SOIL & CROP SCIENCES | RESEARCH ARTICLE

Profitability and resource-use efficiency of sugarcane production in Nawalparasi west district, Nepal

Amita Pandey¹*, Diwas Raj Bista², Thaneswar Bhandari³, Hari Krishna Panta³ and Sudip Devkota⁴

Abstract: The study was undertaken to assess the profitability and resource-use efficiency of sugarcane producers in Nawalparasi West district, Nepal. The primary data were collected from 135 sugarcane farmers’ personal interview. Cost and return analysis and Cobb-Douglas production function were used for analysis. The B:C ratio of main crop was found 1.02 and ratoon crop was 2.08, whereas overall B:C was 1.35. Labor, setts, irrigation and nutrient were found to have significant and positive effect on gross return of sugarcane. Furthermore, labor and tillage hour were found to be over-utilized whereas irrigation, nutrient and setts were found to be underutilized. Insufficiency and unavailability of chemical fertilizer, absence of irrigation and drainage facilities and unavailability of quality setts were reasons for underutilization. Assurance of availability and affordability of setts, fertilizers, irrigation and intervention of modern-integrated agro-machineries can play significant role for efficient use of resources. Moreover, subsidy on inputs and mechanization are recommended to reduce the cost of production and maximize the profit.

ABOUT THE AUTHOR

Ms. Amita Pandey is currently working researcher and agriculture officer under the research and extension wing of Directorate of Research and Extension, Agriculture and Forestry University (AFU), Nepal. She completed her Master’s Degree in Agricultural Economics from Institute of Agriculture and Animal Science, Tribhuvan University, Nepal. Her area of interest includes agricultural-applied economics, agricultural extension, agriculture policy, statistics, food security and gender.

PUBLIC INTEREST STATEMENT

Sugarcane is industrial cash crop and is the most important in terms of area and production of cash crops grown in Nepal. Nepal ranks 41st position in global sugarcane production scenario. Despite of this, the status of sugarcane production is very low with higher cost of production. Though the effective amount of inputs are recommended for sugarcane production, there is inadequate socio-economic studies in relation with capacity of farmers to allocate the cost of input for maximizing the revenue. Resource-use efficiency measures the ability of a farm to use inputs in optimal proportions given their respective prices and the production technology. In this background, this paper aimed at disclosing cost of production, profitability and resource-use efficiency of sugarcane farmers of Nawalparasi west, district, Nepal to help the concerned sugarcane stakeholders in analysis of financial sustainability and possibilities of growing sugarcane as profitable commodity.
1. Introduction
Sugarcane is an important cash crop grown in Nepal. Nepal ranks 41st in sugarcane production in global production scenario (Neupane et al., 2017). Sugarcane contributes 2.1% to Agricultural Gross Domestic Product (AGDP) of the country (MoALD, 2019a). Commercial cultivation of sugarcane is common in tarai region of Nepal. It is cultivated in 41 districts of Nepal, however, commercial production is done in 14 districts only (MoALD, 2019). The annual production of sugarcane in 2018/19 was 3.6 million tonnes, with average productivity of 49.67 tonnes per hectare (MoALD, 2019). Being rich source of carbohydrate, it is used to produce food products like sugar, fructose, syrups, and jaggery (Dotaniya et al., 2016). It is mainly used as raw material for sugar production. Domestic production of sugarcane in Nepal covers 60% of sugar demand of the country (NSMA, 2018). There are around 100,000 commercial sugarcane farmers in Nepal with total area coverage of 71.6 thousand hectare land (Chhetri, 2018; MoALD, 2020).

There are four released varieties of sugarcane (Jitpur-1 (72 tonnes/ha), Jitpur-2 (107 tonnes/ha), Jitpur-3 (90 tonnes/ha) and Jitpur-4 (92 tonnes/ha)) and 12 recommended sugarcane varieties in Nepal. They have higher productivity than existing national productivity i.e. 49.67 tonnes/ha (MoALD, 2020; NARC, 2017). Thus national average productivity of sugarcane is very low in comparison to potential capacity of released variety in Nepal (NARC, 2017). There is huge yield gap between the farmer field and experimental station. Along with low productivity, cost of production is also higher which has ultimately increased the cost of the sugar in factory (Neupane et al., 2017; NSMA, 2018; Pokharel et al., 2019). In neighbour country India, there is provision of agriculture subsidy in different sectors like input subsidy (for fertilizers, power, irrigation and credit), price support subsidy, income subsidy, export subsidy and crop insurance (Ramaswami, 2019). Furthermore in sugarcane sector there is provision of agro-machineries for planting and harvesting, and more than hundreds of high yielding improved sugarcane varieties (Shukla et al., 2018). Thus, the timely availability and sufficient inputs, subsidy, good sugarcane breeding programs and agro-machineries for sugarcane cultivation and harvesting, there is high production and ultimately lower cost of cultivation in comparison to Nepal. However, in context of Nepal, there has been always scarcity of chemical fertilizers, irrigation, plant protection materials, agro-machineries and quality seeds for sugarcane. The poor access and intervention of agro-machineries related with sugarcane cultivation, majority of inter-culture operations are labour intensive. Similarly cost for fertilizers, planting material, intercultural operations, rent of the machineries, human power are also high ultimately leading higher cost of cultivation (Neupane et al., 2017; NSMA, 2018; Pandey & Devkota, 2020a, 2020b; Pokharel et al., 2019).

Resource-use efficiency measures the ability of a farm to use inputs in optimal proportions given their respective prices and the production technology. It is the ability to combine inputs and output in optimal proportion in the light of prices (Fried et al., 1993). In this background, this paper aimed at disclosing cost of production, profitability and resource-use efficiency of sugarcane farmers of Nawalparasi west district to help the concerned sugarcane stakeholders in analysis of financial sustainability and possibilities of growing sugarcane as profitable commodity.

2. Methodology
2.1. Study area
The research was conducted in Nawalparasi west district located in Province no. 5 of Nepal. The annual minimum and maximum temperature of Nawalparasi ranges from 17.5°C to 29.6°C, respectively. The annual average precipitation is 1952.8 mm (MoPE, 2017). The southern belt of this district including tarai and inner tarai region have favourable climate for sugarcane cultivation. In
2018/19, sugarcane was cultivated in 4283 ha (around 5.9% of total sugarcane-cultivated area of Nepal) in Nawalparasi west district. It ranked sixth position in sugarcane cultivation area among commercial sugarcane-producing districts (MoALD, 2019). There are four sugar industries namely; Lumbini Sugar Mill, Bagmati sugar mill, Indra sugar and chemical industry and Mohini sugar mill manufacturing sugar from the local sugarcane produced (NSMA, 2018). Likewise, other sugarcane refining factories are producing other products like gud, ghudkhatta etc.

2.2. Sampling and data collection process
The study performed multistage sampling for selection of research site. The first stage selection of the district was based on presence of sugar-mill. Among the random selection between 8 districts with sugar mills, Nawalparasi district was randomly selected as the study area. In addition, second stage sampling was purposeful to select municipalities and rural municipalities inside district which had higher sugarcane production area and sugarcane farmers. Second stage of sampling was selected based on FGD in Agriculture Knowledge Center of Nawalparasi west, discussion with concerned authorities, and review of district profile. From each selected municipalities, farmers growing sugarcane in more than 0.16 hectare were listed to make sampling frame. Since there were large number of small-scale farmers, so there was high chance of selection of large no of small-scale farmers. Hence, to include all kind of farmers in proportion, farmers with 0.16 ha or above were selected for the study. Proportional allocation of sampling technique was used to obtain an appropriate number of respondents from each selected municipality. For household survey approximately about 10% of sample was selected randomly from sampling frame (Cochran, 1977). Thus, 135 sugarcane growers were selected from 3 municipalities/rural municipalities (55 from Susta, 50 from Pratappur and 30 from Sunwal). Primary data were collected using interview schedule through direct interview of randomly selected sugarcane growers. The standard questionnaire was prepared for the interview.

2.3. Techniques of data analysis
The data collected from household survey was coded and entered in MS excel sheet and analysis was carried out using STATA 13 software. Sum, mean, relative frequency, minima, maxima, and standard deviation were used for descriptive analysis of production, cost and price. Cobb Douglas Stochastic production frontier model was used to estimate the efficiency of sugarcane farmers, Chi Square test was applied to analyze the statistical significance of the differences in means of dependent variables. Correlation and regression analysis were done to identify the relationship between the variables.

2.4. Benefit and cost analysis
The cost of production was calculated taking market value of the variable inputs like human labour (including family labour and hired labour), tractor hired for land preparation, inorganic fertilizer, compost manure, sets, weedicides, irrigation and transportation.

\[
\text{Total variable cost} = C_{\text{labour}} + C_{\text{tractor}} + C_{\text{fert}} + C_{\text{manure}} + C_{\text{sets}} + C_{\text{weedicides}} + C_{\text{irrigation}} + C_{\text{transport}}
\]

Where,

\[
C_{\text{labour}} = \text{Cost on human labor used (US$/ha)}
\]

\[
C_{\text{tractor}} = \text{Cost on tractor hired for land preparation (US$/ha)}
\]

\[
C_{\text{fert}} = \text{Cost on inorganic chemical fertilizers (US$/ha)}
\]

\[
C_{\text{manure}} = \text{Cost on organic manures (US$/ha)}
\]

\[
C_{\text{sets}} = \text{Cost on sets (US$/ha)}
\]
The gross return of sugarcane was calculated multiplying the volume of cane sold with the respective price of cane provided by sugar mill and other sugar refining factories at the harvesting period (Dillon & Hardaker, 1980) which is given as: Gross return (US$/ha) = Total quantity produced (kg/ha) × Price of sugarcane (US$/kg). The mill gate price paid by the sugar mills was based on Minimum Procurement Price (MPP) i.e. US$ 4.52/quintal declared by Government of Nepal. However, 67% of farm household received lower payment than Minimum Procurement Price.

To determine the economic performance of sugarcane production, benefit-cost ratio (B:C ratio) was considered. The undiscounted benefit-cost ratio was estimated as ratio of gross return and total variable cost. The B:C ratio was given as

\[
B : C = \frac{\text{Gross return (US$/ha)}}{\text{Gross variable cost (US$/ha)}}
\]

2.5. Estimation of resource use efficiency

To assess the resource use efficiency of sugarcane growers, Cobb-Douglas production function was fitted. Measures of efficiency like marginal value products, marginal factor costs and input elasticities were derived. The resource-use efficiency was determined as optimum, over and underuse of resources (Gujarati, 2009).

2.6. Model specification

The Cobb-Douglas production function used for analysis is given as,

\[
Y = aX_1^{b_1}X_2^{b_2}X_3^{b_3}X_4^{b_4}X_5^{b_5}e^u \quad (1)
\]

Up on log transformation of equation (1)

\[
\ln Y = \ln a + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + b_5 \ln X_5 + u
\]

Where,

- \(Y\) = Total income from sugarcane production (US$ per hectare)
- \(X_1\) = labor cost (US$ per hectare)
- \(X_2\) = Land preparation cost (US$ per hectare)
- \(X_3\) = Setts cost (US$ per hectare)
- \(X_4\) = Irrigation cost (US$ per hectare)
- \(X_5\) = Chemical fertilizer cost (US$ per hectare)
- \(u\) = Error term
- \(a\) = Intercept
- \(\ln\) = Natural logarithm
Return to scale from sugarcane production was calculated as,

$$\text{RTS} = \Sigma b_i$$

Where, $b_i =$ regression coefficient of $i^{th}$ variables. The sum of $b_i$ from the Cobb–Douglas production function indicates the nature of return to scale.

Return to Scale decision rule:

- $\text{RTS}<1$: Decreasing return to scale,
- $\text{RTS} = 1$: Constant return to scale,
- $\text{RTS}>1$: Increasing return to scale.

Similarly, the efficiency ratio ($r$) was computed using the formula $r = \frac{MVP}{MFC}$.

Where,

- $\text{MFC} =$ Marginal factor cost

The MVP was estimated using the formula: $\text{MVP}_i = b_i \times \frac{Y}{X_i}$

Where,

- $b_i =$ Estimated regression coefficients
- $Y =$ geometric mean of sugarcane output (US$)
- $X_i =$ geometric mean of input (US$)

Decision criteria:

- MVP = MFC indicate optimum use of input
- MVP < MFC indicates that input is over utilized
- MVP > MFC indicates that input is under utilized

The relative percentage change in MVP of each resource was estimated as:

$$D = (1- \frac{\text{MFC}}{\text{MVP}}) \times 100$$

Or, $D = (1-\frac{1}{r}) \times 100$

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

3. Results and discussion

3.1. Socio-economic characteristics

Table 1 depicts socioeconomic characteristics and their effect in sugarcane production. The average household head age in the study area was 47. Similarly, the average household size was 7, which was higher than national average household size of 4.5 (CBS, 2012). The household size was found positive and significant at 5% level of significance for sugarcane
Table 1. Socioeconomic description of study area

| Description                                      | Mean SD | Coefficient | T value | pvalue |
|-------------------------------------------------|---------|-------------|---------|--------|
| Age of household head (years)                   | 47 ± 14 | -.256       | -.25   | .800   |
| Household size (no. of family members)          | 7 ± 3   | 8.86        | 2.28**  | 0.024  |
| Land ownership (hectare)                        | 0.76 ± 0.6 | 1.69      | 2.34**  | 0.021  |
| Area of sugarcane cultivation (hectare)         | 0.61 ± 0.51 | -1.05    | -1.08  | 0.283  |
| Irrigation, (% of total area)                   | 56 ± 44 | 89.68       | 3.23*** | 0.002  |
| Annual HH Income (US$)                          | 1794 ± 1204 | -0.059   | -0.07  | 0.940  |
| Gender of Household head (female)               | 18      | -.4171      | -0.01  | 0.991  |
| Agriculture as main occupation (no.)             | 114     | 17.36       | 0.50   | 0.619  |
| Education (Literate)                            | 83      | 21.32       | 0.70   | 0.486  |
| Constant                                        | 279.75  | 4.74        | 0.00   |        |

Note: ***, ** and * indicate significant at 1%, 5% and 10% probability level respectively.

production. Similarly, ownership of land was found positive and significant at 5% level of significance. Out of 0.76 hectare of average land ownership, 0.61 hectare of land was allocated for sugarcane cultivation. The sugarcane producers without land ownership were operating others’ land as “Adhiya”. About 84.5% of the households were engaged in agriculture as primary occupation. Thus sugarcane was main crop and major source of livelihood in study area.

Furthermore, irrigation was found positive and significant at 1% level of significance but there was inadequate irrigation facility in study area. Irrigation facility was available in 56% of total area only.

The study revealed that 86.7% of household was male-dominated, where all the decisions of household was underneath male counterpart. Similarly, average annual income of household was US$1794.20. Around 38.5% of household head were illiterate. Thus, the extension programs related with sugarcane were required to be carried out in line to the literacy level of sugarcane producers.

3.2. Cost return and profitability from sugarcane production
The study found human labour cost accounting major part US$631.33 per hectare i.e. 40.47% of total cost of sugarcane production. According to (Reza et al., 2016) the neighbour country like Bangladesh, labour incurred 49.81% of total cost whereas (Verma & Solanki, 2020) found 40.2% of total cost accompanied by labour cost in India. Thus, major cost was found accounted by human labour, however the monetary value of Nepal was found to be higher than the neighbour countries. Due to poor access and intervention of agro-machineries for sett transplantation and harvesting, human labour was solely engaged in planting and harvesting. Furthermore, other intercultural operations like weeding, application of plant protection measures, and earthing up were carried out manually.

The sett cost accounted US$ 326.5 per hectare i.e. 21% of total cost. Setts were found to be purchased from nearby sugar-mill, neighbors and some Indian farmers. The cost of setts was similar to the price received by farmers from sugar-mills. The sett cost share of neighbour countries was found lower than Nepal. The cost share of India was found 17.11% in India.
(Verma & Solanki, 2020) and 19% Pakistan (Husain & Khattak, 2011). Similarly, US$ 194.81 per hectare, around 12.5% of total cost was incurred for land preparation. Almost all of the land preparation was carried by the tractors. Disk plough, MB plough, rotator and ridger were widely used for land preparation. The tractors with the given machines were hired and paid on the basis of tillage per hour. However, for ratoon crop draft power was used for loosening the ratoon field soil and weeding purpose. Furthermore, the inorganic fertilizer incurred only US$ 184.99 per hectare i.e. 4% of total cost but in India 11.36% of cost was incurred for fertilizer (Verma & Solanki, 2020). The study revealed that farmers were unable to buy recommended dose of inorganic fertilizer due to insufficiency, timely unavailability and unaffordability of chemical fertilizer. Major fertilizer applied for sugarcane was DAP, Urea, and MoP. Similarly, 8% of total cost was accounted by organic manure. The major form of manure was farm yard manure, bagasse and mustard cake.

The cost of irrigation constituted 3% of total cost. The study found only 56% of total area available with irrigation facilities whereas 44% were deprived of irrigation facilities. The main source of irrigation were deep tube well and river stream. Among 44% of irrigation facilities, deep tube was available with 70% of farmers whereas 30% were relying on river water for irrigation. The cost of irrigation was higher for the farmer irrigating through river stream due to higher fuel charge. Cost of transportation of sugarcane to the sugar mill constituted 11% of the total cost. The source of transport like tractor and bull-cart were used for transportation.

The study found the sugarcane crop reformed after 2 years taking the main and first ratoon production. The main crop was initiated with land preparation, sett transplantation and other cultivation activities, whereas for ratoon crop the remnant of main crop (stump) were regenerated and cultivation activities were carried. Thus, the cost of production of main crop was US$ 3.98/ quintal and higher than that of ratoon US$ 1.81/quintal. Low cost of ratoon cultivation was due to exclusion of seed and land preparation cost. Similarly, average revenue from a hectare of land for main crop was found to be US$ 1584.51 which was higher than ratoon crop (US$1503.28). Likewise, the productivity of main crop was higher than ratoon crop. The average productivity of main crop was 41.9 tonnes/ha whereas ratoon yielded 39.7 tonnes/ha, but in the neighbour countries like Pakistan and India, the sugarcane yield was found to be 48 and 83.12 tonnes/ha, respectively (Aslam, 2016; Verma & Solanki, 2020) i.e. higher than Nepal. The lower productivity of ratoon crop in the study area was due to low input application and careless management of ratoon crop.

The B: C ratio of main crop was 1.02 while it was 2.08 for ratoon crop, thus the profit from ratoon crop was the main reason for the continuity of sugarcane cultivation. The overall B:C ratio including main and ratoon crop was 1.35. Thus, study revealed that despite of higher cost and low benefit from main crop, lower cost and higher benefit from ratoon crop was reasons behind continuing the sugarcane production (Table 2). The result was in line with the study of (Neupane et al., 2017) which reported the B:C ratio of 1.17 for sugarcane cultivation in Nawalparasi district.

3.3. Production function analysis
Human labour, tillage, fertilizer, sett and irrigation were major inputs required for sugarcane cultivation. The study revealed positive effect of all the inputs cost in the income/revenue of sugarcane. The average labour cost was found significant and positive at 5% level of significance. 1% increase in labour cost would increase the total income by 0.23%. Since, smallholder farmers are known to be resource-constrained and sugarcane production is labour-intensive, which means that farmers were heavily relying on manual labour. They would therefore be concerned with maximizing their labour cost to emphasize allocative efficiency. This finding was in line with the finding of (Ali & Jan, 2017; Mohapatra & Sen, 2013). Similarly, 1% increment in sett cost would increase the total income by 0.37% which was significant at 5% level of significance. The improved
and quality setts was available in sugar-mill. The cost of the setts in sugar-mill was higher than the local setts produced from farmer field. Thus, revenue from setts purchased from sugar-mill with higher price was elastic to revenue. This result was in line with the finding of (Jawanjal et al., 2014) who found significant effect of setts cost in revenue. Furthermore, 1% increase in irrigation cost would increase the total income by 0.02% which was significant at 5% level of significance. Since this is not surprising, irrigation is important for increasing the production. According to (Silalertruksa & Gheewala, 2018) irrigated sugarcane yield was 23–54% higher than non-irrigated system. Furthermore, the nutrient cost was found significant at 1% level of significance. Likewise 1% increase in cost for fertilizer would increase the income by 0.38% (Table 3). This result was in line with the study of (Kamruzzaman & Hasanuzzaman, 2007). The use of fertilizer tends to increase production and thereby the revenue of sugarcane farmers. The result was also consistent with (Ali & Jan, 2017; Mohapatra & Sen, 2013). Similarly the tillage cost was found to have positive but insignificant effect on sugarcane revenue, but the study of (Nazir et al., 2013) found positive and significant effect of tillage in sugarcane revenue. This may be due to investing on existing and old machineries. There was no intervention of modern machineries and no use of machineries except for tillage purpose.

The F-value (24.05) was significant at 1% level of significance. Thus, the given model has good explanatory power. Similarly, the Adjusted R-square of the given model was 0.46 which implies that 46% variations in dependent variable were explained by explanatory variables included in the model.

### 3.4. Return to scale

From Table 3, summation of the regression coefficient of the inputs was found to be 1.28 depicting increasing return to scale which means that increase in the cost of the variable input would increase higher amount of income from sugarcane. Further, it indicated that 100% increment in all the input specified in function increases the income by 128%. Thus, the additional proportion of output is higher than the additional input added.

| Table 2. Cost of production and B:C ratios of sugarcane production in Nawalparasi |
|----------------------|---------|------------------|------------------|------------------|
| **Cost**              | **Unit** | **Main crop**    | **Ratoon crop**  | **Share to total** |
|                       |         | **Cost**         | **Cost**         | **cost**         |
| Labor                 | US$/ha  | 1503.28          | 474.01           | 40.47            |
| Seed                  | US$/ha  | 326.5            | -                | 21               |
| Draft power           | US$/ha  | -                | 16.3             | -                |
| Tillage               | US$/ha  | 194.81           | -                | 12.5             |
| Fertilizers           | US$/ha  | 184.99           | 63               | 4                |
| Transport             | US$/ha  | 169.45           | 169.45           | 11               |
| Compost               | US$/ha  | 121.99           | 121.99           | 8                |
| Irrigation            | US$/ha  | 41.69            | 41.69            | 3                |
| Weedicides            | US$/ha  | 4.35             | 4.35             | 0.03             |
| Yield                 | tonnes/ha| 0.35             | 0.33             | -                |
| **Total cost**        | US$/ha  | 1560.17          | 722.53           | 100              |
| **Cost**              | US$/Quintal | 3.98              | 1.81             | -                |
| **Total Revenue**     | US$/ha  | 1584.51          | 1503.28          | -                |
| **B:C ratio**         |         | 1.02             | 2.08             | -                |
| **B:C ration (main and ratoon crop)** |         | 1.35          |                   |                  |
3.5. Resource-use efficiency

The MVC and MFC of respective inputs are presented in Table 4. The ratio of Marginal value product to Marginal-fixed cost for human labour and tillage hour was lower than unity, and greater than unity for sett, irrigation and nutrient. Thus, the study revealed that human labour and tillage in sugarcane production were over-utilized whereas sett, irrigation and fertilizer were underutilized. So, profit can be increased by decreasing the labor and tillage cost, and increasing the expenditure on the inputs like sett, irrigation and fertilizer. Percent adjustment of labour was ~81.8, thus human labour cost was required to be reduced by 81.8% to allocate the human labour cost efficiently. Further the percent adjustment of tillage was ~26.6, thus for efficient allocation of tillage, cost should be reduced by 26.6%. The finding was consistent with the study of (Daniel et al., 2013) but the finding of (Jawanjal et al., 2014) contradicted with this finding, suggesting to expand the use of human labour and increase the cost in tractor for tillage. Further, percent adjustment required for sett, irrigation and fertilizer were 40.8, 94 and 89.7. Thus cost of sett, irrigation and fertilizer should be increased by 40.8%, 94% and 89.7%, respectively, for efficient allocation of the given resources and maximizing the income from sugarcane. This finding was found in line with (Jawanjal et al., 2014) who suggested to increase irrigation, phosphorus and nitrogen for increasing revenue from sugarcane.

4. Conclusions

From the study, sugarcane was found profitable but inadequate to run the livelihood efficiently. The cost of production of main crop was very high, but lower cost and higher B:C ratio of ratoon crop was the reason for continuity of sugarcane cultivation. However, B:C ratio for combined crop was 1.35. Thus, the B:C ratio of the crop can be increased and cost of production can be reduced through reducing the labor and intervention of machineries in inter-culture activities. Further, subsidy on setts and machineries would make the cost of setts and tillage lower. Similarly the resource-use efficiency of the producers depicted that none of the resources were used efficiently. There was over utilization of labour and machineries (for tillage only) and inputs like setts, irrigation, and fertilizers were underutilized. The insufficiency of chemical fertilizer, absence of irrigation and drainage facilities and unavailability of quality setts were prevalent in study area. Thus, the easy availability and affordability on these resources would increase the revenue from sugarcane production.

Table 3. Estimates of coefficients for inputs for sugarcane production

| Factors      | Coefficient | Std. error | t-value | Sig.level |
|--------------|-------------|------------|---------|-----------|
| Labor        | 0.23        | 0.100      | 2.30**  | 0.023     |
| Tillage hour | 0.1         | 0.080      | 1.24    | 0.219     |
| Seed (sett)  | 0.37        | 0.1399     | 2.63**  | 0.010     |
| Irrigation   | 0.02        | 0.0044     | 2.53**  | 0.013     |
| Nutrient     | 0.38        | 0.060      | 6.24*** | 0.000     |
| Constant     | 0.56        | 0.8322     | 0.67    | 0.502     |
| F-value      | 24.05**     |            |         | 0.00      |
| Adjusted R-square | 0.46      |            |         |           |
| R-square     | 0.48        |            |         |           |
| Return to scale | 1.28      |            |         |           |

Note: ***, ** and * indicate significant at 1%, 5% and 10% probability level respectively
| Inputs      | Geometric mean | Co efficient | MVP | MFC | MVP/MFC | Efficiency       | Percent adjustment required |
|------------|----------------|--------------|-----|-----|---------|------------------|----------------------------|
| Revenue    | 174,928.8      |              |     |     |         |                  |                            |
| Labor      | 72,413.01      | 0.23         | 0.55| 1   | 0.55    | Over utilized    | −81.8                     |
| Tillage    | 22,082.51      | 0.1          | 0.79| 1   | 0.79    | Over utilized    | −26.6                     |
| Sett       | 38,197.96      | 0.37         | 1.69| 1   | 1.69    | Underutilized    | 40.8                      |
| Irrigation | 207,2175       | 0.02         | 16.8| 1   | 16.8    | Underutilized    | 94                         |
| Nutrient   | 6849,414       | 0.38         | 9.7 | 1   | 9.7     | Underutilized    | 89.7                      |
| Constant   | 0.56           |              |     |     |         |                  |                            |
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Author details
Amita Pandey1
E-mail: pandeyamrita01.ap@gmail.com
ORCID ID: http://orcid.org/0000-0003-3340-1225
Diwas Raj Bista2
E-mail: bistadiwas@gmail.com
Thaneshwar Bhandari3
E-mail: aigecon.iias2069@gmail.com
Hari Krishna Panta3
Sudip Devkota4
E-mail: sudip.ioas@gmail.com

1 Agriculture Officer, Agriculture and Forestry University, Rampur, Nepal.
2 Senior Agriculture Economist, Prime Minister Agriculture Modernization Project, Ministry of Agriculture and Livestock Development, Kathmandu, Nepal.
3 Institute of Agriculture and Animal Science, Tribhuvan University, Kirtipur, Nepal.
4 Agriculture Officer, Ministry of Agriculture and Livestock Development, Kathmandu, Nepal.

Competing Interests
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