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Research Article

Allocative efficiency and adoption of improved maize variety: A case of eastern hills of Nepal

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ABSTRACT
Production and profit from maize farming can be substantially increased by allocating resources efficiently and adopting improved maize variety. In this context, a study was undertaken to determine the allocative efficiency and factors affecting adoption of improved maize variety in Eastern hills of Nepal. Random sampling was conducted in eastern part of Khotang district namely, Halesi municipality and Diktel Rupakot Majuwagadi municipality during month of March 2019. Pretested semi-structured questionnaire was administered among 80 randomly selected farmers cultivating maize since last two years. Face to face interview was scheduled to obtain data. Cobb Douglas production function was used to determine allocative efficiency; probit regression model was launched to determine factors affecting adoption of improved maize variety. Significant positive relation of cost of seed, planting, and weeding with income has suggested to increase expenditure on certified maize seed over own farm seed, line sowing over broadcasting, and weeding. The model revealed that increasing all the factors of production by 100% would result in increase in income by 71.83%. Furthermore, cultivating improved maize variety is more profitable than own farm seed. Probit regression model showed that, farmers who have received training, who were member of cooperatives and who have received high schooling were more likely to adopt open-pollinated improved maize variety. Unavailability of inputs (seed, fertilizer, and labor), insect pest attack and adverse climatic conditions were major constraint of maize farming. Therefore, it would be better to suggest maize producers to increase expenditure on seed; make maize field weed free and adopt line sowing method. In addition, providing training, increasing access over inputs and encouraging farmers towards cooperatives could be virtuous for sustainable maize production.

Keywords: Cobb douglas production function, probit regression and open pollinated variety

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INTRODUCTION

Maize (*Zea mays* L.) is one of the most important crop in the world. Having highest production potential, Maize, among all other cereals is known as queen of cereals (Singh, 2002). It is used mainly for human food, animal feed and industry. It is the second staple food crop for country and first staple food crop for hill regions of Nepal. Production and productivity of maize in Nepal was 2.55 millions tons and 2.67 tons per hectare (MoAD, 2018). In Nepal, it is the food for more than 14 million people in the hills and is playing a vital role in the livelihood of rural people (Kunwar & Shrestha, 2014).

In hills, Maize, cultivated during summer season as rain-fed sole crop in lowland and relay crop with millet in Bari—slopping upland without bunds. Maize is a source of staple food and feed (for animals) among farmers of hilly region of the country; mainly consumed in the form of *chayakhla, roti,* and *Dhido*—traditional food products of Nepal. In addition, maize is used as a substrate of fermentation for making traditional alcoholic products. Among cereals, maize fulfills about 26.8% of total food requirements in hills and mountains of the country (Sapkota & Pokhrel, 2010). It is an important source of starch (contains 70% of starch by weight), caretonoids (beta-carotene, zeaxanthin, lucin and cytoxanthin), and oils which can also be use for human consumption; fortified maize is rich in iron, zinc, and provitamin A (Chaudhary *et al*., 2013).

Quantity of maize required for food per year is around 2.9 million metric ton; about 6.46 million metric ton feed is required to run the existing poultry industries in our country (K.C. *et al*., 2015). With a larger proportion of maize supply going into food and feed consumption in Nepal, a sustained increase in productivity is undoubtedly crucial for achieving food and feed security in Nepal. However, productivity of maize (2.50 t/ha) in Nepal is far beyond the global average unable to met the constantly increasing demand—five percent per year since last decade (MoAD, 2016; FAO 2013). Moreover, maize farming has been important source of income among rural people. Despite the prodigious importance of maize in Nepal, maize farmers in the country continue to experience low productivity, making nation self-insufficient in the production of crop.

Poor productivity of maize is probably due to the lack of irrigation facility, declining soil fertility and sluggish adoption of production boosting technology (Ransom *et al*., 2013). The low productivity could partly be ascribed to the low adoption of improved maize variety which limit the revenues of farmers and subsequently lead to poverty and food insecurity. Yet, there is a paucity of studies explaining the economic relationship between farm household socioeconomic factors and adoption of improved maize variety. Moreover, the poor productivity might be due to inefficient use of resources of maize production: seed, labor, animal power, and fertilizers. There are only three possible ways to increase maize production: by increasing area of cultivation, utilizing available resources efficiently, and adopting production boosting maize farming technology (Dahal *et al.*, 2019). Since last decades, rapid and unplanned urbanization has dwindled agricultural land, thus it is nearly impossible to increase area of cultivation; utilizing resources efficiently and adopting production boosting technology are the only way to increase maize production. Resources are believed to be utilized efficiently when it is used in best possible way, minimizing cost of

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production (Dhakal *et al.*, 2015). It is very crucial to evaluate whether the farmers are making rational use of available resources or not; they might use resources irrationally or rational use outside the fringe of economic optima level. In this context, a study was undertaken in eastern hills of Nepal to figure out allocative efficiency and factors affecting adoption of improved maize variety.

MATERIALS AND METHODS

The study was conducted in Khotang district, part of province no 1 of federal republic of Nepal with coordinates of 26̊ 50' to 27̊ 28' north and 86̊ 28' to 86̊ 59' east and elevation of 152-3,620 meter above sea level. The beautiful agrarian district encompasses by 50% of mid-hills. In addition, climate here range from tropical to alpine but dominated by sub-tropical. Eastern part of Khotang district namely, Halesi municipality and Diktel Rupakot Majuwagadi municipality were purposefully selected as they were major maize producing region with identifiable maize growers. By using Pre-tested semi-structured questionnaire, face to face interview was scheduled to collect primary data on demography, technologies of maize production, cost of production and income in the month of March 2019. A total of 80 farmers, 40 from Halesi and 40 from Diktel Rupakot Majuwagadi municipality were randomly selected from the population of farmers cultivating maize since last two years. FGD (focal group discussion) and KII (key informant interview) were conducted to validate the information obtained from farmers. On the basis of type of seed used farmers were categorized into two groups, adopters and non- adaptor. Farmers those using improved variety as basic input are adopters while those not using it are grouped in non-adopters. Data analysis was done by using various statistical tools: descriptive statistics (like mean, standard deviation), inferential statistics (like t-test) and analytical statistics (like probit regression model and cobb-douglas production function), with the help of different statistical software like Microsoft Excel, SPSS and STATA.

Econometrics

Cobb-Douglas production function

Cobb-Douglas production function was launched to calculate allocative efficiency 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). This model has been extensively used to determine the allocative efficiency of production of agricultural commodity (Dahal and Rijal, 2019). The given equation enlightens Cobb-Douglas production function:

$$Y=aX_1^{b1}X_2^{b2}X_3^{b3}X_4^{b4}X_5^{b5}X_6^{b6}e^u$$

Y is income of maize production in ropani (Nrs), X_1 is cost of maize seed per ropani, X_2 is cost of land preparation in ropani (Nrs), X_3 is cost maize planting in ropani (Nrs), X_4 is cost of weeding and hoeing in ropani (Nrs), X_5 is cost of manure and pesticides per ropani (Nrs) X_6 is cost of harvesting per ropani (Nrs) . e is error term and b1 to b6 is coefficient to be estimated. The above mentioned equation is linearized in logarithmic function.

$$\ln Y= \ln a+ b1\ln X1+ b2\ln X2+ b3\ln X3+b4\ln X4+b5\ln X5+ b6\ln X6+u$$

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

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The efficiency ratio (r) was computed by dividing MVP with MFC, show in the below equation

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

In above equation MFC and MVP represents,

MFC= Marginal factor cost

MVP= Marginal value product, the marginal value product was calculated by using the 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 of income and cost of individual input

Efficiency estimation: Efficiency of maize production in eastern Nepal was estimated by: if, $r = 1$ indicates resources are being used efficiently, if $r < 1$ indicates resources are over utilized, and if $r > 1$ indicates underutilization of resources.

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

D= (1- MFC/MVP) ×100

Or, D= (1-1/r) ×100

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

Return to scale

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

Benefit cost Analysis

Benefit cost analysis for both the categories was calculated by using following formula (Shrestha, 2015).

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

Probit regression model

Probit model was accessed to determine the factor influencing adoption of improved maize varieties among the studied farmers. Probit is statistical probability model with two categories independent variable (Lao, 1994). Probit model is based on the cumulative normal probability distribution. The binary dependent variable y<takes on the value of zero and one (Aldrish and Nelson, 1984). In binary probit model, farmers cultivating improved maize variety were taken as 1, while those cultivating local variety were taken as zero. It is assumed

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that the ith farmers obtain maximum utility; it has improved variety preference than local variety. The probability Pi of choosing any alternative over not choosing it can be expressed by following equation, where φ represents the cumulative distribution of the standard normal random variable (Uzunoz and Akcay, 2012).

$$P_i = \text{prob}\ [Y_i=1\ |x| = \int_{-\infty}^{xi'ß} (2\ \pi^{\frac{-1}{2}} \exp(-\frac{t^2}{2})dt = \varphi(x_i{'}_{ß})$$

Indexing of problems

Indexing or scaling techniques provides the direction and extremity attitude of the respondent towards any preposition. For quantification of qualitative parameters regarding the farmer perception on insect and disease incidence, input (seed, fertilizers, and labor) availability, adverse climate, lack of technology, irrigation facility, indexing was done.

Different scale value 1, (1-1⁄n),(1-2/n)…….(n denotes the number of categories In ranking) were used to rank insect and pest attack, input availability, lack of technology ,adverse climatic condition

Where,

N = no of categories in ranking

To find overall ranking average of the index was computed and values were compared to give final rank to the variety

The index of important was calculated by using the following formula;

$I_{imp}=\sum(S_i f_j)/N$

Where,

I_{imp}=Index of importance

S_i=scale value

F_i=frequency of importance given by the respondent

N =Total number of respondents

Subedi *et al.* (2019a) used the scaling technique to identify the constraints associated with the potato production in Terai region of Nepal. This formula was applied by Shrestha and Shrestha (2017) to rank the problems associated with maize seed production. Subedi *et al.* (2019b) used this technique to explore the problems associated with wheat production.

RESULTS AND DISCUSSION

Benefit cost analysis

Cost of production of maize and revenue is presented in the table no 2. According to the survey it was found that, total cost of production of improved maize variety was higher than local variety. A plausible explanation to the statement is supported by, improved maize variety adopters are more aware about improved maize cultivation practice. Moreover,

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improved cultivation practice requires higher cost of cultivation than local variety. Cost of production of maize for improved seed adopter was Rs.4370.49 per ropani, whereas for non-adopter was Rs 3051.83 per ropani but the result was statistically non-significant. Consistent with the theory, revenue from improved maize variety was higher than local variety and the result was statistically significant at 1% level of probability. Benefit-cost ratio of improved maize variety and local variety was found 1.44 and 1.15 respectively, revealed that improved maize production was more profitable than local variety. With investment of 1 rupee in improved maize farming, farmers earned additional 44 paisa but the additional earning was only 15 paisa for local variety. This is attributed by the fact that productivity of improved maize variety is higher than own farm seed (local variety).

Table 1 Benefit cost analysis

Variables	adopters	non-adopters	t-value	p-value
Land preparation(Nrs/ropani)	1101.99(156.59)	933.09 (74.91)	1.04	0.3
Seed (Nrs/ropani)	107.62(22.91)	85.97 (7.29)	0.99	0.32
Planting (Nrs/ropani)	752.35(181.84)	515.007(39.91)	1.43	0.16
Weeding and hoeing (Nrs/ropani)	914.93(224.25)	581.82 (60.62)	1.59	1.12
Manure and pesticides (Nrs/ropani)	983.55 (175.37)	779.78 (85.27)	1.12	0.27
Harvesting(Nrs/ropani)	245.48 (32.71)	197.95 (24.58)	1.19	0.24
Total cost(Nrs/ropani)	4370.89 (870.47)	3051.83 (217.94)	1.64	0.11
Total revenue(Nrs/ropani)	4454.92(505.57)	2954.31 (114.19)	3.24***	0.002
B/C ratio(Nrs/ropani)	1.44	1.15	1.84**	0.07

Cobb-Douglas production function analysis

F value was 13.28, statistically highly significant at 1% level of probability, revealed 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 0.4826, indicated that 48.26% of the variation in income from maize was explained by the independent variables included in the model. Cost of seed was statically significant at 1% level probability; 10% increase in cost of seed resulted in 2.95% increase in income, consistent with study conducted by Dhakal *et al.* (2015) and Sapkota *et al.* (2018) but contrast with maize production in eastern terai of Nepal (Adhikari *et al.*, 2018). The increase in income with cost of seed could partly be attributed to the fact that improved seed cost more than local seed. In addition, improved maize varieties have good stress tolerance ability and have potential to give higher yield. Consistent with the theory, cost of weeding and hoeing was statistically significant at 5% level of probability; 10% increase in cost of weeding and hoeing resulted in increase in income by 1.75%. This can be partly ascribed that increase in cost of weeding and hoeing results decrease in competition of maize with weeds—increase in maize production. Cost of planting was statistically significant at 10% level of probability. Coefficient of cost of planting was 0.2486, revealed that 10% increase in cost of planting resulted in increase in income by 2.48%. Positive relationship of cost of planting and income is supported by the fact; row method of sowing maintains optimum plant population and boost maize productivity. In addition, higher labor cost is required to adopt row method of sowing than

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broadcasting. Cost of manure, pesticides, and harvesting had positive relation with output; however, the result was statistically non-significant. Positive relationship of cost of manure and income is consistent with potato production of Nuwakot (Dahal and Rijal, 2019). Cost required for land preparation had negative relation with income revealed, 10% increase in cost of land preparation resulted in decrease in income by 0.92%: however, the result was statistically non-significant. The plausible explanation for this is that farmers were allocating high cost for land preparation—negatively associated with income. The finding is in accordance with (Dahal *et al.*, 2019). The sum of coefficients was 0.7183 which is less than 1 implied decreasing return to scale; 100% increase in all the factor of production included in this model would result in 71.83% increase in maize production similar result was obtained by Dhakal *et al.* (2015).

Table 2. Cobb Douglas Production Function analysis

	Coefficients	Standard Error	t-stat
Constant	4.254208	0.680261	6.253786
seed cost (Nrs/ropani)	0.295089^{***}	0.103281	2.857159
land preparation cost (Nrs/ropani)	-0.09208^{ns}	0.184057	-0.50028
Planting (Nrs/ropani)	0.248635^{*}	0.129368	1.921917
weeding and hoeing (Nrs/ropani)	0.17508^{**}	0.084251	2.078069
manure cum pesticides (Nrs/ropani)	0.062457^{ns}	0.086856	0.719085
Harvesting (Nrs/ropani)	0.029153^{ns}	0.069645	0.418592
R Square	0.521952		
Adjusted R Square	0.48266		
F-ratio	13.28406^{***}		
Standard error	0.452735		
Return to scale	0.718335		

Allocative efficiency of maize producing farmers

The adjustment in the MVPs for optimal resource use is shown in table no.3, indicated that for optimal allocation of resource expenditure on seed, planting, weeding, and hoeing were need to be increased—underutilized resources for maize production in eastern hills of Nepal. Cost of seed need to be increased by 91.946% for sustainable maize production; similar result of under utilization of seed was found by Dhakal et al. (2015) and Sapkota et al. (2018). The increase in the cost of the seed has suggested to allocate more cost on seed to purchase certified seed as compared to local variety—own farm seed. In addition, cost of weeding and hoeing, and planting need to be increased by 41.34% and 4% respectively; has suggested increasing expenditure on adopting line sowing and making maize field weed free. Cost of land preparation, manure, pesticides, and harvesting were over utilized resources for maize production. Thus it would be better to reduce expenditures on these inputs. Similar result of land preparation was observed by Dahal et al., (2019).

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Table 3. Allocative efficiency of maize growers

Inputs	GM	Coefficients	MVP	MFC	r	D	Percent adjustment
Seed cost	74.74	0.2950	12.417	1	12.417	91.946	under utilized
land preparation cost	843.30	-0.092	-0.343	1	-0.343	391.545	over utilized
Planting cost	458.59	0.248	1.705	1	1.705	41.341	under utilized
weeding and hoeing cost	528.42	0.175	1.042	1	1.042	4.030	under utilized
manure and pesticides cost	686.42	0.062	0.286	1	0.286	249.650	over utilized
Harvesting cost	161.1	0.029	0.569	1	0.569	75.746	over utilized

Factors affecting adoption of improved maize variety

Probit model was used to assess the factor influencing the adoption of improved maize variety. The good explanatory power of the model was revealed through likelihood ratio Chi-square (LR chi^2) which was found statistically significant at 1% level of probability; the Pseudo R^2 was found 0.2545. Among nine variables studied under the model, membership of cooperatives, training received and education status were found to be statistically significant. It was found that farmers who have received training, member of cooperative, and who had high education status were more likely to adopt improve maize variety compared to those without these factors. Education status, training received and member of cooperative were statistically significant at 1%, 5% and 10% level of probability respectively. The probability of adoption of improved maize variety was found to be 74.09% and 56.40% higher for those who have received training on scientific maize cultivation practices and those who were members of cooperative respectively. Training is the best measure through which farmers collect information about advancement in farming practices; changes attitude and behavior through enhancement of skill. In addition, membership of cooperatives increases access over resources and probability of rapid knowledge dissemination. Similar result on training and membership of cooperatives was found in maize farming of Northen Ghana and cauliflower farming of Nepal (Danso-Abbeam *et al*., 2017; Dahal *et al*., 2019). Consistent with the theory, education status had significant positive relation with adoption of improved maize variety. This could be attributed to the fact; knowledgeable people are aware about recent advancement in agriculture and more likely to adopt improved maize variety. The model revealed that, gender of house hold head and maize cultivation area had positive relation with adoption of improved maize variety but the result was statistically non-significant. Generally, commercial farmers cultivate maize in larger area and it is plausible to believe that, commercial farmers follow scientific method of farming and more likely to adopt improved maize variety. Male have sound access and control over resources—increases chance of adoption of improved maize variety. Similar result on adoption of improved maize variety was found in low land zones of Tanjania (Kaliba *et al*., 2000). Size of family, irrigated land, and occupation had negative relation with adoption of improved maize seed, the result was statistically non-significant. Adoption of new technology in agriculture requires more labor inputs (Feder *et al*. 1985). In contrast with Feder et al. (1985), family size had negative relation with adoption of improve maize variety; reveals that farmers with larger families are

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more concerned about importance of non-farm activities than maize farming to meet their increasing needs of large family (Kafle & Shah, 2012). Farmers with larger irrigated land had not adopted improved variety as they prefer to cultivate more profitable vegetable crops than maize. Respondents with agriculture as main occupation are marginalized; they could not afford expensive certified seed and prefer own farm seed to improved maize variety.

Table 4 Factor influencing adoption of improved maize variety

Variables	Coefficients	Std.Error	Z	pl> Zl	dy/dx
Education status(years)	0.3308753	0.0965253	3.43***	0.001	0.0963979
Age of HHH(years)	-0.0018242	0.0127492	-0.14	0.886	-0.0005315
Gender of HHH(@)	0.204248	0.3842495	0.53	0.595	0.059506
Family size (number)	-0.0407619	0.0802221	-0.51	0.611	-0.0118757
Cooperative membership(@)	0.5640798	0.3419666	1.65*	0.090	0.1643402
Training received(@)	0 .7409271	0.3607209	2.05**	0.040	0.2158632
Maize cultivated land(ha)	0 .0032348	0.0251743	0.13	0.898	0.0009424
Irrigated land(ha)	-0.0589813	0.0527793	-1.12	0.264	-0.0171837
Occupation(@)	-.1990738	0.3342207	-0.60	0.551	-0.0579986
Constant	-2.946645	0.9463096	-3.11	0.002	

Note:, ** and **** indicate significance at 10%, 5% and 1% level of probability. @ denote dummy variables*

Number of Observation =80
Log-likelihood = -40.873769
LR chi^2 (9) = 27.90
prob>chi^2 = 0.0010

Problem faced by farmers in production of maize

According to the study, it was revealed that the most important problem in maize cultivation was input unavailability followed by insect pest attack, adverse climate, irrigation facility, and lack of technology. The result is in accordance with study conducted by (Subedi *et al.*, 2017; KC *et al.*, 2015). While, in the case of adopter, the foremost important problem was still input unavailability and the second most important problem was insect adverse climate followed by insect pest attack. This is supported by the fact that, improved variety are less adapted to new environment than local own farm seed. Similarly, in case of non-adopter, the foremost important problem was inputs unavailability followed by insect's pest attack and lack of irrigation facility. Pyaudel et al. (2001) reported that the productivity of maize is significantly affected by inputs, infestation of disease and pest and availability of irrigation. Similarly, Subedi (2017) reported that unavailability of inputs (seed and fertilizer), disease and pest and irrigation are the major bottlenecks for boosting maize productivity.

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Table 5. Problems in maize cultivation

		Overall		Adopter		Non-adopter	
S.N.	Problem	Rank	Index	Rank	Index	Rank	Index
1	Insect pest attack	II	0.625	III	0.617391	II	0.635294
2	Inputs unavailability	I	0.77	I	0.852174	I	0.658824
3	Adverse climate	III	0.5825	II	0.652174	V	0.488235
4	Irrigation facility	IV	0.5825	IV	0.5478260	III	0.629412
5	Technology lack	V	0.445	V	0.313043	IV	0.623529

CONCLUSION

Despite being improved maize variety profitable than own farm local seed, majority of farmers have not adopted open pollinated improved maize variety. In addition, they were not utilizing available resources efficiently; unavailability of inputs, prevalence of insect and pest, and adverse climatic condition were the major constraints of maize farming in eastern hills of Nepal. Maize farmers are experiencing low productivity making nation self insufficient in maize production. The empirical evidence reveaed that, farmers who have participated in training and who were members of cooperatives were more likely to adopt improved maize variety. The study suggests maize growing farmers of eastern hills to increase expenditure on seed, follow line sowing method and make maize field weed free. Moreover, government and other concernd agencies are suggested to provide training on scientific maize cultivation practices and eccouraging farmers to involve in agricultural cooperatives.

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Author Contribution

TK designed questionnaire and conducted survey. Data analysis was done by BRD and TK. BRD was responsible for literature search and drafting of manuscript. TK, BRD and SB were responsible for finalization of manuscript. All authors read and approved the final manuscript.

Conflict of interest

The authors declare that there are no conflicts of interest regarding publication of this manuscript.

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