91 | -1.284^ns | 0.202 |
| DAP | 40.21 | 40.12 | 40.3 | -0.215^ns | 0.83 |
| Potash | 12.62 | 12.23 | 13.01 | -1.494^ns | 0.138 |
| Tillage | 11.1 | 10.9 | 11.03 | -0.568^ns | 0.571 |
| FYM(Doko) | 278.58 | 300.33 | 256.83 | 4.415*** | 0.00 |
| Labour | 47.61 | 25.73 | 21.88 | 3.744*** | 0.00 |

*** indicate 1% level of significance and ns indicate non-significant.

**Table 4**: Cost of inputs required in maize farming

| | | Maize grown area | | | |
|---|---|---|---|---|---|
| **Variables** | **Overall** | **Marin** | **KMC** | **t-value** | **p-value** |
| Seed | Rs 325.25 | Rs 292.33 | Rs 378.17 | -2.178** | 0.031 |
| Tillage | Rs 14815 | Rs13080 | Rs 16550 | -10.8*** | 0.00 |
| Labor | Rs 10617.5 | Rs 10293.33 | Rs 10941.67 | -1.441^ns | 0.152 |
| FYM | Rs 13929.17 | Rs 15016.67 | Rs 12841.67 | 4.415*** | 0.00 |
| Urea | Rs 1318.42 | Rs 1287 | Rs 1349.83 | -1.284^ns | 0.202 |
| DAP | Rs 2090.83 | Rs 2086.07 | Rs 2095.6 | -0.215^ns | 0.83 |
| Potash | Rs 252.5 | Rs 244.67 | Rs 260.33 | -1.494^ns | 0.138 |

**, *** and ns indicates 5%, 10% level of significance and non significance.

Farmers of KMC invest more in seed than farmers of Marin because most of the farmers of KMC buy maize seed from agro-vet whereas most of the farmers of Marin use own seed for maize cultivation. The difference was statistically significant at 5% level of significance. Cost incurred for performing tillage operation was higher in KMC this is due to higher cost of animal power. Farmers of Marin invest Rs 13080 for performing tillage operation whereas farmers of KMC invest Rs 16550. The difference was statistically highly significant at 1% level of significance. Labor cost for maize production in KMC was higher than Marin because of higher cost of unit labor. This difference was statistically non-significant. Cost of FYM for production of maize in KMC was higher than Marin and the difference was statistically highly significant at 1% level of significance. Cost incurred for chemical fertilizers (urea, DAP and potash) was higher in KMC than Marin because farmers of KMC apply higher dose of chemical fertilizer as they have good access to chemical fertilizer. This difference was statistically non-significant which is shown in Table 4.

Cone, Stubble and Maize grains are three source of income for maize producing farmers of Sindhuli. All the farmers did not sell cone and stubble. Farmers of Marin earn Rs 621 by selling cone whereas farmers of KMC earn Rs 503.33. The result was statically significant at 5% level of significance. Winter maize growing farmers earns higher by selling cone than spring season as spring season is considered as main season for maize cultivation in Nepal. Farmers of Marin earns higher by selling maize stubble but the result was statistically non-significant. Maize stubble was used as feed for animal during lean period. Farmers of Marin earn Rs 49833.33 and that of KMC earn Rs 48791.67 from maize grains but the result was statistically non significant. The generally sell grains for local wine producers, food for human beings and feed for animals. The share of tillage cost was 34% followed by FYM (32%) and labor (24%). This reveled that huge amount of money, 90% was invested in tillage, FYM and labor. Similar result was obtained in maize seed production of Palpa (Sapkota *et al*., 2018). Maize farming is an important enterprise for the use of animal power for tillage operation, FYM produced by their own livestock and household labor which is in line with maize seed production in western hills of Nepal (Sapkot *et al.*, 2018). Chemical fertilizer and seed share very small amount of cost among other inputs as shown in Fig. 1.

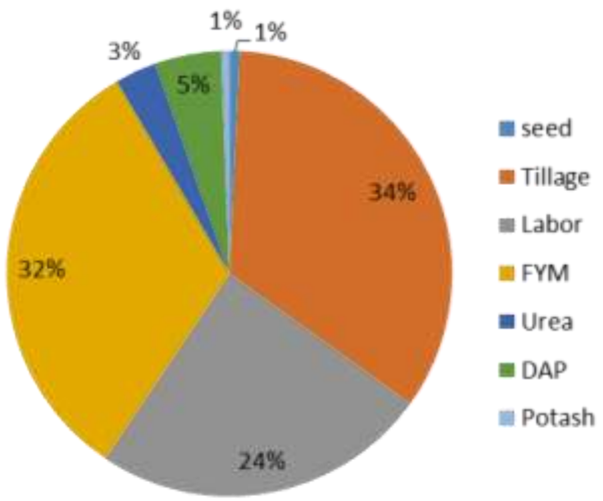


**Fig. 1**: Share in of different cost components for maize cultivation

**Table 5**. Various source of income in maize farming

| | Maize Grown Area | | | | |
|---|---|---|---|---|---|
| **Variables** | **Overall** | **Marin** | **KMC** | **t-value** | **p-value** |
| Cone | Rs 562.58 | Rs 621.833 | Rs 503.33 | 3.198** | 0.002 |
| Stubble | Rs 929.91 | Rs 1010 | Rs 849.833 | 1.87 | 0.064 |
| Grain | Rs 4931.50 | Rs 49833.33 | Rs 48791.67 | 0.702 | 0.484 |

** indicate 5% level of significance

**Table 6**. Profitability of maize farming in Sindhuli

| | Maize Grown Area | | | | |
|---|---|---|---|---|---|
| **Variables** | **Overall** | **Marin** | **KMC** | **t-value** | **p-value** |
| B/C | 1.2 | 1.25 | 1.15 | 2.71*** | 0.008 |
| Total Income | Rs 50805 | Rs 51465.17 | Rs 50144.83 | 0.894 | 0.373 |
| Total cost | Rs 42423.3 | Rs 41361.67 | Rs 43484.93 | -3.102*** | 0.002 |
| Productivity | 1.97ton/ha | 1.99ton/ha | 1.95ton/ha | 0.702ns | 0.484 |
| Profit | Rs 8381.7 | Rs10103.5 | Rs 6659.90 | 2.394** | 0.018 |

**, *** and ns indicate 5%, 10% level of significance and non-significant.

***Profitability of Maize Farming in Sindhuli***

Benefit cost ratio of maize production in Marin rural municipality was higher than KMC municipality. B/C ratio of maize production in Marin was 1.25 and that of KMC was 1.15. This value was statically significant at 5% level of significance. By investing of one rupee in maize production farmers of Marin and KMC gets profit of 25 paisa and 15 paisa respectively. Total cost incurred in production of maize in one hectare in Marin and KMC was Rs 41361.67 and Rs 43484.93 respectively. The cost of production was statically significant at 5% level of significance. Higher cost of production in KMC municipality was due to higher cost of labor and animal power. Total income from maize farming in Marin was higher than that of KMC as shown in Table 6.

The average area and productivity of maize in the research area was 7.91 hectare and 1.97 ton/ha. Productivity in the research area is lower than productivity of Chitwan but higher than Palpa (Dhakal *et al*,. 2015; Sapkota *et al*., 2018). B/C ratio, total cost and total income of maize production in the area was 1.2, Rs 42423.3 and Rs 50805 respectively. Farmers of Marin earns higher profit from maize farming than farmers of KMC, this is due to lower cost of production in Marin rural municipality. Farmers of Marin got Rs 10103.5 whereas farmers of KMC got Rs 6659.90 as profit from one hectare. Maize farming is profitable enterprise in Sindhuli district of Nepal.

***Production Function Analysis***

F value (11.57) was statistically highly significant at 1% level of significance which depicts that the model has good explanatory power; all the independent variable included in the model explained the variation of output. The R- squared value was 33.65%, indicates that 33.65% of the variation in income of maize was explained by the independent variables included in the model. Cost of seed is statically significant at 10% level of significance and cost of chemical fertilizer and FYM was significant at 1% level of significance. 10% increase in chemical fertilizer resulted in increase in income by 7.21% which is consistent with maize production of eastern terai of Nepal, Ghana and Zimbabwe (Adhikari *et al*., 2018; Hanan and Rahaman, 2017; Mango *et al*., 2015). 10% increase in FYM resulted in increase in 2.43% of income similar result was obtained in potato production of Nuwakot (Dahal and Rijal, 2019). 10% increase in seed cost resulted in 0.6% increase in output which is in line with study conducted by (Dhakal *et al.*, 2015; Sapkota *et al*., 2018) but contrast with maize production in eastern terai of Nepal (Adhikari *et al*., 2018). 10% increase in labor and animal power resulted into 0.2% and 0.07% decrease in output which is in line with maize-pumkin mixed cropping (Dhakal *et al*., 2015). Labor and animal power is over utilized resource for potato production in Nuwakot (Dahal and Rijal, 2019).The sum of coefficients was 0.983 which is less than 1 implied decreasing return to scale, similar result was obtained in potato production in central and western hills of Nepal and maize-pumpkin mixed cropping of Chitwan (Dahal and Rijal, 2019; Bajracharya and Sapkota, 2017; Dhakal *et al.*, 2015). 100% increase in all the factor of production included in this model would result in 98.30% increase in maize production.

**Table 7**. Production function of maize production in Sindhuli

| Variables | Coefficients | Standard Error | t-stat | P-value |
|---|---|---|---|---|
| ln(seed cost) | 0.060872936* | 0.033814667 | 1.80019326 | 0.074474642 |
| ln(animal power) | -0.007416239 | 0.080128541 | -0.09255427 | 0.926420127 |
| ln(labor) | -0.020644057 | 0.055448272 | -0.372312 | 0.710351791 |
| ln(chemical fertilizer) | 0.721411619*** | 0.12384163 | 5.82527553 | 5.37269E-08 |
| ln(FYM) | 0.243523257*** | 0.062651465 | 3.88695229 | 0.000170937 |
| Constant | 1.086664981 | 0.63520362 | 1.71073487 | 0.089849979 |
| R Square | 0.336548269 | | | |
| Adjusted R square | 0.307449509 | | | |
| F-value | 11.5657254 | | | |
| Return to scale | | | | |

* and *** indicate 10% and 1% level of significance

**Table 8**: Estimation of allocative efficiency of maize farming

| **Cost of input** | **Coffecient** | **G.Mean** | **MVP** | **MFC** | **MVP/MFC** | **r** | **D** |
|---|---|---|---|---|---|---|---|
| Seed (Nrs/ha) | 0.060872 | 307.7 | 9.930 | 1 | 9.93 | Under utilized | 89.93 |
| Animal power(Nrs/ha) | -0.0074162 | 14621.11 | -0.025 | 1 | -0.025 | Over utilized | 4028.95 |
| labor (Nrs/ha) | -0.0206440 | 16345.94 | -0.063 | 1 | -0.063 | Over utilized | 1677.95 |
| Chemical fertilizer(Nrs/ha) | 0.7214116 | 3642.37 | 9.930 | 1 | 9.93 | Under utilized | 89.93 |
| FYM (Nrs/ha) | 0.2435232 | 13641.49 | 0.895 | 1 | 0.895 | Over utilized | -11.63 |

***Estimation of Allocative Efficiency of Maize Farming***

The adjustment in the MVPs for optimal resource use is shown in Table 8 which indicated that for optimal allocation of resource expenditure on seed and chemical fertilizer were need to be increased by 89.93% each. The increased in the cost of the seed has for more expenditure on seed to purchase certified seed as compared to own farm seed. Similar result of under utilization of chemical fertilizer and seed were found by Dhakal et al. (2015) and Sapkota et al. (2018). Similarly, decreasing cost of human labor and FYM is supported by Dhakal et al. (2015) but decreasing cost of FYM is in contrast with the finding of Dahal and Rijal (2019); Ghimire and Dhakal, (2014). Decreasing in cost of animal power is supported by Sapkota et al. (2018).

## Conclusion

The research area is dominated by Brahmin/chhetri and majority of people follow Hinduism as major religion. Most of the farmers of research area prefer to live in nuclear family with male as household head. Benefit cost ratio in the research area is 1.20 which indicates that maize production was profitable and farmers of Sindhuli get additional 20 paisa with investment of one rupee in maize farming. Productivity, cost and income per hectare of maize farming in Sindhuli was 1.98 tons per hectare, Rs 42423.3 and Rs 50805 respectively. 10% increase in chemical fertilizer, FYM and seed cost resulted in increase in income by 7.21%, 2.43% and 0.6% respectively. 10% increase in labor and animal power resulted into 0.2% and 0.07% decrease in output. For optimal allocation of resource expenditure on seed and chemical fertilizer were need to be increased by 89.93% each. Labor, animal power and FYM were over utilized resources for maize farming. The sum of coefficients was 0.983 which implied decreasing return to scale, 100% increase in all the factor of production included in the model would result in 98.30% increase in maize production. It would be better to increase amount of fertilizer and decrease no of labor and animal power for sustainable maize production in Sindhuli.

## Acknowledgement

Authors want to acknowledge their parents for the support and guidance in academics.

## References

Adhikari SP, Timsina KP, Brown PR, Ghimire YN and Lamichhane J (2018) Technical efficiency of hybrid maize production in eastern terai of Nepal: A stochastic frontier approach. *Journal of Agriculture and Natural Resources*. **1**(1): 189-196. https://doi.org/10.3126/janr.v1i1.22234

Bajracharya M and Sapkota M (2017) Profitability and productivity of potato (*Solanum tuberosum*) in Baguung district, Nepal. *Agriculture and Food Security*.**6**: 47.DOI: 10.1186/s40066-017-0125-5

Bao Hong T (2008, November 20). *Cobb-Douglas Production function*. Retrieved from http://docentes.fe.unl.pt/~jamador/Macro/cobb-douglas.pdf

Chaudhary DP, Kumar S and Yadav OP (2013) Nutritive value of maize: Improvements, applications and constraints. *Maize: Nutrition Dynamics and Novel Uses*. **3**-17.

Dahal BR and Bhandari S (2019) Biofertilizer: A next generation fertilizer for sustainable rice production. *International Journal of Graduate Research and Review*.**5**(1): 1-5.

Dahal BR and Rijal S (2019) Production economics and determints of potato production of Nuwakot district of

Nepal. *International Journal of Applied Science and Biotechnology*.**7**(1):62-68. DOI:10.3126/ijasbt.v7i1.23304

Dhakal SC, Regmi PP, Thapa RB, Sah SK. and Khatri-Chhetri DB (2015) Productivity and profitablity of maize-pumkin mix cropping in Chitwan, Nepal. *Journal of Maize Research and Development* .**1**(1): 112-122. DOI:10.3126/jmrd.v1i1.14249

Ghimire B and Dhakal SC (2014) Production economics of sustainable soil management based cauliflower(*Brassicae oleracea*. L. var. botrytis) in Dhading. *American Journal of Agriculture and Forestry*.**2**(4): 199-205.

Hanan AA and Rahaman AA (2017) Technical efficiency of maize farmers in Ghana: A stochastic frontier approach. *International Journal of Innovation and Specific Research*. **29**(2):110-118.

Khatri-Chhetri G, Karki TB, Shrestha J and Acchami BB (2015) Status and prospects of maize reseach in Nepal. *Journal of Maize Research and Development*.**1**(1):1-9.DOI: 10.3126/jmrd.v1i1.14239

Mango N, Makate C, Mlambo BN, Siziba S and Lundy M (2015) A stochastic frontier analysis of technical efficiency in smallholder maize production in Zimbawe: The post-fast-track land reform outlook. *Coget Economics and Finance* (3). DOI:10.1080/23322039.2015.1117189

McClelland JB, Wetzstein ME and Musser WN (1986) Returns to scale and size in agricultural economics. *Western Journal of Agricultural Economics* , **11** (2), 129-133.

MoAD (2018) *Krishi Diary*. Hariharwan, Kathmandu: Ministry of Agricultural Development, Government of Nepal.

MoAD (2017) *Stastical Information on Nepalese Agriculture (2017)*. Singhadurbar, Kathmandu, Nepal: Monitoring Evaluation and Statistic Division, Agriculture Statistic Section, Ministry of Agricultural Development, Government of Nepal.

Paudyal KR and Poudel SK. (2001) Impact of public and private sector maize research in Nepal. In *Impact of public and private sector maize breeding research in Asia(1966-1999)* (pp. 66-80). Mexico: CIMMIT.

Paudyal KR, Ransom JK., Rajbhandari NP, Adhikari K., Gerpacio RV and Pingali PL (2001) *Maize in Nepal: production system, constraints and priorities for research.* Kathmandu: NARC and CIMMYT.

Pyakurel A, Dahal BR and Rijal S (2019) Effect of molasses and organic fertilizer in soil fertiliy and yield of spinach in Khotang district of Nepal. *International Journal of Applied Science and Biotechnology* **7**(1): 49-53. DOI:10.3126/ijasbt.v7i1.23301

Sapkota D and Pokhrel S (2010) Community based maize seed production in the hills and mountains of Nepal: A review. *Agronomy Journal of Nepal*. **1**: 107.DOI: 10.3126/ajn.v1i0.7550

Sapkota M, Joshi NP, kattel RR and Bajracharya M (2018) Profitablilty and resource use efficiency of maize seed production in Palpa district of Nepal. *SAARC J. Agri*.**16** (1): 157-168. DOI:10.3329/sja.v16i1.37431

Upadhaya S, Gurung D, Paudel D, Koirala K., Sah S, Prasad S et al. (2009) Evulation of quality protein maize(QPM) genotypes under rainfed mid hill environments of Nepal. *Nepal Journal of Science and technology*.**10**: 9-14.DOI: 10.3126/njst.v10i0.2803

Yuan Z (2011) Analysis of agricultural input-output based on Cobb-Douglas production function in Hebei Province, North china. *African Journal of Agricultural Research*. **5** (32): 5916-5922. DOI: 10.5897/AJMR11.961