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# Dynamics and Economic Analysis of Sugarcane Production in Eastern Plains of Nepal

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**Abstract**

The area of sugarcane (*Saccharum officinarum* L.) production in the Eastern Plains of Nepal is decreasing every year due to several factors, including increasing cost of cultivation, lower yield, lower and delay payment, insect and diseases problems. A study was conducted to analyze the productivity and profitability of sugarcane production in this region, where, a randomly selected 80 sugarcane farmers from Sunsari and Morang districts were administered with the questionnaire to collect data between 2017 and 2018. Results of the study revealed that farmers were male dominant (67.50%) with average landholdings of 1.30 hectares (ha). The dominant age group in the farming community was 51 to 60 years and 58.75% of farmers had a primary level of education. The sugarcane production in the study area was profitable with benefit cost ratio (B/C) 1.38 and 1.34 for main and ratoon crops, respectively. The net income was NRs. 91369.70 and NRs. 36065.00 for main and ratoon crops, respectively. The coefficient of multiple determinations ($R^2$) was 0.79, which means that variations in the explanatory variable explained 79.80% of the variation in the dependent variable. Lower productivity, unscientific price fixation, and delay payment of the sugarcane by the sugar mills were the major problems found in the study area. Labor expenses constitute half of the total cost of cultivation, so mechanizations are needed to lower the cost and increase the profit. Co-coordination among different stakeholders, including the government entity, is required for scientific pricing and sustainable production of sugarcane.

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## Introduction

The Eastern Indo-Gangetic Plains (EIGP) is the houses of poor and disadvantaged people (Chauhan *et al.,* 2012; Keil *et al.,* 2017).[1,2] The Eastern Plains of Nepal lies in the EIGP with 0.25 million hectares (Mha) of land (Bhatt *et al.,* 2016)[3] which extends between 26°09' and 28°07' latitude, and 86°06' and 88°03' longitude with a large geographical and climate range. This Eastern Plains of Nepal is characterized with low agricultural productivity (Keil *et al*., 2017; Pokharel *et al.,* 2018)[2,4] which affects rural farmers' income and the national gross domestic product of the country. Rice (*Oryza sativa* L.), maize (*Zea mays* L.), wheat (*Triticum aestivum* L.), potato (*Solanum tuberosum* L.), sugarcane (*Saccharum officinarum* L.), oilseeds (*Brassica* spp.), jute (*Corchorus* spp.) are the principal crops grown in this region. Sugarcane is mostly cultivated in low land environments in the Eastern Plains region of Nepal through two crop rotations: main crop (first-year crop) and the ratoon crop (second-year crop).

Sugarcane is one of the major cash crops of Nepal. Nepal ranks 34$^{th}$ in terms of harvested area, and 39th in yield with 0.16% i.e., 1.95 million tons (Mt) globally (FAOSTAT, 2018).[5] It has grown on an area of 71466.00 hectares (ha) with production 3234711.00 tons (t) and out of which 12.53% (8954.68 ha) area lies in the study area with 10.88 % (351936.56 t) production of sugarcane (MOAD, 2017).[6] The average productivity of sugarcane in this region (39.52 t ha$^{-1}$) is lower than the national productivity (45.12 t ha$^{-1}$) (MOLMAC, 2018)[7] and the global average (56.29 t ha$^{-1}$) (FAOSTAT, 2018).[5] Nepal's contribution on global sugarcane production in terms of area, production and productivity were declined in recent years (FAOSTAT, 2018; MOAD, 2017).[5,6]

Sugarcane production in the Eastern Plains is suited due to its flat topography, sandy loam soil, sub-tropical climatic conditions, water availability through Koshi river (the major river system of Nepal). Government of Nepal has recommended four high yielding varieties with at least 70.45 t ha$^{-1}$ productivity (SQCC, 2018)[8] despite poor adoption of mechanization, manual labor-based farming, poor management of disease and pest, scarcity of quality inputs, poor pricing mechanism, delayed payment (Neupane *et al.,* 2017).[9] High production cost is the major limitations to the sugarcane cultivation in Nepal.

There are 13 sugar mills in Nepal, with 3.11 Mt of annual crushing capacity (ICMAP, 2010).3[10] In this region, there are seven sugar mills which crush 70.37% of the total cane crushed in Nepal (ICMAP, 2010).[10] But due to lack of sugarcane, those mills are operating under capacity. Nepalese sugar mills produce around 0.10 Mt of sugar annually, which is less than the domestic demand (0.16 Mt). Nepal needs more sugarcane, which is about 80000.00 t of production worth NRs. 11800000.00 (NRs. 112.00= $1.00 USD) (MOF, 2017)[11] to fulfill our national demand but the area under crop has been decreasing largely in recent years mainly due to inadequate motivation to the farmers. Sugarcane productivity in developing countries has been influenced by biotic, abiotic, and socio-economic factors (Esayas *et al.,* 2016).[12] Besides, there were a series of protests and agitation for pricing related issues between sugar mills and growers. Hence, this study was focused on exploring the dynamics and economic analysis of sugarcane farming in the eastern region of Nepal.

## Research Questions

- Are the socio-economic characteristics of the sugarcane farmers affecting production in Nepal?
- Is sugarcane a profitable business in Eastern Plains of Nepal?
- What are the challenges with the sugarcane production in Nepal?
- What are the factors affecting sugarcane production in Nepal?

## Methodology

### Study Area

The study was conducted in Sunsari and Morang districts of eastern Nepal (Figure 1). Sugarcane cultivation constituted 2204 ha and 4000 ha in Morang and Sunsari districts, respectively (MOLMAC, 2018).[7] The average temperature of this region varies from 10 to 20$^{o}$C in the winter to maximum 35 to 43$^{o}$C in the summer, and average annual rainfall is around 1950 mm. The Eastern Sugar Company is also located in Sunsari district, which is the only outlet for the sugarcane producers in this region.

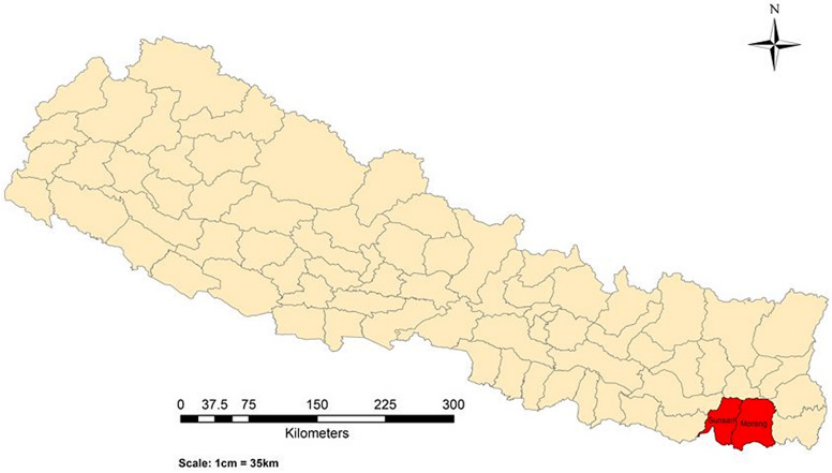


**Fig. 1: Study location of the Sugarcane production in Eastern region of Nepal**

**Sampling and Data Collection Techniques**

Two districts were purposively selected for this study as both contribute 69.31% area under sugarcane cultivation in the eastern region. Two-stage random sampling techniques were used to select the respondents. Four rural municipalities with sugarcane as dominant crop were selected two in each of the districts. Twenty farmers were selected in each of the clusters from the list of sugarcane producers provided by the Eastern Sugar Mill, Sunsari, and District Agriculture Development Offices of Sunsari and Morang districts and making 80 sugarcane farmer respondents in the study altogether. A semi-structured questionnaire was administered to explore the output level, input use, socio-economic factors associated with sugarcane production. During the study, we visited Eastern Sugar Mill, Barju, Sunsari for several informal discussions on different aspects of sugarcane processing issues.

**Data Analysis**

Descriptive statistics, including frequency distribution, mean, percentage, standard deviation, standard error were used to analyze the data collected using Microsoft Excel 2007. Farm budget was also used to determine the economics of sugarcane production in Eastern Plains of Nepal. The potential of cash crop was assessed using the Focus Group Discussion (FGD) and questionnaire with farmers. Cobb-Douglas production function was used to determine the factors affecting sugarcane production in the region.

**Farm Budget Model**

Farm budget is a detailed physical and financial plan needed for the operation of farm enterprises over time (Olukosi and Erhabor, 1991).[13] The net farm income gives a clear indication of the level of profitability (Hamidu, 2005)[14] of sugarcane production. The farm budget can be expressed as follows:

$$NFI = TR - TC \quad ...(1)$$

$$TC = TVC + TFC \quad ...(2)$$

So,

$$NFI = TR - (TVC + TFC) \quad ...(3)$$

Where,
NFI = Net farm income
TR= Total farm revenue
TC = Total cost
TVC = Total variable cost
TFC = Total fixed cost

**Benefit and Cost Ratio**

Benefit and cost ratio (B/C) gives an idea about the recovery of cost incurred during the production by the return from products. This analysis was done in terms of benefits and costs at a household level by using B/C analysis. The present value of the costs and benefits of the sugarcane production region was carried out by using the following formula.

$$B/C = \text{Gross Return/Total Cost} \quad ...(4)$$

**Production Function Analysis**

Cobb-Douglas production analysis was used to assess the resource use efficiency of sugarcane production. It was assumed that there exists a linear relationship between the yield of sugarcane and other factors affecting the yield of sugarcane such as sett quantity, area under cultivation, manures, and fertilizers, chemicals (pesticides), irrigation and labor used in the production. The theoretical multiple regression model understudy was as follows;

$$Y=f\{X_1, X_2,X_3,X_4,X_5,X_6,U\} \quad ...(5)$$

Where,
Y= Gross Income of Sugarcane (NRs.)
$X_1$= Sett (t)
$X_2$= Land (ha)
$X_3$= Manure and Fertilizer (Kg)
$X_4$= Chemicals (kg)
$X_5$= Water (irrigation time in hours)
$X_6$= Labor (man days)
U= Random error term

This model has been used widely in the study of resource use efficiency. This function can further be expressed as follows:

$$Y= a+ X_1b_1+ X_2b_2 + X_3b_3 + X_4b_4+ X_5b_5+ X_6b_6+U \quad ...(6)$$

This model can be further expressed in logarithmic form as follows:

$$\log Y= \log a+ \log X_1b_1+ \log X_2b_2 + \log X_3b_3 + \log X_4b_4 + \log X_5b_5 + \log X_6b_6+U \quad ...(7)$$

**Resource Use Efficiency**

The allocative efficiency index of a resource used was determined by the ratio of Marginal Value Product (MVP) of variable input and the Marginal Factor Cost (MFC) for the input and tested for its equality to one, i.e. (MVP/MFC) =1. Following Goni *et al.,* (2007)[15] the efficiency of resource use was calculated as;

AEI= MVP/MFC

Where, AEI= Allocative Efficiency Index, MVP= Marginal value product of variable input and MFC= Marginal factor cost.

The standard way to examine such efficiency is to compare MVP with the MFC of each variable input which was computed by multiplying the production coefficient (elasticity, in this particular case) of a given resource with the ratio of geometric mean value of output and input variables (Rabbani *et al.,* 2013).[16]

Therefore, MVPxi= dy/dxi, which is the product of regression coefficient with the ratio of geometric mean of gross return to the level of use of ith resource. Again, the relative percentage change in MVP of each resource required to obtain optimal resource allocation, i.e., AEI=1 or MVP= MFC was estimated using the following equation below;

D= (1-MFC/MVP) × 100 or, D= (1-1/AEI) × 100 where, D= absolute value of percentage change in MVP of each resource and AEI = Allocative Efficiency Index (Mijindadi, 1980).[17]

**Results and Discussions**

**Socio-Economic Characteristics of the Study Area**

The average age of sugarcane farmers as household head/ respondents was about 53.7 years with minimum 25 years and maximum 88 years. Majority of the respondents (43.75%) belong to the age range 51-60, very few youths were found to be engaged in sugarcane cultivation, i.e., about 8.75% with age less than 30. This data is in agreement that rural youth's distraction in agri-enterprises is found in Nepal (MOAD, 2017; Pokharel, 2017).[6,18] The lack of productive age group (31-40) in sugarcane farming indicates risk aversion in adopting new farming techniques that ultimately results in low productivity of the crop. Majority of the respondents was male (67.51%) whereas rest 32.49% was female among the study population (n=80) and similarly the labor cost constitutes more than half of the production cost (Figure 2) which indicates that sugarcane production is strenuous and labor-intensive (Aina *et al.,* 2015).[19] The majority of the respondents are with a primary level of education (58.80%) followed by illiterate (25.00%), secondary level (11.20%) and the respondent with tertiary (university level) education was about 5.00%. The average landholdings of sugarcane producers farmers in the eastern plain region were 2.50 ha, which was higher than the national average landholdings

0.82 ha (MOAD, 2017).[6] The majority (48.80%) of the respondents engaged in sugarcane production had an average farm size of 1 to 2 ha, followed by 2 to 4 ha with (38.70%). Also, those with 4 to 6 ha landholdings constituted 10.00% and more than 6 ha was only 2.50%. The nucleus family constitutes 83.8% of the total surveyed population and 16.25% were in a joint family. The respondents belonging to the joint family hold more than 4 ha landholdings. Most of the respondents (76.20%) participated in different training programs on sugarcane production, whereas rests (23.80%) of the respondents were not receiving any sugarcane training program.

**Table 1: Socio-economic characteristics of the sugarcane farmers in Eastern Plains of Nepal in 2018**

| S.N. | Variables | No. of respondents | Percentage | Min | Max | Average |
|---|---|---|---|---|---|---|
| 1 | **Age (years)** | | | | | |
| | 21-30 | 7 | 8.75 | 25 | 88 | 14 |
| | 31-40 | 11 | 13.75 | | | |
| | 41-50 | 9 | 11.25 | | | |
| | 51-60 | 35 | 43.75 | | | |
| | > 60 | 18 | 22.50 | | | |
| 2 | **Gender** | | | | | |
| | Male | 54 | 67.50 | | | |
| | Female | 26 | 32.50 | | | |
| | Others | - | - | | | |
| 3 | **Level of education** | | | | | |
| | Illiterate | 20 | 25.00 | | | |
| | Primary | 47 | 58.80 | | | |
| | Secondary | 9 | 11.20 | | | |
| | Tertiary | 4 | 5.00 | | | |
| 4 | **Land holdings (ha)** | | | | | |
| | 1-2 ha | 39 | 48.80 | 1.00 | 7.00 | 1.30 |
| | 2-4 ha | 31 | 38.70 | | | |
| | 4-6 ha | 8 | 10.00 | | | |
| | > 6 ha | 2 | 2.50 | | | |
| 5 | **Family size** | | | | | |
| | Single | 67 | 83.80 | | | |
| | Joint | 13 | 16.20 | | | |
| 6 | **Training about Sugarcane** | | | | | |
| | Yes | 61 | 76.20 | | | |
| | No | 19 | 23.80 | | | |

**Cost and Benefits of Sugarcane Production**

The cost and benefits associated were assessed in two cropping calendars of two consecutive seasons. The annual estimates of the expenditures with different sub-activities on sugarcane production and the benefits were summarized in Table 2.

Major expenses in main crop were labor cost (50.72%), seed materials/setts (14.81%), manures and fertilizers (14.03%), land preparation/mechanical (9.84%), chemicals (7.45%) and irrigation charge (3.15%) which is shown in Figure 2 with the total cost of about NRs. 238912.32 or $2133.15 USD whereas in ratoon crop the crop establishment cost was about half than that of the main crop (NRs. 104650.00 or $934.38 USD). Results showed that nine farmers out of 80 (11.25%) were not using irrigation, and 37 farmers out of 80 (46.25%) were not using any herbicides in their farm, 12 out of 80 farmers (15.00%) were not using any micronutrients

in their sugarcane farm. Similarly, the application of insecticides and fungicides was not common (5 and 26 out of 80 for insect and disease management chemicals, respectively). Nine farmers out of 80 (11.25%) were not performing earthing up in the sugarcane, and eight farmers out of 80 (10.00%) were using propping or tie-up the canes in the field (data not shown).

**Benefits Associated with Sugarcane Production**

Although sugarcane has several benefits like cane, green foliage, fodder, roofing and thatching materials, the sugarcane farmers in Eastern Plains were concentrated on the cane for monetary returns. The demand for molasses and bagasse is very low, so only sugar is taken as the main product (DADO-Sunsari, 2017).[20]

The yield was 62.20 t $ha^{-1}$ in the main crop while 26.50 t $ha^{-1}$ in the ratoon crop. The price received by the farmers was NRs. 5310.00 $t^{-1}$ fresh cane in 2018 (DADO-Sunsari, 2017).[20] The gross income was NRs. 330282.00 ($2948.95 USD) from main season crop and NRs. 140714.00 ($1256.38 USD) from ratoon crop with B/C 1.38 and 1.34 respectively (Table 2). The net income per hectare was NRs.

**Table 2: Cost of sugarcane production in Eastern Plains of Nepal in 2018**

| | | | | Main Crop (Year I) | | | Ratoon Crop (Year II) | | |
|---|---|---|---|---|---|---|---|---|---|
| **S.N.** | **Activities** | **Sub-activities** | **Unit** | **Quantity** | **Amount (NRs $ha^{-1}$)** | **Amount (USD $ha^{-1}$)** | **Quantity** | **Amount (NRs $ha^{-1}$)** | **Amount (USD $ha^{-1}$)** |
| 1 | Land Preparation | Harrowing, trenching | lumpsump | 1 | 23829.75 | 212.77 | 1 | 18000.00 | 160.71 |
| 2 | Seed Materials | Seed purchasing | ha | 1 | 32966.93 | 294.35 | 1 | | - |
| | | Seed transportation | lumpsump | 1 | 2268.75 | 20.26 | 1 | | - |
| 3 | Planting (Labors) | Seed planting | labor | 36 | 14400.00 | 128.57 | 1 | | - |
| | | Seed treatment | labors | 7 | 4200.00 | 37.50 | 1 | | - |
| | | Trench preparation | lumpsump | 1 | 8287.50 | 74.00 | 1 | | - |
| | | Irrigation cost | lumpsump | 1 | 7532.25 | 67.25 | 1 | 10000.00 | 89.29 |
| | | Herbicides application | lumpsump | 1 | 2397.19 | 21.40 | 1 | | - |
| | | Manual weeding | lumpsump | 1 | 12717.75 | 113.55 | 1 | 4200.00 | 37.50 |
| | | Urea and application | lumpsump | 1 | 6889.72 | 61.52 | 1 | 3500.00 | 31.25 |
| | | DAP and application | lumpsump | 1 | 8651.16 | 77.24 | 1 | | - |
| | | MOP and application | lumpsump | 1 | 3062.81 | 27.35 | 1 | | - |
| | | Micronutrients and application | lumpsump | 1 | 4303.13 | 38.42 | 1 | | - |
| | | FYM/Compost/Organic Manure and use | lumpsump | 1 | 10623.23 | 94.85 | 1 | | - |
| | | Insects management | lumpsump | 1 | 10663.88 | 95.21 | 1 | 4000.00 | 35.71 |
| | | Diseases management | lumpsump | 1 | 436.95 | 3.90 | 1 | 750.00 | 6.70 |
| | | Earthing Up | lumpsump | 1 | 6348.75 | 56.69 | 1 | 3200.00 | 28.57 |
| | | Propping Up | lumpsump | 1 | 1230.00 | 10.98 | 1 | | - |
| | | Harvesting | lumpsump | 1 | 40872.38 | 364.93 | 1 | 33000.00 | 294.64 |
| | | Transportation to Mill | lumpsump | 1 | 37230.19 | 332.41 | 1 | 28000.00 | 250.00 |
| 4 | Total estimated amount | | | | 238912.32 | 2133.15 | | 104650 | 934.38 |
| 5 | Yield | | t | | 62.20 | | | 26.50 | |
| 6 | Price | | t | | 5310.00 | 4.74 | | 5310.00 | |
| 7 | Gross Income | | | NRs | 330282.00 | 2948.95 | | 140715.00 | 1256.38 |
| 8 | B/C | | | | 1.38 | | | 1.34 | |
| 9 | Net Income | | | NRs | 91369.71 | 815.80 | | 36065.00 | 322.01 |

91369.71 ($815.80 USD) from main season crop and NRs. 36065.00 ($322.01 USD) from the ratoon crop. The recovery rate of sugarcane was 9.02% for sugar, 4.00% for bagasse, and 4.50% for molasses (i.e., 100.00 kg of sugarcane produce 9.02 kg sugar, 4.00 kg bagasse, and 4.50 L molasses). The price of sugar $kg^{-1}$, bagasse $kg^{-1}$ and molasses $L^{-1}$ were NRs. 71.00, 1.00, and 2.00, respectively (ESML, 2017).[21]

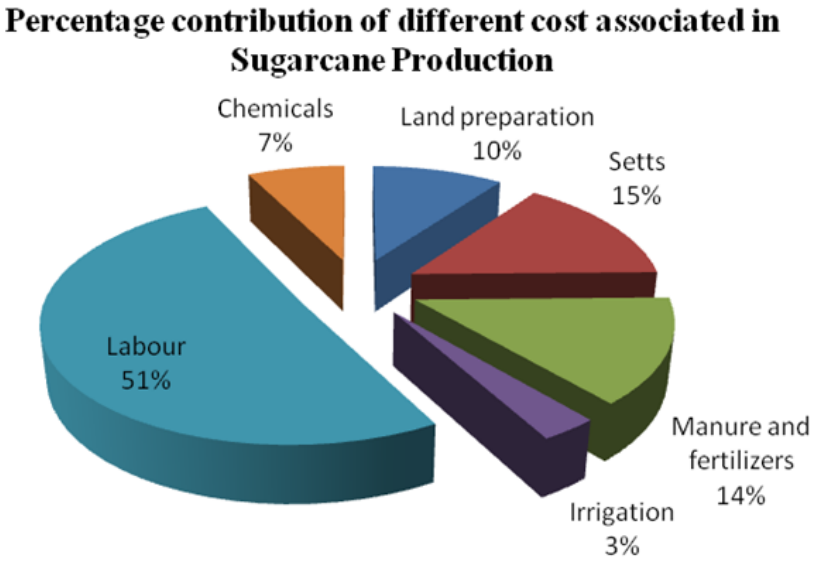


**Fig. 2: Percentage contribution of different costs associated with sugarcane production in the Eastern Plains of Nepal in 2018**

**Cost and Return Analysis of Sugarcane Production**

The cost and return analysis of sugarcane production in the Eastern Plains of Nepal was summarized in Table 3. Results show that the total variable cost (TVC) accounted for 97.15% and FC accounts for 2.85%. Majority of the sugarcane farmers have their lands, the land rent per hectare NRs. 7000.00 was taken as an average rent of the land in the study area. Out of the variable cost labor charge particularly on trench preparation and sett planting, weeding, earthing and hoeing uploading and unloading to transport truck accounts about half of the total cost of cultivation. Majority of the farmer's in the study area are found to borrow the loan from local level cooperatives, and due to long payback period, delay payment by sugar mills make farmer trouble in repaying their loan on time (DADO-Sunsari, 2017; DADO-Morang, 2017; Sharma, 2013).[20,22,23] Labor constituted the major inputs in sugarcane cultivation, so sugarcane production is both labor and capital intensive (Aina *et al.,* 2015).[19] Planting materials/sett and manures and fertilizers account one-quarter of the total cost of cultivation and are shown in Figure 2 and Table 3. Although, the B/C reported by MOAD was higher (2.29 for eastern region) (MOAD, 2017)[6] than the observed ratio (Table 2); eastern region yields higher B:C as compared to the rest of the country, for example, 1.17 for Nawalparasi district (Neupane *et al.,* 2017)[9] and 1.78 for Bara district (MOAD, 2017).[6] Our results showed that sugarcane production is under profitable in the study area.

**Production Analysis**

The Cobb-Douglas production function was selected as it agrees with the prior expectation that setts, land preparation, manures and fertilizers, chemicals, irrigation and labor costs have a positive influence on sugarcane production in the region, which is presented in Table 4. The coefficient of multiple determinations ($R^2$) is a summary measure which informs about the fitness of the date in the regression line. The results indicate that the explanatory variables in the model have explained 79.70% of the variations in gross return. The value of adjusted $R^2$ was 0.79, indicating that after taking into account

the degree of freedom (df) 79.80% of the variation in the dependent variable explained by the explanatory variables included in the model. The F value for overall significance was 584.70, and it was highly significant implying that all the explanatory variables included in the model are important for explaining the variation of the dependent variables in Sugarcane production in the region. We found that manures and fertilizers, irrigation and labor charge have a negative influence in gross income which means an increase in the manures and fertilizers, irrigation and labor will decrease in gross income by 0.19%, 0.01%, and 0.15% respectively. And similarly, an increase in the cost of setts, land preparation, chemicals would have a positive influence on gross income i.e., 0.08%, 0.19%, and 0.08% respectively.

The geometric mean, coefficient, estimated MVP of different inputs used in sugarcane production is presented in Table 5. The allocative efficiency index (AEI) of land preparation (1.89) and different chemicals (insecticides and fungicides) (1.17) were positive, indicated theirs under utilization. The AEI on sett materials (0.58), manures and fertilizers (-1.35), irrigation charge (-0.32), and labor cost (-0.44) indicated over utilization of the inputs in sugarcane production. Sett materials were positively correlated with the sugarcane production whereas manures and fertilizers, irrigation charge and labor cost were negatively correlated with the production as a result lesser profit could be obtained by increasing on these inputs. The land preparation and application of chemicals should require to increase

**Table 3: Cost and return analysis of sugarcane production in Eastern Plains of Nepal in 2018**

| Inputs | Cost (NRs $ha^{-1}$) | Cost (USD $ha^{-1}$) | Gross total (NRs) | Gross total (USD) | Percentage |
|---|---|---|---|---|---|
| **Variable Cost** | | | | | |
| **Land Preparation (harrowing)** | 23829.75 | 212.77 | 23829.75 | 212.77 | 9.69 |
| **Seed materials (setts)** | | - | 35235.68 | 314.6 | 14.33 |
| Sett costs | 32966.93 | 294.35 | | - | |
| Transport cost | 2268.75 | 20.26 | | - | |
| **Manure and Fertilizer** | 33530.04 | 299.38 | 33530.04 | 299.38 | 13.63 |
| **Chemicals (Disease, Insects)** | 17698.01 | 158.02 | 17698.01 | 158.02 | 7.20 |
| **Irrigation** | 7532.25 | 67.25 | 7532.25 | 67.25 | 3.06 |
| **Labor** | | - | 121086.56 | 1081.13 | 49.24 |
| Trench preparation and planting sett | 22687.5 | 202.57 | | - | |
| Manual weeding | 12717.75 | 113.55 | | - | |
| Earthing and propping Up | 7578.75 | 67.67 | | - | |
| Harvesting cost | 40872.38 | 364.93 | | - | |
| Transport from field to mill | 37230.19 | 332.41 | | - | |
| **Sub-Total (TVC)** | | - | 238912.29 | 2133.15 | 97.15 |
| **Fixed Cost** | | - | | - | |
| Land rent | 7000.00 | 62.50 | 7000.00 | 62.50 | 2.85 |
| **Sub-Total (TFC)** | 7000.00 | 62.50 | 7000.00 | 62.50 | 2.85 |
| **Total Cost of Production (TC)** | | - | 245912.29 | 2195.65 | 100.00 |
| **Returns (NRS/$ha^{-1}$)** | | - | | - | |
| Yield/ $ha^{-1}$ (main crop) | 622.00 | 5.55 | | - | |
| Gross farm income (main crop) | 330282.00 | 2948.95 | | - | |
| Net farm income (main crop) | 91369.71 | 815.80 | | - | |
| B/C | 1.34 | | 1.38 | | |

by 47.09% and 14.74% respectively whereas cost on sett materials, manures and fertilizers, irrigation and labor should be reduced by 72.22%, 173.66%, 410.58%, and 324.4% respectively to optimal allocation of resources used in sugarcane production in the region. The level of adjustments for the use of different inputs in sugarcane production gives a clear idea on sustainable management of the scarce resource in boosting crop production.

**Table 4: Regression coefficient and t-values from the Cobb-Douglas Production Function of sugarcane production in Eastern Plains region of Nepal in 2018**

| Variables | Coefficient | Std. Error | t-value |
|---|---|---|---|
| Constant term (a) | 4.60 | 2.60 | 1.77* |
| Setts ($X_1$) | 0.08 | 0.09 | 0.89 |
| Land preparation ($X_2$) | 0.19 | 0.17 | 1.17* |
| Manures and fertilizers ($X_3$) | -0.19 | 0.10 | -1.89 |
| Chemicals ($X_4$) | 0.08 | 0.10 | 0.90 |
| Irrigation ($X_5$) | -0.00 | 0.01 | -0.65* |
| Labor ($X_6$) | -0.15 | 0.09 | -1.59 |
| F-Value | 584.70** | | |
| R square | 0.79 | | |
| Adjuster R square | 0.79 | | |

**Significant at 1%, *Significant at 5% level of confidence

**Table 5: Estimates of measure of allocative efficiency index (AEI) of sugarcane production in Eastern Plains of Nepal in 2018**

| S.N. | Inputs (NRs $ha^{-1}$) | Geometric mean | Coefficient | MVP | AEI | Efficiency | % adjustment required |
|---|---|---|---|---|---|---|---|
| 1 | Setts materials | 32956.01 | 0.08 | 308.31 | 0.58 | Over | -72.22 |
| 2 | Land preparation | 23827.96 | 0.19 | 1003.66 | 1.89 | Under | 47.09 |
| 3 | Manures and fertilizers | 33523.26 | -0.19 | -720.78 | -1.35 | Over | 173.66 |
| 4 | Chemicals | 16711.92 | 0.08 | 622.83 | 1.17 | Under | 14.74 |
| 5 | Irrigation charge | 6522.95 | -0.00 | -170.96 | -0.32 | Over | 410.58 |
| 6 | Labor cost | 79232.46 | -0.15 | -236.62 | -0.44 | Over | 324.4 |

**Challenges to Sugarcane Producers**

Although, sugarcane crop is an important cash crop of Nepal (MOAD, 2017; 2004)[6,25] beset with many problems: low productivity of the cultivated varieties, higher production cost, yearly fluctuation of the production, poor pricing mechanism. Key informant survey and FGD in five different locations in the study area identified these problems to the sugarcane producers. Our results show that the area under sugarcane crop has been declined in these years due to lesser benefit as anticipated. The major constraints to sugarcane farmers in the study area were identified and ranked in order of priority, as presented in Table 6.

Government of Nepal is attempting efforts on the modernization of agriculture, but sugarcane research and development (R and D) is paying lesser attention due to which the development of good and smart agronomic management practices was lacking

due to which farmers were opting the conventional practices. The lack of research and development (R and D) support on sugarcane and lack of technical human resources working on sugarcane widen the yield gap between experiment station and farmers' field in Nepal (ICMAP, 2010; NSRP, 2017).[10,24]

**Table 6: Challenges associated with sugarcane producers in the Eastern Plains of Nepal in 2018**

| S.N. | Problems | Frequency | Percentage | Rank |
|---|---|---|---|---|
| a. | Delay in payment | 80 | 100.00 | 1 |
| b. | Low productivity and lack of good agricultural practices | 80 | 100.00 | 2 |
| c. | Low farm gate price (unscientific pricing mechanism) | 78 | 97.50 | 3 |
| d. | Insects and diseases | 75 | 93.80 | 4 |
| e. | Lack of technical knowledge | 65 | 81.20 | 5 |

Besides, the major troublesome in the sugarcane is price fixation. Sugarcane producers were receiving their payments very late from the sugar mills. The delay in payment to farmers is also the prime reason in the declining area of the crop in Nepal. There was a dispute between sugarcane producers and sugar mills every year about the price fixation. Lack of credit facilities as sugarcane is considered a medium-term business (which usually takes two years) (MOAD, 2017; Neupane *et al.,* 2017).[6,9]

As government efforts are on through modernization of agriculture (MOAD, 2004),[25] so development of agri-insurance policy on sugarcane crop, scientific price fixation and contract farming in addition to better endowment with scientific knowledge and skills will boost the sugarcane productivity and will increase the overall productivity and profitability of the sugarcane farmers in the region.

**Conclusion**

Government of Nepal effort is to increase sugarcane production, but the supply gap has not fulfilled yet. The study confirms that sugarcane production in the plain region is reasonably a profitable enterprise with a B/C of 1.38 (main crop) and 1.34 (ratoon crop) for each unit of investment, although its productivity on farmer's field is very low as compared to the experimented yield. The dependency on manual labors increases the production cost of sugarcane in Nepal. Half of the production costs were used in labor expenses in different operations so lowering these expenses by mechanical means is the need of time to make sugarcane production business more sustainable.

Major problems include lower productivity, delayed payment, unscientific price fixation, which distracts farmers from allocating more area for sugarcane crop. Price fixation based on the recovery rate will be the viable option over prevailing weight-based system so that sugar mill will seek profitable techniques to increase the recovery percent and farmers will also seek for the good management practices to increase the efficiency of the farm along with increment in the productivity. Enabling an environment coupled with plans and policies in the profit potential areas for promoting mechanization, reducing labor drudgery, providing subsidy on quality and timely supply of inputs (setts, manures and fertilizers), proper and scientific crop management knowledge and skills, scientific pricing mechanism, motivation to young generations will have paramount scope in developing the win-win situation of the farmers and sugar mills. The focus on R and D in sugarcane production will increase the productivity of the crop and make the sugarcane-based agri- enterprises more profitable and sustainable in Eastern Plains of Nepal.

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**Conflicts of Interest**

The authors declare no conflict of interest.

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