Profitability, productivity and resource use efficiency of banana production in Hetauda-Dumkibas road corridor, Nepal

Manoj Sharma1*, Shiva Chandra Dhakal1, Raj Kumar Adhikari2 and Ujjal Tiwari1

Abstract: The study employed cost-return analysis, Cobb-Douglas production function and marginal value product-marginal factor cost (MVP-MFC) approach to estimate and analyze profitability, productivity and resource use efficiency, respectively, of banana production in the Hetauda-Dumkibas road corridor. Primary data and information were collected from a total of 160 banana producers, 80 from each district, using pretested semi-structured questionnaires. The benefit-cost ratio (BCR) of banana was 1.57 in the first cropping season and 1.92 in succeeding cropping seasons, indicating that one USD spent on banana production yielded 57 cents profit from the first cropping season and 92 cents from succeeding cropping seasons. Suckers, fertilizers, labors and fixed variables were found to have positive and significant effects on gross income of banana production. The return to scale (1.037) was found slightly increasing. The analysis of resource use efficiency showed that fixed variables (mainly, rental value and insurance), suckers and labors were underutilized resources while plant protection chemicals and manures were overutilized resources. Expensive and poor insurance coverage, insufficiency of quality suckers and timely unavailability of labors were major reasons for underutilization, while easy availability of manures and higher occurrence of pests and diseases were reasons for overutilization of manures and plant protection chemicals, respectively.

ABOUT THE AUTHOR
Manoj Sharma received his B.Sc. degree in Agriculture Science from Tribhuvan University in 2017. He graduated with M.Sc. (Agricultural Economics) from the Agriculture and Forestry University, Nepal in 2020. His research interests mainly focus in the area of value chain development, food security and food systems. He has published a few articles in journals like Journal of Agriculture, Food Systems and Community Development, International Journal of Applied Science and Biotechnology, and South Asian Journal of Social Studies and Economics.

PUBLIC INTEREST STATEMENT
Banana is the second most important summer fruit crop of Nepal contributing to the local economy through employment and income generation. Over these years, production and yield of bananas have been increasing; however the gap between existing yield and potential yield is still significant. Similarly, imports of bananas are rising because of unmet demand from domestic production. On this premise, research projects are needed to provide ways forward to all stakeholders, so that concerted efforts could be put in place at both policies and implementation level to increase yield and production. In particular, this paper has shown the areas of interventions at farmer level through analysis of cost-benefit, productivity and resource use efficiency. Intervention strategies to enhance insurance coverage, disease/pest resistant varieties, and farm mechanization were found to be needed in the study area.
Therefore, research on tissue culture technology should be promoted to produce a large scale of disease and pest resistant varieties of bananas. Moreover, policy efforts to enhance reliable distribution networks of insurance companies and intercultural agro-machineries are recommended to increase profitability and productivity from banana production.

**Subjects:** Horticulture; Agriculture and Food; Economics

**Keywords:** BCR; production function; resource use efficiency; banana; Nepal

1. **Introduction**

In Nepal, banana is considered as a commercial crop with comparatively higher benefit-cost ratio (BCR) ranging from 1.5 to 4 depending upon varieties and locations (MRSMP, 2017; NHPC, 2017). This is also second most important summer crop, sharing 21% of total summer fruits production, which can contribute significantly to enhance livelihood of people due to its potential expansion on production area, productivity, high demand situation and a sustainable crop in climate change context (G. Pandey et al., 2017; Ranjitkar et al., 2016). In 2019 AD, the total productive area and production of bananas in Nepal is reported to be 16,615 ha and 278,890 tonnes, respectively (FAOSTAT, 2020). In addition, total quantity and value of imports of banana and related commodities are around 54,345 tonnes and US$ 6,836 thousands, respectively, while exports is negligible (FAOSTAT, 2020). These figures clearly show the unmet demand of banana produce in Nepal, which is because of poor productivity, higher post-harvest loss and little market attention (SAWTEE, 2016; Thapa & Dhimal, 2017).

Hetauda-Dumkibas road corridor located across two major banana producing districts, Chitwan and Nawalparasi East, contributes about 13% of total production of Nepal (MOALD, 2020). In fiscal year 2018/19, the productive area and production of bananas in these districts are 1,872 ha and 35,373.5 tonnes, respectively (MOALD, 2020). The corridor ranges from plain region to midhills of siwaliks having high potential for commercial banana production. In developing countries like Nepal, the banana subsector could contribute significantly to the local economy and food security through employment and income generation. The subsector could be more justified in the corridor because it could be incorporated into a mixed agroforestry system in hilly areas and could provide sustainable living wage to farmers and workers (ICIMOD, 2015; Ranjitkar et al., 2016). The Ministry of Agriculture and Livestock Development (MOALD) has emphasized the corridor for banana production and marketing, and announced a zone of banana in Chitwan district and a block in Nawalparasi East district under pocket package strategy. Other organizations like United Nations Development Programmes (UNDP) and Korean International Cooperation Agency (KOICA) are also involved to enhance the livelihoods, entrepreneurship and activity creation for the people of the corridor. However, smallholding banana farmers of developing countries face larger sets of production challenges especially related to resource (land, labor and capital) uses and technical know-how (Tinzaara et al., 2018). Other constraints include accessibility to information and technologies to maintain competitiveness in the dynamic environment of farming, market and policies. Preliminary studies within these areas also show that lower productivity and limited research & development (R&D) are major constraints at the farmers’ level (Ghimire et al., 2019; Shrestha et al., 2018). To enhance the commercialization of banana subsector and convert the efforts of all developing partners into considerable effects, it is prime important to understand how well producers are making plans and managing resources to maximize the returns, minimize costs, and improve overall efficiency (MRSMP, 2017; De Wit, 1992). However, limited scientific studies have been done so far to analyze the efficiency of resources used and their relationship with gross revenue in the corridor.

The optimal use of resources leads to efficient farming and helps to enhance commercialization and intensification by increasing remuneration and competitiveness (Mutoko et al., 2014).
Information on production costs, productivity and profitability are crucial to judge the appropriate resource allocations and find the scope of effective cost management (Haque, 2006). Evidence-based recommendations can only help agricultural economists and policy makers to formulate the appropriate policies to promote banana business. Thus, the paper is aimed to estimate and analyze the profitability, productivity and resource use efficiency of banana production in the corridor, and finally come up with policy recommendations.

2. Research methodology

2.1. Study area

Chitwan and Nawalparasi East, two major districts lying across Hetauda-Dumkibas road corridor, were selected purposely as they are major banana producing districts and have high potentiality to produce more bananas (Table 1). Chitwan district is situated within 27° 21' 45" to 27° 52' 30" North latitude and 83° 54' 45" to 84° 48' 15" East longitude, while Nawalparasi district (older name before Federal Nepal which is now divided into two new districts as Nawalparasi East and Nawalparasi West) is situated at latitude of 27°37'09.84" North and longitude of 84°01'12.00" East (CBS, 2017, 2018), which are shown in Figure 1.

2.2. Sampling and data collection process

The total of 160 banana producers was selected randomly from the study area taking 80 banana producers from each district using the sampling formulae. The formula used to determine the sample size, as given by Yamane (1967), followed as:

\[ n = \frac{N}{1 + Ne^2} = \frac{400}{1 + 400 \times 0.1} = 80 \]  

(i)

Where, \( n \) = sample size, \( N \) = population size (sampling frame) & \( e \) = level of precision considered as 10%.

In Chitwan district, sampling frame was 403 based on the producers' numbers registered at Chitwan Banana Producers Associations (CBPA) from Ratnanagar, Kalika and Khairahani municipalities. Likewise, in Nawalparasi East district, numbers of producers engaged on Kalika Banana Block Implementation Committee of Madhyabindu municipality were 200. Based on discussion with locals and representatives of cooperatives of Kawasoti municipality, the producers were found to be tentatively 200. In total, the sampling frame of Nawalparasi East district was 400.

| Characteristics          | Chitwan | Nawalparasi East |
|--------------------------|---------|------------------|
| Area (km²)               | 2,238.39| 1,331.16         |
| Total local levels (Numbers) | 6       | 8                |
| Population density (Number/km²) | 261     | 234.08           |
| Area of plantation (ha)  | 1,510   | 470              |
| Productive area (ha)     | 1,412   | 460              |
| Production (Mt)           | 26,432  | 8,941.5          |
| Productivity (Mt/ha)      | 18.5    | 20.8             |
| Rainfall (mm)             | 2,150   | 2,175            |
| Altitude (masl)           | 141–1,945| 300–1,936       |

Source: CBS (2017); CBS (2018) and MOALD (2020)
The primary data was collected through household survey, focused group discussion, key informant interview and by field observation using both structured and semi-structured questionnaires. The secondary data were also collected from reports of government and nongovernment organizations, annual agricultural statistical books and other sources available within agricultural offices of study areas. Data collected from the survey were coded, entered and analyzed through MS Excel 2013 and STATA. The accuracy of the data was checked using cross tabulations and logical checks.

2.3. Variables selection and data analysis

Total costs: The total cost of production is the summation of fixed costs and variable costs involved during the production process both in cash and kind form.

Fixed costs: Fixed costs included rental value of land, insurance costs, taxation and levies and overheads like depreciation on equipment. The prevailing rental values of land accounted for rental costs of lands, which were asked to banana farmers. Depreciation cost was calculated at 15% rate by using the “Straight Line” method (PKF Nepal, 2019). The total cost of insurance premium and taxes paid by producers were also added into fixed cost.

\[ \text{Fixed costs} = \text{Rental value} + \text{Insurance cost} + \text{Depreciation cost} + \text{Taxation and levies} \]
Variable costs: The expenses included into variable cost were expenses on land preparation cost, saplings/suckers; farmyard manure, chemical fertilizers, plant protection chemicals, human labor and others. As banana is a perennial crop, which replaces itself in another growing season, the variables costs of suckers and land preparations were excluded after the first cropping season.

\[ Variable \ cost = \text{Land preparation cost} + \text{Suckers cost} + \text{Labors cost} + \text{Manures cost} + \text{Fertilizers cost} + \text{Plant protection costs} + \text{Irrigation cost} + \text{Other costs} \]  

(iii)

The details about variable costs are described below;

- **Land preparation cost**: Land preparation was done mainly by tractors, which was measured in hours. The rate of tractor operation taken per hour was calculated. The cost of forming pits was also included into this cost item.

- **Banana suckers**: The average purchasing price of suckers at local level was considered to calculate cost of suckers.

- **Farmyard manure and fertilizers**: Prevailing prices in the region was considered to work out the cost of farmyard manure whereas in case of chemical fertilizers, prevailing market prices at local agrovets were taken into consideration. The fertilizers used in the study area were urea, di-ammonium phosphate (DAP), potash, borax, sulphur, ammonium phosphate, single super phosphate (SSP) and zinc sulphate.

- **Plant protection chemicals**: Banana crop is prone to number of pests like pseudostem weevils, rhizome weevil, banana aphids etc. and diseases like fusarium wilt, sigatoka disease, bunchy top virus etc. Most of these pests and diseases were controlled by using chemical sprays and dusting. Various plant protection chemicals like cypermethrin, mancozeb, metalaxyl, and butachlor were considered at an average of prevailing market prices provided by local agrovets.

- **Labor**: The cost of labor services (both family and hired labor) were calculated by considering prevailing wage rates in each district. The wage rate of men was higher than that of women in both districts.

- **Irrigation**: The costs of irrigation were calculated in varied ways in the study areas, which included cost of electricity, cost of diesels and levy for canal irrigation systems.

- **Other costs**: Other costs included miscellaneous costs like marketing costs, transportation cost, repairs and maintenance cost etc. including interest on working capitals. Interest rate was taken as 11% as suggested by Agricultural Development Bank Limited (ADB/L).

**Gross revenue**: It was the value of the total banana crops including main and by-product multiplied by farm gate price.

\[ \text{Gross revenue} = \text{Total products} \times \text{Farm gate price} \]  

(iv)

**Gross profit**: It was calculated by subtracting total cost of banana production from gross revenue.

\[ \text{Gross profit} = \text{Gross revenue} - \text{Total costs} \]  

(v)

**Benefit cost ratio (BCR)**: This was carried out by diving the gross revenue by total cost of production. In other words, it was ratio of per finger price of banana to per finger cost of production.

\[ \text{Benefit cost ratio} = \frac{(\text{Total revenue collected})}{(\text{Total cost incurred})} \]  

(vi)

2.4. **Cobb-Douglas production function**

The Cobb-Douglas production function (CDPF) was used to estimate the technical efficiency of different resources using gross income as dependent variables and cost of resources as
dependent variables. Various studies like Dave et al. (2016), Bajracharya and Sapkota (2017), and Mukul and Rahman (2013) used this function to establish input-output relationship, which can be expressed as:

\[ Y = aX_1^\beta_1 X_2^\beta_2 X_3^\beta_3 X_4^\beta_4 X_5^\beta_5 X_6^\beta_6 e^\epsilon \]  

Where, \( Y \) is gross revenue from banana production, \( X_1 \) is suckers cost, \( X_2 \) is labor cost, \( X_3 \) is manure cost, \( X_4 \) is fertilizer cost, \( X_5 \) is plant protection cost, \( X_6 \) is total fixed cost, \( \epsilon \) is error term, and \( \beta_1 \ldots \beta_6 \) are coefficients to be estimated.

Taking log on both sides, we get linear form of CDPF as shown in below:

\[ \log(Y) = \log(a) + \beta_1 \log(X_1) + \beta_2 \log(X_2) + \beta_3 \log(X_3) + \beta_4 \log(X_4) + \beta_5 \log(X_5) + \beta_6 \log(X_6) + \epsilon \]  

The summation of values of coefficients of each input gives the value of returns of scale (RTS). If RTS is greater than one, it indicates the increasing returns to scale; if RTS is equal to one it indicates the constant return to scale and if RTS is less than one, it indicates the decreasing returns to scale.

Resource use efficiency (RUE) ratio was estimated using marginal value product-marginal factor cost (MVP-MFC) analysis approach, which has been used by study of A. Pandey et al. (2020) and Konja et al. (2019).

Marginal value product was calculated by using coefficients of each input, which is shown below:

\[ \text{MVP} = \frac{\text{Geometric mean of gross revenue}(Y)}{\text{Geometric mean of input}(X_i)} \]  

The efficiency ratio (r) was calculated by using formula,

\[ r = \frac{\text{MVP}}{\text{MFC}} \]  

Where, MFC is marginal factor cost or price per unit input at their geometric means.

Decision criteria: \( r > 1 \) indicates the underutilization of resources, \( r < 1 \) overutilization of resources and \( r = 1 \) indicates the efficient utilization of resources.

3. Results and discussions

3.1. Socio-economic and demographic characteristics

The socio-economic and demographic characteristics of banana producers are shown in Table 2. The average age of the household head was found to be 51.84 years which ranged from 22 to 82 years. Chitwan district had a comparatively younger household head with an average age of 49.29 years as compared to Nawalparasi East district (54.39 years), and the difference was statistically significant at 1% level. This showed that younger farmers were attracted more to banana farming in Chitwan district; possibly, because of higher profit realized from banana production in Chitwan compared to Nawalparasi East. The mean years of schooling was eight years with standard deviation of 4.80 years. The average years of schooling was low (5.23 years) in Nawalparasi East in comparison with Chitwan (9.78 years), and the difference was statistically significant at 1% level. This was because most banana farming areas in Nawalparasi East district belonged to rural areas, where facilities of education were less accessible. The average family size of farmers was around 6 in which about 47% of total members were involved in the farming operations of bananas. The average household size (6) was almost similar for both districts, which was a bit higher as compared to national average household size (4.88) (CBS, 2012). The average livestock unit was 1.58 LSU with a standard deviation of 1.46 in the study area which was significantly different in Chitwan district (1.13 LSU) and Nawalparasi East district (2.03 LSU) at 1% level. Accounting for children below 15 and elders of above 60 years as dependents and others
Table 2. Socioeconomic and demographic descriptions of the study area

| Variables                        | Total          | Chitwan        | Nawalparasi East | Mean difference | T value |
|----------------------------------|----------------|----------------|------------------|-----------------|---------|
| Age of household head (years)    | 51.84 (12.46)  | 49.29 (11.12)  | 54.39 (13.26)    | -5.10***        | -2.64   |
| Years of schooling               | 7.51 (4.81)    | 9.79 (3.59)    | 5.22 (4.80)      | 4.56***         | 6.81    |
| Household size (numbers)         | 5.83 (2.25)    | 5.74 (2.00)    | 5.92 (2.48)      | -0.19           | -0.53   |
| Livestock unit (LSU)             | 1.58 (1.46)    | 1.13 (1.77)    | 2.03 (1.29)      | -0.90***        | -5.19   |
| Economically active members      | 3.93 (1.66)    | 3.98 (1.46)    | 3.89 (1.86)      | 0.09            | 0.33    |
| Years of experience              | 8.75 (6.77)    | 4.88 (3.95)    | 12.61 (6.81)     | -7.73***        | -8.79   |
| Total landholding size (Kattha)  | 46.65 (90.87)  | 69.72 (122.19) | 23.58 (24.69)    | 46.15***        | 3.31    |
| Land under banana cultivation    | 41.64 (92.57)  | 68.15 (123.96) | 15.14 (21.40)    | 53.01***        | 3.77    |
| Distance to highway (km)         | 4.12 (2.44)    | 5.08 (2.27)    | 3.16 (2.23)      | 1.92***         | 5.40    |
| Distance to nearest markets (km) | 5.09 (13.74)   | 4.16 (4.05)    | 6.03 (19.01)     | -1.86           | -0.86   |

Note: ***, **, and * represent level of significance below 1%, 5%, and 10% level, respectively; standard deviations are enclosed into parenthesis; 1 Hectare = 30 Kattha.
Source: Field Survey (2019).

as economically active members, the dependency ratio was 46.84% in Hetauda-Dumkibas road corridor, which was calculated by dividing the numbers of dependent members to numbers of economically active members. The economically active members were four in the study area. The farmers had an average of 8.75 years of banana farming experience with a standard deviation of 6.75 years. The years of experience of Chitwan’s farmers was 4.88 years while that of Nawalparasi East district had 12.61 years. This significant difference could be due to involvement of elder farmers in banana farming in Nawalparasi East district. The total landholding size was higher (69.72 Kattha) in Chitwan district as compared to Nawalparasi East district (23.58 Kattha), and the difference was statistically significant at 1% level. Similarly, land under banana plantation was also significantly higher in Chitwan district (68.15 Kattha) as compared to Nawalparasi East district (15.14 Kattha). The average distance of farmland to highway was 4.12 km in the study area, which was significantly higher (5.08 km) in Chitwan district as compared to Nawalparasi East district (3.16 km). The average distance to the nearest market was 5.09 km in the study area which was not significantly different for two districts.

3.2. Resources used and cost of production
The major inputs used for the banana cultivation were suckers, human labors, manures, fertilizers and plant protection chemicals as shown in Table 3. Human labors (both men and women) were used during land preparation, pit formation, suckers plantation and various intercultural operations. The major fertilizers used for banana cultivation were urea, DAP, potash and borax in the study area.
Table 3: Resources used for banana production

| Inputs                              | Total        | Chitwan    | Nawalparasi East | Mean difference | T value |
|-------------------------------------|--------------|------------|------------------|-----------------|---------|
| Suckers used (numbers per ha)       | 2,034.05 (407.50) | 2,130.51 (387.57) | 1,937.58 (406.37) | 192.92***     | 3.07    |
| Human labors (mansdays/ha)          | 95.80 (23.47) | 94.81 (30.91) | 96.80 (12.30) | −1.99          | −0.54   |
| Manures (Mt/ha)                     | 6.05 (3.67)  | 4.77 (3.42) | 7.33 (3.47) | −3.08**        | −2.58   |
| Fertilizers (kg/ha)                 | 2.105.51 (1,897.45) | 2,546.36 (1,867.56) | 1,664.65 (1,834.35) | 881.71***     | 3.01    |
| Plant protection chemicals (litre/ha) | 26.02 (18.09) | 27.53 (26.37) | 22.50 (19.43) | 5.03*          | 1.77    |
| Fungicides (kg/ha)                  | 2.68 (7.19)  | 2.52 (5.09) | 2.85 (8.83) | −0.33          | −0.29   |

Note: ***, **, and * represent level of significance below 1%, 5%, and 10% level, respectively; standard deviations are enclosed into parenthesis.
Source: Field Survey (2019).

The average number of suckers planted was around 2,034 per hectare. This was lower in Nawalparasi East district (1,937.58) than that of Chitwan district (2,130.51), and the difference was significantly different at 1% level. The reason was many farmers of Nawalparasi East district had cultivated banana crops in sloppy land, where plant density was low. Likewise, the human labors employed in banana cultivation was higher in Nawalparasi East district (96.81 mansdays/ha) as compared to Chitwan district (94.81 mansdays/ha); however, the difference was not statistically significant. The use of manures in Nawalparasi East district (7.33 Mt/ha) was higher than that of Chitwan district (4.77 Mt/ha), which was statistically significant at 5% level. The amount of fertilizers used in banana cultivation was 2105.51 kg per hectare in the study areas. The higher fertilizer rate was observed in Chitwan district (2,546.36 kg per ha) as compared to Nawalparasi East district (1,664.65 kg per ha), and the difference was statistically significant at 1% level. The use of plant protection chemicals was significantly low in Nawalparasi East district (22.50 litre/ha) as compared to Chitwan district (27.53 litre/ha). This was because most farmers in Nawalparasi East district had adopted cattle and buffalo farming. So that farmyard manure replaced fertilizers in Nawalparasi East district. In addition, many farmers depended upon the grass and forages grown between rows of banana crops, which resulted in lower pesticide use. The use of fungicides was 2.68 kg/ha in the total area, which was almost similar for both districts.

The average total cost incurred in the first cropping season of banana production was found NRs. 408,166 per hectare, which was reduced to NRs. 332,895 per hectare in succeeding cropping seasons because of the excluded cost of suckers and land preparation (Table 4). The total cost of banana production was lower in Nawalparasi East district (NRs. 375,427 per ha and NRs. 301,586 per ha incurred in the first cropping and succeeding cropping seasons) as compared to Chitwan district (NRs. 440,904 per ha and NRs. 364,203 per ha incurred in the first cropping season and succeeding cropping seasons) and the difference was significantly different at 1% level. It was largely because of the difference in the cost incurred for fixed variables, land preparation, manures and fertilizers. The finding was higher than previous study of Shrestha et al. (2018) and Ghimire et al. (2019), which calculated cost of production as NRs. 358,547 per ha excluding land rent and NRs. 365,244.81 per ha in Chitwan district.
### Table 4. Cost analysis of resources used for banana production (NRs. per hectare)

| Cost items                                | Total       | Chitwan    | Nawalparasi East | Mean difference | T value |
|-------------------------------------------|-------------|------------|------------------|-----------------|---------|
| Land preparation cost*                    | 35,934.97   | 37,381.89  | 34,488.05        | 2,893.84***     | 3.07    |
| Suckers cost†                             | 31,876.52   | 31,718.39  | 32,034.64        | −316.25         | −0.11   |
| Labors cost                               | 83,496.33   | 81,778.64  | 85,214.02        | −9,790.63       | −1.07   |
| Manure cost                               | 28,955.55   | 22,441.15  | 35,469.95        | −13,028.80***   | −3.83   |
| Fertilizers cost                          | 76,128.81   | 83,588.18  | 68,669.44        | 14,918.74**     | 0.03    |
| Plant protection cost                     | 24,687.19   | 26,701.51  | 22,672.87        | 4,028.64        | 1.40    |
| Irrigation cost                           | 3,698.92    | 3,155.84   | 4,242.00         | −1,086.16       | −0.70   |
| Total fixed cost                          | 90,670.67   | 12,173.15  | 59,609.86        | 62,121.63***    | 26.71   |
| Others cost                               | 32,716.04   | 32,406.72  | 33,025.37        | −618.66         | −0.45   |
| Others cost†                              | 25,256.83   | 24,805.69  | 25,707.88        | −902.19         | −0.69   |
| Total cost of the first cropping season   | 408,150.50  | 440,903.80 | 375,427.20       | 65,477.60***    | 5.07    |
| Total cost of succeeding cropping seasons | 332,894.80  | 364,202.50 | 301,586          | 62,616.48***    | 5.28    |

Note: ***, ** and * represent level of significance below 1%, 5% and 10% level, respectively; standard deviations are enclosed in parenthesis; † represents costs accounted for the first cropping season only; ‡ represents cost accounted for succeeding cropping seasons only.

Source: Field Survey (2019).

The total fixed cost shared maximum (around 22 to 27%) followed by human labors (21 to 25%) and fertilizers costs (19 to 23%) as shown in Figure 2 and Figure 3. Other inputs like suckers, manures, irrigation facilities and plant protection chemicals shared almost a similar percentage of total cost between 6% and 9% in the study areas. Similar kind of study conducted by Shrestha et al. (2018) in Chitwan district found that the highest cost was shared by labor (19.48%) in banana cultivation which was followed by machines (19.23%) and fertilizers (16.49%). Likewise, the study of Ghimire et al. (2019) reported that rental value of banana orchard shared the highest amount of cost (21.34%), followed by labor (15.32%), machine (15.12%) and fertilizers (12.96%) in Chitwan district. The cost incurred to land preparation was significantly low in Nawalparasi East district (NRs. 34,488 per ha) as compared Chitwan district (NRs. 37,381 per ha) at 1% level. The reason was many farmers had their own draught bullocks and used them for tillage operations in Nawalparasi East districts, which saved costs to be incurred in tractors and machineries during land preparation. The cost of manures incurred in banana cultivation was higher in Nawalparasi East district (NRs. 35,470 per ha) as compared to Chitwan district (NRs. 22,441 per ha), and the difference was statistically significant at 1% level. In contrast, the fertilizers cost was statistically higher for Chitwan district (NRs. 83,588 per ha) at 5% level compared to Nawalparasi East district (NRs. 68,669 per ha). The reason was higher application rate of fertilizers in Chitwan as compared to Nawalparasi East district. Likewise, the fixed cost was higher (NRs. 121,732 per ha) in Chitwan.
district than that of Nawalparasi East district (NRs. 59,610 per ha) and the difference was statistically significant. The major reason was higher rental cost in Chitwan district because farms lands were nearer to metropolitan city, Bharatpur. Other costs involved in the first cropping season and succeeding cropping seasons were NRs. 32,716 per ha and NRs. 25,257 per ha, respectively, which were almost the same for both districts. The cost incurred for suckers, labors, plant protection chemicals and irrigation in banana cultivation were NRs. 31,877 per ha, NRs. 83,496 per ha, NRs. 24,687 per ha and NRs. 3,699 per ha respectively, which were almost the same for both districts as well and also statistically insignificant.

3.3. Cost return and productivity analysis
Total productivity of bananas was higher in Chitwan district (156,739.5 fingers per ha) as compared to Nawalparasi East district (148,095 fingers per ha), however the difference was statistically insignificant (Table 5). The average gross revenue from banana production was NRs. 638,953 per ha. The revenue from the production was higher (NRs. 779,764 per ha) in Chitwan district as compared to Nawalparasi East district (NRs. 498,143 per ha), and the difference was statistically significant at 1% level. Per hectare gross profit from the first cropping season was NRs. 230,788 in the study area, while this was higher (NRs. 338,860) in Chitwan district as compared to Nawalparasi East district (NRs. 122,717). In succeeding cropping seasons, the gross profit per ha increased to NRs. 306,059 per ha, which was again higher (NRs. 415,561 per ha) for Chitwan district.
as compared to Nawalparasi East district (NRs. 196,557 per ha). The differences in gross profit from banana production in the two districts were statistically significant at 1% level. Previous study of Shrestha et al. (2018), Ghimire et al. (2019), and Dulal and Kattel (2020) conducted in Chitwan district found almost similar amount of the gross return from banana production as NRs. 555,324.9 per ha, NRs. 628,433.8 per ha and NRs. 549,719.77 per ha, respectively.

### 3.4. Benefit-cost ratio (BCR) analysis

The per finger cost of banana cultivation in the first cropping season was found to be NRs. 2.81 in Chitwan district and NRs. 2.54 in Nawalparasi East district, while it was decreased to NRs. 2.32 and NRs. 2.03 per finger, respectively, in succeeding cropping seasons (Table 6). Likewise, the price of bananas was found to be NRs. 4.97 per finger in Chitwan district and NRs. 3.36 per finger in Nawalparasi East district. BCR of banana was calculated as 1.57 and 1.92 of the first cropping season and succeeding cropping seasons, respectively. This suggested that 1 USD spent on banana production yielded 56 cents from the first cropping season, which was further increased by 35 cents in succeeding cropping seasons. Banana production was a profitable crop in the study area. BCR was higher in Chitwan district (1.76 in the first cropping season and 2.14 in succeeding cropping seasons) as compared to Nawalparasi East district (1.32 in the first cropping season and 1.65 in succeeding cropping seasons). The study of MRSMP (2017) conducted in different parts of Nepal calculated the BCR of banana production ranging from 1.5 to 3 in the

### Table 5. Cost return and productivity of banana production

| Particulars                           | Total            | Chitwan district | Nawalparasi East district | Mean difference | T value |
|---------------------------------------|------------------|------------------|---------------------------|-----------------|---------|
| Productivity (fingers/ha)             | 152,417.10 (104,282.40) | 156,739.50 (129,321.90) | 148,094.80 (71,591.41) | 8,644.70 | 0.52    |
| Gross profit (NRs. per ha)            | 638,953.40 (477,654.30) | 779,763.90 (568,805) | 498,142.90 (308,406.30) | 281,620.90*** | 3.89    |
| Gross profit per ha (the first crop)  | 230,788.40 (462,365.80) | 338,860.10 (562,499.30) | 122,716.70 (300,350.10) | 216,143.30*** | 3.03    |
| Gross profit per ha (succeeding crops) | 306,059.20 (463,720.30) | 415,561.40 (565,566.80) | 196,556.90 (297,731.70) | 219,004.50*** | 3.06    |

Note: *** *, ** and * represent level of significance below 1%, 5% and 10% level, respectively; standard deviations are enclosed into parenthesis

Source: Field Survey (2019)

### Table 6. Benefit-cost ratio analysis of banana production

| Particulars                                | Total | Chitwan district | Nawalparasi East district |
|--------------------------------------------|-------|------------------|---------------------------|
| BCR (the first crop)                       | 1.57  | 1.77             | 1.33                      |
| BCR (succeeding crops)                     | 1.92  | 2.14             | 1.65                      |
| Per finger cost (NRs.) of cultivation (the first crop) | 2.68  | 2.81             | 2.54                      |
| Per finger cost (NRs.) of cultivation (succeeding crops) | 2.18  | 2.32             | 2.04                      |
| Price per finger at producer level (NRs.)  | 4.19  | 4.97             | 3.36                      |

Source: Field Survey (2019)
first cropping season and 1.5 to 4.22 in succeeding cropping seasons. The economic analysis of Shrestha et al. (2018), Ghimire et al. (2019), and Dulol and Kattel (2020) estimated the BCR as 1.28, 1.55 and 2.18, respectively, which are similar to findings of this study.

3.5. Production function analysis
Using the Cobb-Douglas production function (CDPF), gross income of production is regressed with independent cost items. The F value (6, 153) was statistically significant at 1% level and showed that the model has good explanatory power. The value of R squared indicated that 85.78% of variation in farm income from bananas was explained by dependent cost variables included in the model. From model, the cost incurred for suckers, fertilizers, labor and fixed costs were significant predictors of revenue collected from banana production (Table 7). One percent increase in sucker cost would increase revenue from bananas by 0.29%, under ceteris paribus, which is significant at 5% level. Similar kind of study conducted in Bangladesh by Mukul and Rahman (2013) revealed the positive impact of suckers on revenue collection from banana production. Similarly, Dave et al. (2016) also found the significant effect of suckers on income from banana farming. The result revealed that 1% increase in cost of manure would decrease the revenue collected from bananas by 0.01%, which however was non-significant. Similarly, one percent increase in cost of fertilizers would increase the income from bananas by 0.16%, which was, however, not significant. Likewise, 1% increase in the cost of plant protection chemicals would decrease the income from bananas by 0.002%, which was statistically insignificant. In addition, 1% increase in the cost of labors would increase the income from bananas by 0.23%, which was statistically significant at 10% level. This finding was in contrast to the study of Mukul and Rahman (2013) which showed the negative impact of labors cost in income from banana farming. The regression coefficient of total fixed cost indicated that 1% increase in cost of total fixed cost would increase the income from banana by 0.36%, which was statistically significant at 1% level.

3.6. Returns to scale
The return to scale was calculated by adding all coefficients of independent cost items, which was equaled to 1.037 indicating slightly increasing return to scale in banana production (Table 7). This implied that an increase in the cost of variable inputs would return slightly higher amount of income from banana production. The additional proportion of output is slightly higher than the

| Table 7. Production function analysis of banana production |
|----------------------------------------------------------|
| **Explanatory variables**                                | **Coefficient** | **Standard Error** | **t**  | **P value** |
| Lag(Suckers cost)                                        | .294**          | .120               | 2.45   | 0.016       |
| Lag(Manure cost)                                         | -.013           | .014               | -.93   | 0.354       |
| Lag(Fertilizers cost)                                    | .160**          | .076               | 2.10   | 0.038       |
| Lag(Plant protection cost)                               | -.002           | .026               | -0.08  | 0.935       |
| Lag(Labor cost)                                          | .235*           | .120               | 1.96   | 0.052       |
| Lag(Total fixed costs)                                   | .364***         | .101               | 3.59   | 0.000       |
| Constant                                                 | .745***         | .177               | 4.22   | 0.000       |
| R-squared                                                | 0.859           |                    |        |             |
| Adjusted R square                                        | 0.852           |                    |        |             |
| F (6, 153)                                               | 153.850***      |                    |        |             |
| Returns to scale                                         | 1.037           |                    |        |             |

Note: ***, ** and * represent level of significance below 1%, 5%, and 10% level, respectively; standard deviations are enclosed into parenthesis
Source: Field Survey (2019)
additional input employed. Similar to this finding, Dave et al. (2016) found return to scale was 1.072 of banana production in Gujarat, India. In contrast, Dulal and Kattel (2020) found elasticity of banana production less than unity (0.245) in Chitwan district.

3.7. Resource use efficiency (RUE) of banana production

The utilization of resources is considered as efficient when marginal value product (MVP) equals marginal factor cost (MFC) i.e. allocative efficiency (MVP/MFC) equals one. MFC of all resources were expressed in terms of an additional rupees spent on providing individual resources. MVP for each resource represents the expected additional gross income caused by an additional one unit of that resource keeping other resources constant, which were calculated using coefficient from CDPF.

The resource use efficiency ratio was highest for total fixed costs (1.97) followed by suckers cost (1.59) and labors cost (1.27), as shown in Table 8. This indicated that spending more on total fixed costs, suckers cost and labors cost would yield more returns. For instance, every additional rupee spent on total fixed items, suckers and labors would result in the returns of NRs. 1.97, NRs. 1.59, and NRs. 1.27, respectively. These were the cases of underutilization of resources and also statistically significant. This finding was supported by the study of Sakamma et al. (2018) done in banana production in India which found the value of resource use efficiency of suckers greater than one. Fertilizers, plant protection chemicals and manures were found as over utilized resources. The negative ratio of manure cost (−0.068) and plant protection cost (−0.012) suggested that every additional rupees spent on manures and plant protection chemicals would reduce the gross revenue by NRs. 0.068 and 0.012; however ratios were not statistically significant. The efficiency ratio of fertilizers was 0.86 which indicated that additional one rupee spent on fertilizers would yield only NRs. 0.86.

4. Conclusions and recommendations

Two districts were geographically almost similar, however the socio-economic and demographic characteristics like age of household head, education level, years of experience and land holding size were found to be significantly different among producers. Cost-return analysis showed that banana business is profitable; however, mediocre BCR suggested that there is ample scope to get higher return from banana farming. The production challenges were insect/pest and disease infestation, poor quality suckers, timely unavailability of fertilizers and labors, and absence of irrigations and drainage facilities. Thus, the study recommends farm level policies directed to improve availability and accessibility of resources like suckers, fertilizers, labors and irrigation facilities to get higher profitability. The production function analysis revealed that costs of suckers, fertilizers, labors and fixed items were significant predictors of revenue collected from

| Table 8. Resource use efficiency of banana cultivation |
|-----------------------------------------------|
| **Explanatory variables** | **Coefficient** | **Geometric mean** | **MVP** | **MFC** | **r(MVP/MFC)** |
| Lag(Suckers cost) | .294** | 4.179 | 1.591 | 1 | 1.591 |
| Lag(Manure cost) | −0.013 | 2.809 | −0.068 | 1 | −0.068 |
| Lag(Fertilizers cost) | .160** | 4.512 | 0.863 | 1 | 0.863 |
| Lag(Plant protection cost) | −.002 | 3.986 | −0.012 | 1 | −0.012 |
| Lag(Labor cost) | .235* | 4.617 | 1.269 | 1 | 1.269 |
| Lag(Total fixed costs) | .364*** | 4.629 | 1.967 | 1 | 1.967 |

Note: ***, ** and * represent level of significance below 1%, 5%, and 10% level, respectively
Source: Field Survey (2019)
banana cultivation. The return to scale (1.037) was found slightly increasing. Resource use efficiency ratio showed that fixed variables, suckers and labors were underutilized while fertilizers, plant protection chemicals and manures were overutilized. This indicated that spending more on fixed variables (rental cost and insurances), suckers and labors would yield more returns. However, share of labor and suckers costs in the study areas were already higher as compared to other studies. This implied that mechanization in banana farming especially to support intercultural operations could be an alternative to solve the problem of unavailability and underutilization of labors, which could further increase return. Regarding the suckers, research and development of tissue culture varieties of banana would be the best option to control pests and disease, reduce cost and increase efficiency. Higher moral hazard and poor coverage of agricultural insurances led to underutilization of fixed costs. Policies directed to strengthen the reliable and efficient distribution networks of insurance companies are highly recommended in the study area. The RUE of fertilizers was less than unity (0.86), which suggested that there is a problem with proper fertilizer use, which could be corrected through timely application and right fertilizer choice for banana crops.

Author contributions
All authors contributed to conception and design of the research study. The collection, analysis and interpretation of data were performed by Manoj Sharma. The first draft prepared by Mr. Sharma, and other authors commented and provided suggestions on the draft. All authors read and approved the final manuscript.

Disclosure statement
The author(s) declared that they have no conflict of interests.

Acknowledgements
We would like to appreciate the Directorate of Research and Extension (DOREX) and Dr. Naba Raj Devkota, Director of DOREX for facilitating the fund and cooperation throughout the research period. My gratitude goes to Bijay Sapkota, Sandesh Dhakal and Abhishek Pudasani for their effort to collect reliable data through traveling to the distant villages of Chitwan and Nawalparasi East districts. We are thankful to both anonymous reviewers who helped this paper to put into this form.

Funding
This research was funded by Value Chain Development of Fruits and Vegetables Project (VCDP), the joint initiative of the Ministry of Agriculture and Livestock Development (MoALD), United Nations Development Programme (UNDP) and Korean International Cooperation Agency (KOICA). The research is supported by Directorate of Research and Extension (DOREX), Agriculture and Forestry University (AFU) through facilitating the fund and cooperation throughout the research period.

Author details
Manoj Sharma1
E-mail: paudel.manoz55@gmail.com
ORCID ID: http://orcid.org/0000-0001-5023-1913
Shiva Chandra Dhakal1
Raj Kumar Adhikari2
Ujjal Tiwari1
1 Department of Agricultural Economics and Agribusiness Management, Agriculture and Forestry University (AFU), Rampur, Chitwan, Nepal.
2 Value Chain Development of Fruit and Vegetables Project (VCDP), Nepal.

Data availability
The dataset used to analyze during the current study is available on Mendeley Data (http://dx.doi.org/10.17632/c59mcc7k1.r).

Citation information
Cite this article as: Profitability, productivity and resource use efficiency of banana production in Hetauda-Dumkibas road corridor, Nepal, Manoj Sharma, Shiva Chandra Dhakal, Raj Kumar Adhikari & Ujjal Tiwari, Cogent Food & Agriculture (2021), 7: 1917134.

References
Bajracharya, M., & Sapkota, M. (2017). Profitability and productivity of potato (Solanum tuberosum) in Baglung district, Nepal. Agriculture & Food Security, 6(1), 47. https://doi.org/10.1186/s40066-017-0125-5
CBS. (2012). National population and housing census 2011 (national report). Kathmandu: Government of Nepal. National Planning Commission. Central Bureau of Statistics. Retrieved from https://catalog.ihsn.org/catalog/4210/related-materials. Accessed on 4 January, 2021.
CBS. (2013). Chitwan district profile-2074. Government of Nepal. National Planning Commission. Central Bureau of Statistics. Office, Chitwan. Retrieved from https://cbs.gov.np/wp-content/uploads/2018/12/District-Profile-of-Chitwan-2074-Book-1.pdf. Accessed on 4 January 2021.
CBS. (2019). Municipality & rural municipality profile of Nawalparasi East-2075. Government of Nepal. National Planning Commission. Central Bureau of Statistics. Office, Chitwan. Retrieved from the Central Bureau of Statistics website: https://cbs.gov.np/wp-content/uploads/2019/03/thankyou%20Office%20book%20Nawalparasi.pdf. Accessed on 4 January 2021.
Dafe, A. K., Zalo, Y. C., & Pandur, R. S. (2016). Comparative economics of banana cultivation in Anand district of Gujarat. Economic Affairs, 61(2), 305–312. https://doi.org/10.5958/0976-4666.2016.00039.5
De Wit, C. D. (1992). Resource use efficiency in agriculture. Agricultural Systems. 40(1–3), 125–151. https://doi.org/10.1016/0308-521X(92)90018-J
Dulal, S., & Kattel, R. R. (2020). Resource use efficiency of banana production and impact of insurance scheme adoption on banana farming in Chitwan, Nepal. International Journal of Applied Sciences and Biotechnology, 8(2), 170–178. https://doi.org/10.3126/ijasbt.v8i2.299120
FAOSTAT. (2020). FAOSTAT database (2019). Retrieved from http://www.fao.org/faostat/en/#data/QC. Accessed on 4 January 2021.
Ghimire, S., Koirala, B., Devkota, S., & Basnet, G. (2019). Economic analysis of commercial banana cultivation
and supply chain analysis in Chitwan, Nepal. Journal of Pharmacognosy and Phytochemistry, 8(5), 190–196. Accessed on 5 January 2021 Retrieved from https://www.phytojournal.com/archives/2019/vol8Issue5S/PortESP-B-5-64-65B.pdf

Hoque, T. (2006). Resource use efficiency in Indian agriculture. Indian Journal of Agricultural Economics, 61(1), 65–76. Accessed on 4 January 2021 Retrieved from https://ageconsearch.umn.edu/record/204445/files/05-keynote20paper207Hoque.pdf

ICIMOD. (2015). Expanding banana production in Nepal. Kathmandu: International Centre for Integrated Mountain Development. Retrieved from http://www.icimod.org/v2/bull3/index.php/cms4/imagic?q=18964, Accessed on 4 January 2021.

Konjo, D. T., Mabe, F. N., Alhassan, H., & Yildiz, F. (2019). Technical and resource-use efficiency among smallholder rice farmers in Northern Ghana. Cogent Food & Agriculture, 5(1), 1651473. https://doi.org/10.1080/23311932.2019.1651473

MOALD. (2020). Statistical information on Nepalese agriculture 2017/176 (2018/19). Kathmandu: Ministry of Agricultural and Livestock Development, Government of Nepal. Retrieved from https://fs3-ap-southeast-1.amazonaws.com/prod-gov-agriculture/server-assets/publication-1595229368881-0dc12.pdf. Accessed on 4 January 2021.

MRSMP. (2017). Average cost of production and benefit cost analysis of fruit farming in Nepal-2073/74 (2016/17). Lalitpur: Government of Nepal, Ministry of Agriculture, Department of Agriculture, Agribusiness Promotion and Market Development Directorate, Market Research and Statistics Management Program (MRSMP). Retrieved from https://nepalin.data.com/media/items/10/Average_Cost_of_Production_and_Gross_Profit_of_Fruit_Farming_in_Nepal_2014_015.pdf. Accessed on 4 January 2021.

Mukul, A. Z. A., & Rahman, M. A. (2013). Production and profitability of banana in Bangladesh-an economic analysis. International Journal of Economics, Finance and Management Sciences, 1(5), 159–165. https://doi.org/10.11648/j.ijefm.20131003.15

Mutoko, M. C., Hein, L., & Shisanya, C. A. (2014). Farm diversity, resource use efficiency and sustainable land management in the western highlands of Kenya. Journal of Rural Studies, 36, 108–120. https://doi.org/10.1016/j.jrurstud.2014.07.006

NHPC. (2017). Volume I: Final main report. Kathmandu: Fruit Development Project, Nepal Horticulture Promotion Centre (NHPC). Retrieved from https://ncfd.gov.np/sites/default/files/2020-08/E0%A4%AB%E0%A4%A8%E0%A4%B2%E0%A4%AA%E0%A4%BF%E0%A4%A9%E0%A4%B8%E0%A4%BF%E0%A4%80%E0%A4%85%E0%A4%87%E0%A4%9A%E0%A4%A6%E0%A4%87.pdf. Accessed on 1 January 2021.

Pandey, A., Bista, D. R., Bhandari, T., Panta, H. K., Devkota, S., & Tejoda Moral, M. (2020). Profitability and resource-use efficiency of sugarcane production in Nawalparasi west district, Nepal. Cogent Food & Agriculture, 6(1), 185792. https://doi.org/10.1080/23311932.2020.185792

Pandey, G., Basnet, S., Pant, B., Bhattarai, K., Gyawali, B., & Tiwari, A. (2017). An analysis of vegetables and fruits production scenario in Nepal. Asian Research Journal of Agriculture, 6(3), 1–10. https://doi.org/10.9734/ARJA/2017/36442

PKF Nepal. (2019). Nepal taxaton 2019 edition. Kathmandu: PKF T.R. Upadhyo and Co. Retrieved from https://pkftrunco.com.np/uploads/publication/file/Taxation%20Nepal%20202019%2020190805043400.pdf. Accessed from 4 January 2021.

Ranjikitkar, S., Sujakhu, N. M., Merz, J., Kindt, R., Xu, J., Matin, M. A., Zomer, R. J., & Ali, M. (2016). Suitability analysis and projected climate change impact on banana and coffee production zones in Nepal. PloS One, 11(9), e0163916. https://doi.org/10.1371/journal.pone.0163916

Sakambo, S., Umesh, K. B., & Rangegowda, R. (2018). Resource use efficiency and externality associated with banana production in Karnataka, (India). International Association of Agricultural Economists (IAAE). Retrieved from https://ageconsearch.umn.edu/record/277222/. Accessed on 4 January, 2021

SAWTEE. (2016). A study of vegetable and fruit export from Eastern region of Nepal. South Asia Watch on Trade, Economics and Environment (SAWTEE). Kathmandu: Variety Printers. Retrieved from http://www.savette.org/publications/Research-Brief-6.pdf. Accessed on 4 January 2021.

Shrestha, A., Sapkota, B., Regmi, R., & Dhungana, S. M. (2019). Economics of production and marketing of banana in Chitwan district, Nepal. Azarian Journal of Agriculture, 5(1), 12–19 Retrieved from http://azarianjournals.in/wp-content/uploads/oja17120101.pdf. Accessed on 4 January, 2021

Thapa, M. B., & Dhimal, S. (2017). Horticulture development in Nepal: Prospects, challenges and strategies. Universal Journal of Agricultural Research, 5(3), 177–180. https://doi.org/10.13189/ujar.2017.050301

Tinzoara, W., Stoian, D., Ocimati, W., Kikulwe, E., ... Otieno, G. (2018). Challenges and opportunities for smallholders in banana value chains. Achieving Sustainable Cultivation of Bananas Volume 1, 65–90. doi:10.19109/uis.2017.0020.10

Yomone, T. (1997). Statistics: An introductory analysis (2nd edition). Harper and Row.
