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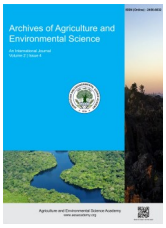

ORIGINAL RESEARCH ARTICLE

# Tomato production in Nawalparasi East district, Nepal: Socio-economic, marketing, institutional, and constraint analysis

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**ABSTRACT**

A survey was conducted to assess the socio-economics, marketing, institutional involvement and problems of the production of tomato in Nawalparasi East District, Nepal. Among the tomato farmers of Kawasoti Municipality - 17 and Madhyabindhu Municipality - 1, 94 farmers were selected for the survey. Data were collected through a household survey using a semi-structured questionnaire, and analyzed using Excel and IBM SPSS Statistics software. Various descriptive methods, like mean, standard deviation, and frequency, were used in the analysis of data and diagrams like bar graphs and charts for the visualization of the data. Cost, net return, gross return, and benefit-cost ratio were calculated to understand the economics of tomato production. The average cost of tomato production in the study site was NRs. 3,90,500.15 (2808.42 USD) per hectare. Human labour, fertilizer, and mulching were significant contributors to the cost of production of tomatoes. Similarly, net margin and benefit-cost ratio were found to be NRs. 127534.85 (917.21 USD) per hectare and 1.33. Producer → Wholesale Market → Retailer → Consumer was the most dominant, and 60 % of the farmers have received training for the production of tomatoes through different organizations. Also, 69 % of them were getting some kind of subsidy on seed, mulching, and irrigation facilities through different institutions. The major production and marketing problems were incidence of disease and pests, unavailability of quality seeds, high middleman margin, and price fluctuation. However, the study indicated that tomato production is a highly potential agricultural enterprise for the study area.



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## INTRODUCTION

Due to population growth, technological advancements, and rising purchasing power resulting from increased incomes and migrant remittances, there is a surge in vegetable demand (CASA Nepal Country Team, 2020). Vegetable farming in Nepal remains predominantly subsistence-based, and productivity has not increased at the same rate as production and cultivation areas have expanded, resulting in insufficient production to meet domestic demand (Adhikari & Pokharel, 2020). In the fiscal year of 2022/2023, Nepal imported vegetables, certain roots, and tubers worth 31.87 billion rupees (Department of Customs, 2023). Tomato (*Solanum lycopersicum* L.), from the family Solanaceae, has been widely cultivated in Nepal's tropical and subtropical regions (Bhandari *et al*., 2016). It is the third most produced vegetable after cauliflower and cabbage in Nepal (MoALD, 2023). In fiscal year 2022/23, tomato was cultivated in an area of 22911 hectares with a production of 422703 metric tonnes and a productivity of 18.45 metric tonnes/hectare in Nepal (MoALD, 2023). Open field cultivation during autumn and winter is common in Terai, inner Terai, and foothills, whereas cultivation inside plastic tunnels in the summer-rainy season in the hills is gaining popularity in Nepal (Ghimire *et al*., 2018). Nawalparasi East has huge potential and is an emerging hub for

tomato production. The area, production, and yield of tomatoes in Nawalparasi East in the fiscal year 2021/22 were 90 hectares, 1630 metric tonnes/, and 18.11 metric tonnes/hectares , respectively (MoALD, 2023). Tomato production is affected by various technological, marketing, biotic, and abiotic constraints, including poor irrigation, inadequate inputs and practices, limited access to quality seeds and markets, weak infrastructure and bargaining power, as well as pest, disease pressures, and competition from imports (Gautam *et al*., 2024). The incidence of the disease has increased due to climate change, and if heavy doses of pesticides hadn't been sprayed, the production would have declined heavily due to various climate-induced diseases such as late blight, black spots, leaf curl, and burning of plants (Bhandari *et al*., 2021). The post-harvest loss in tomatoes is the result of improper handling, packaging, grading, off-road situations, use of low-level technology, lack of basic equipment and facilities at collection centers, improper marketing, and lack of qualified workers (Maharjan & Dhakal, 2023). Tomato is mostly cultivated on leased land, and there isn't a strong land leasing policy that can secure long-term production. Along with this, the unavailability of loans and subsidies has hindered seasonal tomato production and investment requirements (Bhandari *et al*., 2016). Tomato marketing has become highly complex and difficult due to the presence of a large number of middlemen, and different types of physical, social, economic, and facilitating marketing functions and services (Koirala *et al*., 2022). There was a necessity to analyze the economic aspects of tomato production in Nawalparasi East district, which will facilitate the development of strategies aimed at enhancing the production, productivity, and profitability of this significant crop. The lack of farm-level data on vegetable production, marketing, institutional involvement and the economic aspects related to farmers' issues has led to hindrance in policy formation and addressing the needs of the farmers at the ground level. Therefore, there was a crucial need to undertake a thorough analysis of farm performance in vegetable production and marketing holistically to understand the influence of different components within the system on this sector. The objective of this study was to bridge this gap by offering valuable insights into the socio-economic condition of tomato farmers, marketing, institutional involvement, constraints, and production economics of tomato production, specifically in the Nawalparasi East district of Nepal. Furthermore, this study's outcomes would help expand tomato farming, emphasizing strategies to optimize production and efficiently allocate resources for optimal results.

## MATERIALS AND METHODS

### Study area

Nawalparasi East district is in the Terai region, which lies in the western part of the Gandaki Province of Nepal. Nawalparasi East lies at approximately 27.65° North latitude and 84.15° East longitude. The study was conducted in Madhyabindhu Municipality, Ward 1, and Kawasoti Municipality, Ward 17 of Nawalparasi East.

### Sampling procedure and techniques

A multistage sampling technique was used in this study. In the first stage, Nawalparasi East district was chosen purposively for the survey. The second stage involved selecting areas of Madhyabindu Municipality and Kawasoti Municipality, where most vegetable farmers are located. The third stage employed selecting wards Madhyabindu-1 and Kawasoti-17 with the highest tomato production for the study. In the final stage, tomato farmers were selected through a simple random sampling technique from those two wards. The sample size was calculated by using Raosoft software at a 10 % margin of error and a 95% confidence level. The survey was carried out among the 94 farmers, 49 respondent farmers from Madhyabindhu-1, and 45 farmers from Kawasoti-17.

### Data collection

Different sources of data and techniques of data collection were used to gather the information for the fulfilment of research objectives. Primary sources and relevant secondary sources of data were used. Quantitative as well as qualitative data were collected for the study. Farmers producing tomatoes in the study area were the primary source of information. A household survey using an interview schedule was the primary technique to obtain information regarding the cost of production, return, area coverage, mode of selling, and existing problems of production and marketing of tomatoes. Additionally, focus group discussions and key informant interviews were conducted to gather data from primary sources (Basnet, 2018; Kumar, 1989). A semi-structured questionnaire was developed to acquire the necessary data for the study. The field survey for data collection was done in May-June 2024. Reports, journal articles, newspaper articles, books, as well as publications from governmental bodies, non-governmental organizations, and international non-governmental organizations relevant to the study were used as sources of secondary information.

### Data analysis

Microsoft Excel 2019 and IBM SPSS Statistics 25 were used for data entry, cleansing, and analysis. Different parameters were analyzed using descriptive statistical methods like mean, standard deviation, frequency, and percentage. Additionally, some of the data were visualized using bar graphs and pie charts. The total cost incurred for tomato production by the respondent farmers was estimated by adding both fixed and variable costs as below:

Total cost = Total Fixed Cost + Total Variable Cost

Net return (Profit) is calculated as the difference between gross return (GR) earned from production and total cost (TC) incurred during production.

Net return (NR) = Gross Return (GR) – Total Cost (TC)

Where, GR = Gross return = P * Q; P = Per kg price of tomato (in NRs.); Q = Quantity of tomato produced (in kg); TC = Total Cost of production (in NRs.)

The ratio between the gross return (GR) and total cost (TC) of tomato production was taken to calculate the benefit-cost ratio.

Benefit-Cost Ratio (BCR) = Gross return (GR) / Total cost (TC)

### Problems ranking of tomato production and marketing

When developing the index, qualitative data will be taken into account. Farmers' perceptions of the extent of production will be analyzed through the computation of weighted indexes based on response frequencies. The severity of problems was rated on a scale from 1 to 5, with corresponding weights assigned to each level: 5 (most severe) carried a weight of 1.00, 4 (highly severe) had a weight of 0.80, 3 (moderately severe) was given 0.60, 2 (less severe) was assigned 0.40, and 1 (least severe) had a weight of 0.20. This weighting system was used to quantify the severity of each problem for analysis. Similar five-point ratings was used to rank farmers' views on a range of production and marketing-related topics. To arrive at reliable conclusions, the priority index was computed using weighted average methods. The following formula was used to calculate the index of importance:

$$I_{imp} = \frac{\sum S_i f_i}{N}$$

where, $I_{imp}$ = index of importance; $\sum$ = summation; $S_i$ = $I^{th}$ scale value; $f_i$ = frequency of the $i^{th}$ importance given by the respondents; $N$ = total number of respondents

The methods adopted from Koirala *et al.* (2022), Kunwar & Maharjan (2019), and Paudel & Adhikari (2018) were used for the analysis of data for this commodity.

## RESULTS AND DISCUSSION

### Socio-economic status of the study site

In the study area of Nawalparasi East, there were 24 females (25.5%) and 70 males (74.5%) household heads in 94 respondents' families (Table 1). The age distribution of the household heads represents that the largest proportion falls within the 50-60 years' age group, accounting for 36 individuals (38.3%), followed by the 40-50 years' age group with 30 individuals (31.9%), and the 60-70 years' age group with 13 individuals (13.8%). The 30-40 age group includes 9 individuals (9.6%), the 70–80 years' group consists of 5 individuals (5.3%), and the 20-30 years' group includes only 1 individual (1.1%). The study found that 37 (39.4%) household heads completed their primary level of education, 29 (30.9%) completed the secondary level, 1 (1.1%) completed the higher education, 10 (10.6%) were literate but didn't attend school, and 17 (18.1%) were illiterate. The study concluded that 91 (96.8 %) respondents' families were Hindu, and only 3 (3.6%) of them were Christian, which clearly shows the majority of the Hindu population in the study site. There were 47 Janjatis (50.0%), 41 Chhetris (43.6%), and 6 Brahmins (6.4%) out of 94 respondents (Table 1). The average annual income from agricultural, job, business, remittance, and pension was NRs. 199418.4692, NRs. 43382.98, NRs. 26063.83, NRs. 400425.53 and NRs. 30186.17, respectively, which shows that the average annual income from remittance was greater than agriculture (Table 2). Similar observations on socio-economic characteristics were observed by Pandey *et al.* (2024) while conducting a survey in Nawalparasi East.

**Table 1.** Socio-demographic characteristics of the farmers of study site.

| **Gender of the household head** | Frequency | Percent |
|---|---|---|
| Female | 24 | 25.5 |
| Male | 70 | 74.5 |
| **Age of the household head (Years)** | | |
| 20-30 | 1 | 1.1 |
| 30-40 | 9 | 9.6 |
| 40-50 | 30 | 31.9 |
| 50-60 | 36 | 38.3 |
| 60-70 | 13 | 13.8 |
| 70-80 | 5 | 5.3 |
| **Education of the household head** | | |
| Primary level | 37 | 39.4 |
| Secondary level | 29 | 30.9 |
| Illiterate | 17 | 18.1 |
| Literate but didn't attend school | 10 | 10.6 |
| Higher Education | 1 | 1.1 |
| **Religion of the household** | | |
| Hindu | 91 | 96.8 |
| Christian | 3 | 3.2 |
| **Ethnicity of the household** | | |
| Janjati | 47 | 50.0 |
| Chhetri | 41 | 43.6 |
| Brahmin | 6 | 6.4 |

**Table 2.** Status of income, land holding status, experience of farming of farmers in the study site.

| Sources of income | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|
| Agriculture | 25000.00 | 630000.00 | 199418.4692 | 133280.30320 |
| Job | 0 | 600000 | 43382.98 | 121063.753 |
| Business | 0 | 500000 | 26063.83 | 98845.139 |
| Remittance | 0 | 5000000 | 400425.53 | 729801.733 |
| Pension | 0 | 360000 | 30186.17 | 80600.901 |
| **Land holding status (Hectare)** | | | | |
| Owned Agricultural land | 0 | 2.03 | 0.3900 | 0.39719 |
| Rented Agricultural Land | 0 | 1.35 | 0.2003 | 0.29006 |
| Tomato Cultivated Owned Land | 0 | 0.51 | 0.0910 | 0.09583 |
| Tomato Cultivated Rented Land | 0 | 0.24 | 0.0140 | 0.04032 |
| **Experience** | | | | |
| Experience in Farming | 2 | 40 | 15.05 | 8.159 |
| Experience in Tomato Farming | 1 | 30 | 5.63 | 4.663 |

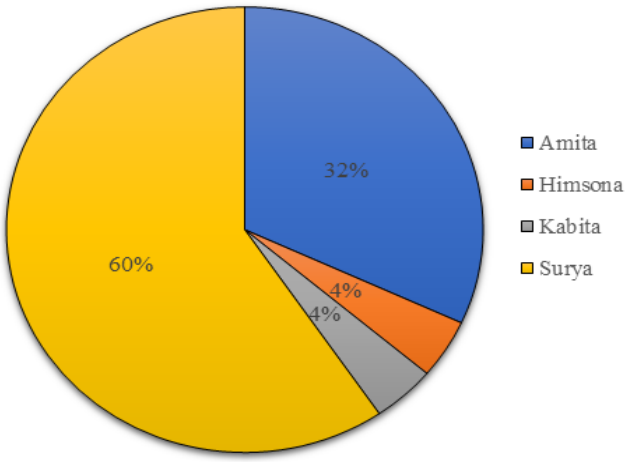


**Figure 1.** *Variety of tomatoes grown in the study site.*

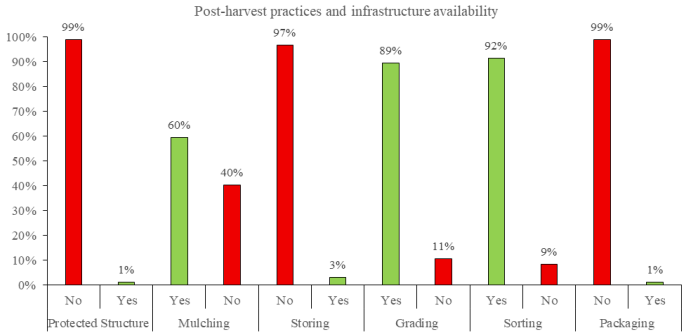


**Figure 2.** *Infrastructure availability and post-harvest practices among farmers.*

## Status of tomato farming

The farmers of the study site own 0.39 hectares of land, whereas 0.2 hectares of land is rented by the farmers who don't have land in their name (Table 2). The tomato is cultivated in 0.091 hectares of owned land and 0.01 hectares of rented land in that region. The farmers of the study site have 15.05 years of experience in farming and 5.63 years of experience in tomato farming on average. It was found that the Surya variety of tomatoes is cultivated by 60% of the farmers, followed by Amita (32%), Himsona (4%), and Kabita (4%) (Figure 1). Pandey *et al.* (2024) also noted the prevalence of these varieties of tomatoes in the study site. In the study site, 99% respondents do not practice protected structures in tomato production (Figure 2). Mulching was practiced by 60% of the respondents, whereas 40% didn't practice mulching. Grading was done by 89% of the farmers, and sorting was done by 92% of the farmers of the study site. 97 % of respondents didn't practice storing, and 99 % of the farmers didn't practice packaging of tomatoes after harvesting. The 50 % of the farmers obtain seed from government organizations like the Prime Minister Agriculture Modernization Project's Project Implementation Unit, Agriculture Knowledge Centers and Municipal offices (Figure 3). Remaining farmers obtain seed from agro-vet shops (28%), Cooperatives (20%) and Nongovernment Organization/International Nongovernment Organization (2%). Likewise, farmers obtain chemical fertilizer mostly from agro-vet shops (50%), followed by cooperatives (43%), and government organizations (7%). 50% of the respondents produce manure on their own home, 40% buy it from neighbours, 5% from cooperatives and 4% from the agro-vet shops (Figure 3).

## Market analysis

Producers, traders, wholesale markets, collection centers, retailers, and consumers were stakeholders involved in the marketing of tomatoes in Nawalparasi East. Similar actors were found to be involved in the marketing of tomato production by previous studies (Gautam *et al.*, 2024; Koirala *et al.*, 2022; Kunwar & Maharjan, 2019; S. Paudel & K.C., 2023) The most common marketing channel involved in tomato marketing was Producer → Wholesale Market → Retail → Consumer, with 57 responses, which account for 50.9% of responses and 60.6% of cases. After that, Producer → Collection Centers → Traders → Retailer → Consumer is involved in the marketing of tomato, with 32 (28.6%) responses accounting for 34.0% of cases (Table 3). Both Producer → Consumer and Producer → Trader → Retailer → Consumer marketing channels account for 8.0% of responses and 9.6% of cases. Lastly, Producer → Retailer → Consumer represents 4.5% of responses and 5.3% of the cases. The farmers obtain their information about the market primarily from villagers, accounting for 37.8% of responses and 57.4% of the cases, followed by government organizations with 29.8% of the cases and 19.6% of the responses. Both nearby markets and progressive farmers contribute equally to the information network, each accounting for 18.9% of the responses and 28.7% of the cases. The information communication technology only holds 4.9% of the responses and 7.4% of the cases, being the lowest contributor in the source of market information (Table 3).

**Table 3.** Marketing channels and market information of tomato production in the study site.

| Marketing channels | Responses | | Percent of Cases |
|---|---|---|---|
| | N | Percent | |
| Producer → Wholesale Market → Retailer →Consumer | 57 | 50.9% | 60.6% |
| Producer → Collection Centers → Traders – Retailer → Consumer | 32 | 28.6% | 34.0% |
| Producer → Consumer | 9 | 8.0% | 9.6% |
| Producer → Trader → Retailer → Consumer | 9 | 8.0% | 9.6% |
| Producer → Retailer → Consumer | 5 | 4.5% | 5.3% |
| **Total** | **112** | **100.0%** | **119.1%** |
| **Source of market information** | **Responses** | | **Percent of Cases** |
| | **N** | **Percent** | |
| Villagers | 54 | 37.8% | 57.4% |
| Government Organization | 28 | 19.6% | 29.8% |
| Information Communication Technology | 7 | 4.9% | 7.4% |
| Nearby Market | 27 | 18.9% | 28.7% |
| Progressive Farmers | 27 | 18.9% | 28.7% |
| **Total** | **143** | **100.0%** | **152.1%** |

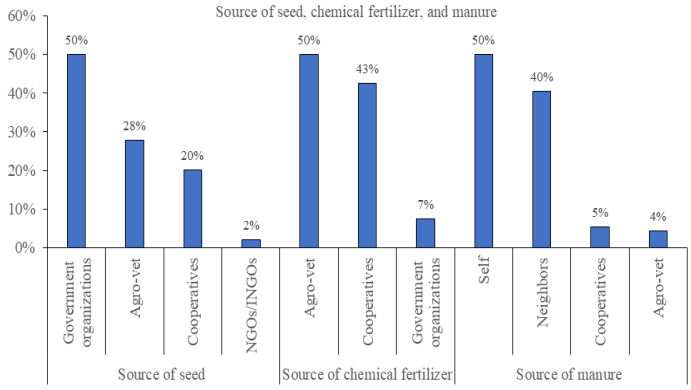


**Figure 3.** *Source of seed, chemical fertilizer, and manure.*

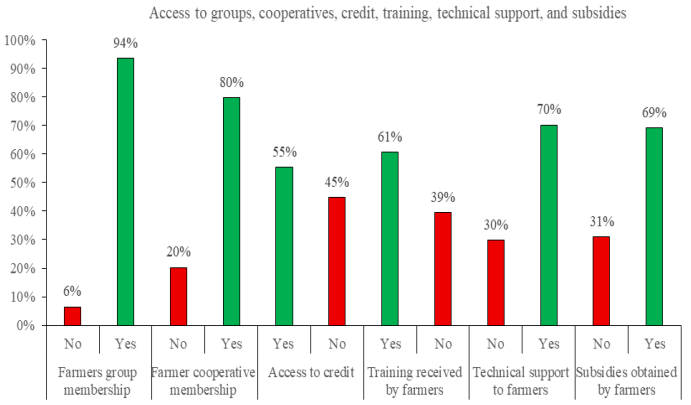


**Figure 4.** *Farmer's access to groups, cooperatives, credit, training, technical support, and subsidies.*

## Institutional involvement in tomato farming

Various institutions like farmers' groups, cooperatives, banks, microcredit, government organizations, non-government organization, etc. were found to be involved in the tomato production in Nawalparasi East. 94% of farmers had farmer group membership, and 80 (75) of farmers had farmer cooperative membership (Figure 4). A similar observation on the cooperative membership was observed by Pandey *et al.* (2024) in their research. 55% of the farmers have access to credit from local people, cooperative, bank and microcredit for tomato production. Farmers get credit mostly from the cooperative, accounting for 52.2% of responses and 90.4% of cases, followed by banks with 28.9% of responses and 50 % of cases (Table 4). Likewise, Microcredit also provide credit to the farmers, accounting for 16.7% of the responses and 28.8% of cases. Farmers get loans least from local people of the village, with 2.2% of responses, and 3.8% of cases. 61 % of the farmers had received training on tomato farming, whereas 39% of the farmers hadn't received training. Farmers received training mostly from government organization, with 70.2% of cases and 54.1% of responses, followed by non-government organization with 36.8% of cases and 28.4 % of the responses, and from cooperatives, accounting for 22.8% of the cases and 17.6% of the responses. In the study site, 70% of the farmers have obtained technical support in tomato farming, whereas 30% hadn't. Government organization was found to be leading in providing technical support to the farmer, with 82.3% of cases and 73.9% of responses, followed by a non-government organization with 24.2% of cases and 21.7% of responses and from cooperatives, accounting for 4.5% of cases and 4.3% of responses. It was found that 69 % of the farmers had received subsidies, whereas 31% hadn't obtained any kind of subsidies (Figure 4). Subsidies were mostly available through government organization, accounting for 92.3% of cases and 88.2% of responses, followed by non-government organization with 10.8% of cases and 10.3% of responses and from cooperatives, accounting for 1.5% of cases and 1.5% of responses (Table 4).

## Problems in the production and marketing of tomatoes

In the production of tomato in Nawalparsi East, it was found that the disease and insect pest damage were the most problematic in the tomato production, with the highest index score (0.87) (Figure 5). Lack improved farming practices (index 0.78) ranks second, showing gap in modern, effective techniques among tomato growers, followed by unavailability of quality seeds (index 0.73) at third and unavailability of pesticide and fertilizer at right time (index 0.42) at fourth, whereas lack of irrigation has the lowest index (0.25), suggesting lower concern for fewer farmers compared to others. Pandey *et al.* (2024) also found insect pest damage and disease to be a major problem in tomato production. Not only in Nawalparasi East, disease and pest damage were major problems in the tomato production in many regions of Nepal (Gautam *et al.*, 2024; Kunwar & Maharjan, 2019; Paudel & Adhikari, 2018; Wagle *et al.*, 2024). In

**Table 4.** Status of farmers leveraging from different institutions in tomato production in the study site.

| Sources of credit | Responses | | Percent of Cases |
|---|---|---|---|
| | N | Percent | |
| Local people | 2 | 2.2% | 3.8% |
| Cooperative | 47 | 52.2% | 90.4% |
| Bank | 26 | 28.9% | 50.0% |
| Microcredit | 15 | 16.7% | 28.8% |
| **Total** | **90** | **100.0%** | **173.1%** |
| **Training Providing Institution** | **Responses** | | **Percent of Cases** |
| | **N** | **Percent** | |
| Government organization | 40 | 54.1% | 70.2% |
| Cooperatives | 13 | 17.6% | 22.8% |
| Non-governmental organization | 21 | 28.4% | 36.8% |
| **Total** | **74** | **100.0%** | **129.8%** |
| **Technical Support Providing Institution** | **Responses** | | **Percent of Cases** |
| | **N** | **Percent** | |
| Government organization | 51 | 73.9% | 82.3% |
| Non-governmental organization | 15 | 21.7% | 24.2% |
| Cooperatives | 3 | 4.3% | 4.8% |
| **Total** | **69** | **100.0%** | **111.3%** |
| **Subsidies Providing Institution** | **Responses** | | **Percent of Cases** |
| | **N** | **Percent** | |
| Government organization | 60 | 88.2% | 92.3% |
| Non-governmental organization | 7 | 10.3% | 10.8% |
| Cooperatives | 1 | 1.5% | 1.5% |
| **Total** | **68** | **100.0%** | **104.6%** |

**Table 5.** Economic indicators of tomato production in the Nawalparasi East.

| Particulars | Amount |
|---|---|
| **Variable Costs** | |
| Machinery Cost (NRs/Ha) | 20280.07 (5.19%) |
| Seed Cost (NRs/Ha) | 25274.3 (6.47%) |
| Mulching (NRs/Ha) | 38917.96 (9.97%) |
| **Labor Cost** | |
| Nursery Preparation (NRs/Ha) | 5327.73 (1.36%) |
| Field Preparation (NRs/Ha) | 16271.13 (4.17%) |
| Planting (NRs/Ha) | 17665.81 (4.52%) |
| Weeding (NRs/Ha) | 26332.67 (6.74%) |
| Training (NRs/Ha) | 20560.13 (5.27%) |
| Harvesting (NRs/Ha) | 44515.59 (11.40%) |
| **Fertilizer** | |
| **Organic fertilizer** | |
| Farm Yard Manure (NRs/Ha) | 43955.56 (11.26%) |
| Poultry Manure (NRs/Ha) | 18479.97 (4.73%) |
| **Chemical fertilizer** | |
| Urea (NRs/Ha) | 3816.9 (0.98%) |
| DAP (NRs/Ha) | 9363.07 (2.40%) |
| Potash (NRs/Ha) | 1362.33 (0.35%) |
| **Micronutrient (NRs/Ha)** | **8195.00 (2.10%)** |
| Plant Protection (NRs/Ha) | 33479.14 (8.57%) |
| Hormone (NRs/Ha) | 22308.07 (5.71%) |
| Total variable cost (NRs/Ha) | 356105.4 (91.19%) |
| Total fixed cost (NRs/Ha) | 34394.61 (8.81%) |
| Total cost (NRs/Ha) | 390500.15 (100%) |
| Average Production per hectare (kg) | 17015 |
| Average post-harvest loss per hectare (kg) | 2214 |
| Total amount of tomatoes sold per hectare (kg) | 14801 |
| Average price per kg (NRs) | 35 |
| Gross revenue (NRs) | 518035 |
| Net margin (NRs) | 127534.85 |
| Benefit cost ratio | 1.33 |

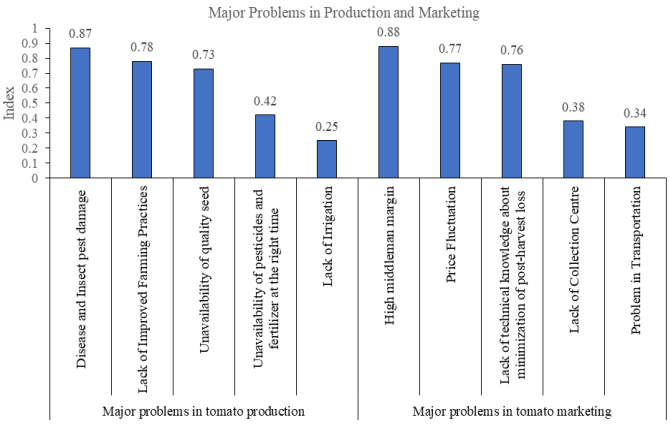


**Figure 5.** *Ranking of problems in tomato production and marketing in the study site.*

the marketing of tomatoes, it was found that a high middleman margin was the problem faced by farmers with the highest index score (0.88), followed by price fluctuation at the second rank with an index score of 0.77. Koirala *et al.* (2022) also reported that the presence of a middleman affected the marketing of the tomatoes. Lack of technical knowledge about minimization of post-harvest loss was ranked third, and lack of collection center ranked fourth with index scores of 0.76 and 0.34, respectively. The lowest index score (0.34) was obtained for the problem in transportation, indicating that marketing in tomato production was less of a concern than others (Figure 5).

## Economic analysis

Cost of production includes variable costs and fixed costs. The variable cost includes cost of machinery, seed, mulching, labor cost during nursery preparation, field preparation, planting, weeding, training, and harvesting, fertilizer cost of organic fertilizer like farm yard and poultry manure and chemical fertilizer

like urea, diammonium phosphate (DAP), potash, micronutrient, plant protection, hormone. The total variable cost contributed NRs. 3,56,105.4 (91.19%) to the total cost of tomato production in Nawalparasi East, whereas total fixed cost contributed NRs. 34,394.61 (8.81 %) (Table 5). It was found that the labour cost of harvesting contributes mostly to the total variable cost by NRs. 44,515.59 (11.40%), followed by farm yard manure with NRs. 43,955.56 (11.26%) and the cost of mulching, accounting for NRs. 38,917.96 (9.97%). Then, plant protection contributes by NRs 33,479.14 (8.57%) and labour cost of weeding by NRs. 26,332.67 (6.74%). Likewise, the cost of seed and hormone accounts for NRs. 25274.3 (6.47%) and NRs. 22308.07 (5.71%), respectively, in variable cost. Following this, the labour cost of training and the machinery cost contributed NRs. 20,560.13 (5.27%) and NRs. 20,280.07 (5.19%), respectively, while poultry manure accounted for NRs. 18,479.97 (4.73%). The labour cost of planting amounted to NRs. 17,665.81 (4.52%), and field preparation cost NRs. 16,271.13 (4.17%). Similarly, micronutrient application contributed to NRs. 8,195.00 (2.10%), and among the chemical fertilizers, DAP accounted for the NRs. 9,363.07 (2.40%), urea NRs. 3,816.90 (0.98%), and potash had the lowest share with NRs. 1,362.33 (0.35%). Additionally, nursery preparation required NRs. 5,327.73 (1.36%) of the total variable cost (Table 5). Similar findings of labour cost and farmyard contributing more to the variable cost of tomato production in Nawalparasi district were reported by Gaire & Dahal (2021) and Pandey *et al*. (2024). The average production of tomatoes per hectare was 17,015 kg, and the average post-harvest loss was 2,214 kg/hectare. The total amount of tomatoes sold was found to be 14,801 kg per hectare, and it was sold for an average price of NRs. 35 per kg (Table 5). The gross revenue, net margin, and benefit cost ratio of tomato production were NRs. 518035, NRs. 127534.85 and 1.33, respectively.

## Conclusion

In conclusion, Nawalparasi East contains both challenges and opportunities for tomato production. Proper insect pest and disease management should be followed in tomato production for better outcomes of production. Most tomato producers don't practice farming in protective structures, even though tomato production greatly increases, suggesting a lack of investment in innovative farming techniques. Information and communication technology plays a minimal role in the transfer of information about the market, which slows down the marketing of tomatoes. Most of the farmers are members of farmer groups and cooperatives; therefore, government organizations should collaborate with these organizations for better delivery of programs and training for tomato production. Inclusion of technology and machinery for the decrease of labour cost and market creation, storage and post-harvest management, along with better policy and regulations should be a major focus to control the middleman in the marketing of tomato. Increasing accessibility of technology, machinery, fertilizer, plant protection, seed material, training, and extension services through institutional involvement will increase the productivity of tomato production, which is a must at the present condition. Market study, analysis, and information should be gathered and provided feasibly to the farmers, and all the stakeholders should work collaboratively to minimize price fluctuation and middlemen in the markets. All the participants present in the tomato production should come together to solve the prevalent problems and generate solutions to promote economic resilience within this area.

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## DECLARATIONS

### Authors contribution

Conceptualization: P.K.; Methodology: P.K. and A.U.; Software and validation: P.K. and A.U.; Formal analysis: P.K. and A.U.; Investigation: P.K. and A.U.; Resources: P.K.; Data curation: P.K. and A.U.; Writing—original draft preparation: P.K. and A.U.; Writing—review and editing: P.K. and A.U.; Visualization: P.K. and A.U.; Supervision: P.K.; Project administration: P.K.; Funding acquisition: P.K. All authors have read and agreed to the published version of the manuscript.

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