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Production Economics, Marketing Efficiency, and Value Chain Analysis of Potato (*Solanum tuberosum* L.) in Dadeldhura District, Nepal

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ABSTRACT

Potato (*Solanum tuberosum* L.) is an important staple and cash crop in Nepal, yet limited empirical evidence exists on its production economics, marketing efficiency, and value chain performance in Far-Western hill districts. This study analyzed the profitability, marketing efficiency, and value chain dynamics of potato production in Dadeldhura district, Nepal, using primary data collected in 2018 from 60 potato-growing households and key market actors through semi-structured questionnaires. Cost–benefit analysis, market margin analysis, Cobb–Douglas production function, and value chain analysis were employed to assess production and marketing performance. The average potato productivity was 19.53 t ha^{-1}, while the total production cost and gross return were NRs 311,859.53 ha^{-1} and NRs 661,142.20 ha^{-1}, respectively, resulting in a benefit–cost ratio of 2.12. Moreover, labor (β = 0.403), farmyard manure (β = 0.406), and chemical fertilizers (β = 0.575) had significant positive effects on potato production. Similarly, four marketing channels were identified, among which the Producers–Collectors–Wholesalers–Retailers–Consumers channel handled 59.74% of total potato sales but recorded the lowest producer's share (74.8%) and the highest market margin (NRs 11.32 kg^{-1}). In contrast, direct producer-to-consumer marketing provided a 100% producer's share and the highest marketing efficiency. Furthermore, major constraints included price fluctuation, lack of mechanization, pest and disease incidence, inadequate storage facilities, and high middlemen margins. The findings highlight the importance of improving market coordination, strengthening producer organizations, expanding storage infrastructure, and promoting direct marketing systems to enhance producer returns and support sustainable potato commercialization in Nepal.

INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the world's most important food crops and ranks fourth after rice, wheat, and maize in terms of global food importance (Knapp & Peralta, 2016; Reddy *et al.,* 2018; FAO, 2024). The crop is cultivated in more than 150 countries and contributes significantly to food security, nutrition, and rural livelihoods, particularly in developing countries (Dongyu, 2022; Çalışkan *et al.,* 2023). Globally, potato is cultivated on about 16.8 million ha with an annual production of nearly 389 million t, while Asia contributes almost half of total global production (FAO, 2024; Wang *et al.,* 2023). Besides being an important source of carbohydrates, potato also supplies proteins, dietary fiber, potassium, vitamins, and antioxidants essential for human health (Beals, 2019; Khalid *et al.,* 2020; Arnarson, 2023). Owing to its contribution to food security and poverty reduction, the United Nations declared 2008 as the International Year of the Potato (International Potato Center, 2010).

In Nepal, potato is an important staple and cash crop cultivated across diverse agroecological regions ranging from 65 to 4,000 m above sea level (Bajracharya & Sapkota, 2017). The crop plays a major role in household food security, income generation, and employment, particularly in hill and mountain districts where cereal productivity is relatively low (Sapkota & Bajracharya, 2018; Gairhe *et al.,* 2023). In 2020/21, potato occupied about 198,788 ha with a total production of 3.41 million t and an average productivity of 17.20 t ha^{-1} (MoALD, 2022). Potato contributes about 6.35% to the agricultural gross domestic product of Nepal and ranks first in productivity among major food crops (AITC, 2021; Gairhe *et al.,* 2017). The average per capita potato consumption in Nepal reached 90.2 kg year^{-1}, and demand has continued to increase due to population growth and changing food preferences (FAOSTAT, 2023). Despite its importance, national productivity remains lower than the productivity achieved in many potato-producing countries, indicating substantial scope for improvement through better production and marketing system. Several studies in Nepal reported that potato farmers face serious production and marketing constraints that limit farm profitability and market competitiveness. Limited access to quality seed tubers, increasing labor costs, poor storage facilities, pest and disease incidence, and inadequate extension support have been identified as major production-related problems (Gairhe *et al.,* 2017; Karki *et al.,* 2023). Similarly, weak market infrastructure, high transportation costs, price instability, lack of organized collection systems, and the dominance of intermediaries reduce producers'

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share in the consumer price and weaken value chain efficiency (MoALD, 2022; Karki *et al.,* 2023). Previous studies also indicated that post-harvest losses and market inefficiencies are more severe in remote hill districts because of limited road access and poor coordination among value chain actors (Gairhe *et al.,* 2017). However, district-level empirical evidence quantifying production economics, marketing margins, producer's share, and value chain performance remains limited, particularly in Far-Western Nepal.

Dadeldhura district possesses favorable agro-climatic conditions for potato cultivation and has recently experienced increasing commercialization due to expanding road connectivity and market access (Poudel *et al.,* 2025). To promote agricultural commercialization, the Government of Nepal implemented the Prime Minister Agriculture Modernization Project (PMAMP) in 2016, which focuses on productivity enhancement, commercialization, and value chain development of priority commodities through pocket, block, zone, and super zone approaches. Under the revised federal agricultural structure, Dadeldhura district has been designated as a potato super zone because of its production potential and market importance. According to MoALD (2023/24), potato was cultivated on about 1,550 ha in the district with a production of 30,830 t and productivity of 19.89 t ha^{-1}, which is higher than the national average productivity. Despite these opportunities and policy interventions, limited empirical information exists regarding the profitability of potato production, market efficiency, value chain coordination, and producer returns in the district.

Therefore, this study was conducted under the hypothesis that potato cultivation in Dadeldhura district is economically profitable; however, inefficient marketing systems and weak coordination among value chain actors reduce producers' returns. The main objective of the study was to analyze the production economics and market dynamics of potato cultivation in Dadeldhura district of Nepal. Specifically, the study aimed to (i) estimate the costs and returns of potato production, (ii) identify major marketing channels and value chain actors, (iii) analyze market margins and producer's share, and (iv) assess major production and marketing constraints affecting potato producers.

MATERIALS AND METHODS

Study Site

The study was conducted in Ganyapdhura Rural Municipality and Amargadhi Municipality of Dadeldhura District, Sudurpashchim Province, Nepal. These municipalities were purposively selected because they represent the major potato-producing command areas of the district under the Potato Super Zone program. Dadeldhura district lies between 29°05' to 29°29' N latitude and 80°15' to 80°55' E longitude. The district is characterized by a mid-hill mountainous landscape with favorable agro-climatic conditions for potato cultivation, including cool temperatures, well-drained soils, and suitable rainfall distribution. Potato is one of the major cash crops of the district and contributes substantially to household income and local market supply. The district has been included under the Prime Minister Agriculture Modernization Project (PMAMP) as a Potato Super Zone to promote commercialization, productivity enhancement, and value chain development (PMAMP, 2022). The average potato productivity of the district is estimated at 19.89 t ha^{-1}, with a cultivated area of approximately 1,550 ha and total production of 30,830 metric tons (MoALD, 2023/24).

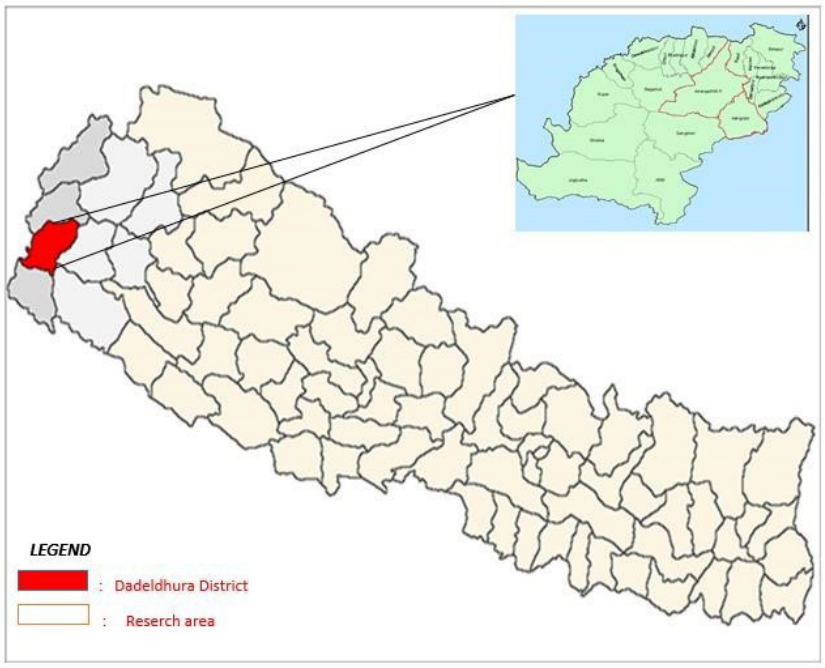

Figure 1: Geographic location of the study area in Dadeldhura district, Nepal, 2018

Sampling Procedure and Sample Size

A simple random sampling technique was used to select potato-growing households. Primary information related to production economics, marketing practices, and constraints was collected from farmers with at least one years of experience in potato cultivation. In total, 60 potato-growing households were selected, along with key market actors including wholesalers, collectors, and retailers. The distribution of respondents by municipality is presented in Table 1.

Table 1: Marketing actors involved in the potato value chain in Dadeldhura district, 2018

Research area	Farmers (No.)	Wholesalers (No.)	Collectors (No.)	Retailers (No.)
Ganyapdhura Rural Municipality	30	1	3	5
Amargadhi Municipality	30	1	2	3
Total	60	2	5	8

Source: Field survey, 2018

Data Collection

The study utilized both primary and secondary data. Primary data were collected in 2018 through household surveys, telephone interviews, and direct field observations using a pre-tested semi-structured questionnaire. The questionnaire was pre-tested with 20 respondents from nearby rural municipalities to ensure reliability and clarity. Secondary data on potato area, production, and production trends were obtained from published reports of the Agriculture Knowledge Centre, Dadeldhura; PMAMP Potato Super Zone Office; Ministry of Agriculture and Livestock Development (MOALD); Department of Agriculture (DOA); Central Bureau of Statistics (CBS); and the National Potato Development Program.

Data Analysis

Collected data were coded and entered into Microsoft Excel for analysis. Descriptive statistics were used to analyze the socio-economic characteristics of farm households. Mean values were calculated using the simple arithmetic mean. Cost–benefit analysis was employed to estimate production costs, returns, and profitability.

Cost of Potato Production

Only variable costs were considered in the estimation of production costs per hectare. These included costs of seed tubers, organic manure, synthetic fertilizers, seed treatment, labor for various farm operations, pest and disease management, and packaging. Labor costs were converted into man-days to estimate the actual cost of production per unit output.

Market Channel, Market Margin, and Producer's Share

Marketing channels were identified based on the flow of potatoes from producers to final consumers.

Gross Marketing Margin (GMM)

Gross Marketing margin is the difference between the retailer's price and the price received by the producer for a unit of product. It is calculated by using the formula given by Abad *et al.* (2024), and Bhandari *et al.* (2021):

"Market margin=Retail Price-Farm gate price" (1)

Net Marketing Margin (NMM)

The net marketing margin measures the actual return retained by intermediaries after subtracting marketing costs such as transportation, handling, packaging, storage, and losses as given by Laorden *et al.,* 2011.

$$\text{"NMM"} = \text{"GMM"} - C_m \quad (2)$$

where

Cm= total marketing cost incurred by intermediaries per kg of potato (NRs kg^{-1})

Marketing Efficiency (ME)

Marketing efficiency was calculated by using Shepherd's Index, which evaluates how efficiently marketing services are delivered relative to their cost. A more effective marketing system is indicated by a higher index value. Marketing efficiency was calculated by using the given formula by Abad *et al.* (2024) and Dastagiri *et al.* (2013):

$$\text{"ME"} = V/C_m \quad (3)$$

where

V= value of goods sold at retail level (NRs kg^{-1})

Cm= total marketing cost (NRs kg^{-1})

In channels where no intermediaries were involved (direct producer-to-consumer sales), marketing costs were zero, resulting in maximum marketing efficiency.

Producers Share

The producer's share is defined as the amount received by the producer expressed as a percentage of the retail price, and is calculated by using Khazaal & Rahim (2025):

Producers share= (Farm gate price /Retailer price)x100 (4)

Econometric Model: Cobb–Douglas Production Function

A Cobb–Douglas production function was used on farm-level data to analyze the relationship between potato yield and key production inputs. Since all 60 observations have positive values, output and input were used for logarithmic transformation.

Potato production was shown as a function of land usage, labor, organic manure, and chemical fertilizer inputs. The Cobb–Douglas functional form was chosen due to its capacity to provide direct estimates of output elasticities and facilitate the evaluation of returns to scale, as given by

Wassihun *et al.* (2019) and Sharma Wagle (2017).
The model is specified as:

$$\ln(Y_i) = \beta_0 + \beta_1 \ln(\text{Land}_i) + \beta_2 \ln(\text{Labor}_i) + \beta_3 \ln(\text{FYM}_i) + \beta_4 \ln(\text{Fertilizer}_i) + \varepsilon_i \quad (5)$$

where,
Y_i denotes potato output (kg) of the ith farm
Land_i is land under potato cultivation (ha)
Labor_i represents labor use (man-days)
FYM_i denotes farmyard manure applied (kg)
Fertilizer_i is total chemical fertilizer use (kg), computed as the sum of urea, DAP, and potash.
The error term ε_i is unobserved factors affecting production. All variables were transformed into natural logarithms, which enables the estimated coefficients to be interpreted as output elasticities. The model was estimated using ordinary least squares (OLS). Returns to scale were assessed by aggregating the predicted input elasticities.

Benefit Cost Ratio (BCR)
Profitability of potato production was assessed using the benefit–cost ratio (BCR), calculated as the ratio of gross return to total variable cost, following Bajracharya and Sapkota (2017) and Karki *et al.* (2023).

$$B/C = \text{Gross return}/\text{Total variable cost} \quad (6)$$

Problems Analysis
Problems are analyzed through preference ranking, in which items are ranked or prioritized in relation to other similar items based on their level of preference. Ranking is carried out by calculating the weighted indices of importance of problems as reported by farmers (Khanal *et al.,* 2025; Nepal *et al.,* 2023). The priority index is calculated as:

$$\text{Priority index/Index of Importance (Iimp)} = (\sum(S_i \times F_i))/N \quad (7)$$

Where,
F_i= Frequency of ith scale
S_i= Scale value at ith priority (I=1 to 5)
N= Total number of respondents

Value Chain Analysis of Potato
Value chain analysis was conducted to identify key actors and activities involved in the flow of potatoes from producers to consumers (Kaplinsky & Morris, 2001).

RESULTS AND DISCUSSION

Socio-demographic characteristics of farm households
Among the 60 surveyed households, male-headed households dominated (78.33%) (Table 2). Literacy among respondents was 60%. Brahmin (48.33%) and Chhetri (35.00%) households constituted the majority of respondents, while Dalit (11.67%) and Janajati (5.00%) representation was relatively low. Agriculture was the main occupation for 78.33% of households, followed by business (10.00%) and public service (6.67%). Regarding production practices, 71.67% of farmers practiced sole cropping, while 15.00% practiced mixed cropping. Most farmers (73.33%) had received training on potato production, and the commonly cultivated varieties were Desire and Cardinal. Irrigation facilities were used by 79.02% of farmers, while the remaining relied on rainfall. The average age of household head was 38.06 years (SD =

Table 2: Socio-demographic characteristics of sampled potato-growing households in Dadeldhura district, Nepal, 2018 (n = 60)

Variable	Category	Frequency (n)	Percentage (%)
Gender of household head	Male	47	78.33
	Female	13	21.67
Education status	Literate	36	60
	Illiterate	24	40
Ethnicity	Brahmin	29	48.33
	Chhetri	21	35
	Janajati	3	5
	Dalit	7	11.67
Main occupation	Agriculture	47	78.33
	Business	6	10
	Public service	4	6.67
	Others	3	5
Potato cultivation practice	Sole cropping	43	71.67
	Mixed cropping	9	15
	Both	8	13.33
Training status	Received training	44	73.33
	Not received	16	26.67

Table 3: Descriptive statistics of household and farm characteristics of potato-growing households in Dadeldhura district, Nepal, 2018

Variable	Mean	SD	Minimum	Maximum
Age of household head (years)	38.06	11.24	18	67
Family size (number)	5.94	2.13	2	11
Farming experience (years)	7.8	4.96	1	28
Irrigated landholding (ha)	0.3	0.19	0	0.6
Non-irrigated landholding (ha)	0.48	0.27	0	0.8
Total landholding (ha)	0.39	0.23	0.05	1.1

11.24), ranging from 18 to 67 years (Table 3). The average household size was 5.94 members (SD = 2.13), with a minimum of 2 and a maximum of 11. The average farming experience was 7.8 years (SD = 4.96), ranging from 1 to 28 years. The average landholding size was 0.39 ha (SD = 0.23), with landholdings ranging from 0.05 to 1.10 ha.

Economics of Potato Production in the Study Area

Potato Production and Productivity

The average potato productivity in the study area was

Table 4: Potato production, cultivated area, and productivity in the study area of Dadeldhura district, Nepal, 2018

Study Area	Production (t)	Area (ha)	Productivity (t ha-1)
Ganyapdhura Rural Municipality	201.5	10.98	18.35
Amargadhi Municipality	268.71	12.97	20.71
Total	470.21	23.95	19.63
Mean	235.11	11.98	19.53

19.63 t ha^{-1} (Table 4). Amargadhi Municipality recorded higher productivity (20.71 t ha^{-1}) than Ganyapdhura Rural Municipality (18.35 t ha^{-1}). Similarly, total potato production was higher in Amargadhi Municipality (268.71 t) compared to Ganyapdhura Rural Municipality (201.50 t). The higher productivity observed in Amargadhi Municipality indicated comparatively better production performance in the area during the study period.

Cost of Potato Production

The total cost of potato production was NRs 311,859.53 ha^{-1} (Table 5). Human labor constituted the highest

Table 5: Cost structure of potato production in Dadeldhura district, Nepal, 2018 (NRs ha^{-1})

Cost component	Cost (NRs ha^{-1})	Share of total cost (%)
Organic manure	63,369.86	20.32
Synthetic fertilizers	31,809.67	10.2
Seed treatment	6,892.10	2.21
Seed tubers	73,318.18	23.51
Human labor (all operations)	88,973.52	32.95
Insect and pest management	25,291.81	8.11
Packaging	8,420.21	2.7
Total cost of production	311,859.53	100

share of the total production cost (32.95%), followed by seed tubers (23.51%) and organic manure (20.32%). Synthetic fertilizers accounted for 10.20% of the total cost, whereas insect and pest management contributed 8.11%. Packaging and seed treatment represented the lowest cost shares, accounting for 2.70% and 2.21% of the total production cost, respectively.

Gross Return from Selling the Potato

The average area under potato production in Dadeldhura

Table 6: Economic indicators of potato production in Dadeldhura district, Nepal, 2018

Indicator	Mean value
Average area under potato cultivation (ha)	0.39
Potato yield (kg ha^{-1})	19,629.70
Farm-gate price (NRs kg^{-1})	33.68

Gross revenue (NRs ha^{-1})	661,142.20
Cost of potato production (NRs ha^{-1})	311,859.53
Benefit–cost (B/C) ratio	2.12

was 0.39 ha, with a mean productivity of 19.53 t ha^{-1} (Table 6). Gross revenue from potato cultivation was NRs 661,142.20 ha^{-1}, while the total production cost was NRs 311,859.53 ha^{-1}. The benefit–cost (B/C) ratio of potato production was 2.12.

Market Chain Actors and Their Roles in Potato Production and Marketing

Input Suppliers

In the study area, the key input suppliers include the Agriculture Knowledge Centre (AKC), Potato Superzone, agro-vets, and cooperatives, which are primarily involved in the supply of production inputs. A total of eight agro-vets operate in the area, supplying seed tubers, chemical pesticides, fertilizers, and agricultural tools to farmers. In addition, development initiatives such as the Raising Incomes of Small and Medium Farmers Project (RISMFP) and the Rural Enterprise and Economic Development (REED) project have been actively supporting the commercialization of potato production to improve farmers' livelihoods.

Producers

Three categories of potato producers were identified in the study area: subsistence farmers, small-scale commercial farmers, and commercial farmers. The majority of farmers are subsistence producers, who consume part of their produce and sell the surplus through available market outlets, while a smaller proportion practices fully commercial potato production. Subsistence farmers mainly rely on household labor and are involved in all production and post-harvest activities, including sorting and grading.

Collectors

Collectors are key actors in the potato value chain, purchasing potatoes from producers and selling them mainly to retailers and wholesalers. In some cases, producers themselves also act as collectors. Most collectors in the study area are responsible for sorting, packing, storing, and transporting potatoes. They are also involved in storing potatoes in cold storage facilities and later selling them as seed potatoes within the region. In addition, collectors supply potatoes directly to local retailers.

Wholesalers

The role of wholesalers in the study area is relatively limited. They mainly collect potatoes from collectors and transport them to distant markets, while also supplying potatoes to retailers.

Retailers

Retailers are responsible for selling potatoes to final consumers. Two types of retailers operate in the study area: local retailers and distant retailers. Local retailers serve nearby consumers, whereas distant retailers sell potatoes in larger urban markets such as Kathmandu, Dhangadhi, and other major cities. Retailers mainly purchase potatoes directly from producers, with some supplies sourced from wholesalers.

Consumers

Consumers in the study area mainly include hotels, individual households, and institutions, where a substantial quantity of potatoes is consumed. Depending on the marketing channel, consumers purchase potatoes from producers, wholesalers, cooperatives, or retailers.

Marketing Channels in the Study Area

Based on the field-based study, four distinct potato marketing channels were identified:

A. Channel I: Producers → Consumers

This is the shortest marketing channel and accounts for 30.8% of total potato sales.

B. Channel II: Producers → Retailers → Consumers

This channel accounts for 8.73% of total potato sales.

C. Channel III: Producers → Cooperatives → Consumers

This channel accounts for only 0.07% of total potato sales. Cooperatives purchase fresh potatoes and, during the planting season, sell them as seed potatoes at minimal cost.

D. Channel IV: Producers → Collectors → Wholesalers → Retailers → Consumers

This is the longest and most dominant marketing channel, accounting for 59.74% of the total potatoes sold in the study area.

Table 7: Gross marketing margin, net marketing margin, producer's share, and marketing efficiency across potato marketing channels in Dadeldhura district, Nepal, 2018

Indicator	Channel I	Channel II	Channel III	Channel IV
Farm-gate price (NRs kg^{-1})	45	41.5	38.4	33.68
Retail price (NRs kg^{-1})	45	45	45	45
Gross marketing margin (GMM)	0	3.5	6.6	11.32
Total marketing cost (NRs kg^{-1})	0	1.2	2.4	4.8

Net marketing margin (NMM)	0	2.3	4.2	6.52
Marketing efficiency (ME)	∞*	37.5	18.75	9.38

** ME was infinite for Channel I because marketing cost was 0*

The marketing margin, producer's share, and marketing efficiency across different marketing channels are presented in Table 7. In Channel I, where producers directly sold potatoes to consumers, the producer's share was 100%, and both GMM and NMM were zero due to the absence of intermediaries, resulting in the highest marketing efficiency. Channel II recorded a GMM of NRs 3.50 kg^{-1} with a producer's share of 92.2%. Channel III showed a GMM of NRs 6.60 kg^{-1} and a producer's share of 85.3%. Channel IV exhibited the highest GMM (NRs 11.32 kg^{-1}) and NMM, but the lowest producer's share (74.8%) and marketing efficiency.

Cobb–Douglas Production Function Estimates

Labor, FYM, and chemical fertilizer inputs demonstrated positive and statistically significant effects on potato yield at the 1% significance level (Table 8). Among these inputs, chemical fertilizer showed the highest elasticity (0.575), followed by FYM (0.406) and labor (0.403). The coefficient for land under potato cultivation was negative (−0.566) and statistically significant. The model explained a significant portion of the variation in potato production, with an R^2 value of 0.585. The estimated returns to scale were 0.82.

Table 8: Cobb–Douglas production function estimates for potato production in Dadeldhura district, Nepal, 2018

Variable	Coefficient (Elasticity)	Std. Error	t-value	p-value
ln (Land)	−0.566***	0.072	−7.81	<0.001
ln(Labor)	0.403***	0.01	40.4	<0.001
ln(FYM)	0.406***	0.01	41.28	<0.001
ln(Total fertilizer)	0.575***	0.003	191.67	<0.001
Observations	60			
R^2	0.585			
Adjusted R^2	0.578			
F-statistic	81.70***			
Returns to scale (Σβ)	0.82			

****Significant at the 1% level*

Production and Marketing Constraints of Potato Cultivation

Price fluctuation due to the Indian market was ranked as the most severe constraint with an index value of 0.81, followed by lack of mechanization (0.78), incidence of disease and pests (0.73), and lack of storage facilities (0.69) (Table 9). Other major problems included high middlemen margins (0.64), lack of irrigation facilities (0.61), limited extension services (0.58), lack of grading and packaging facilities (0.52), losses from wild animals (0.48), and lack of quality fertilizers (0.42).

Table 9: Major production and marketing constraints of potato cultivation in Dadeldhura district, Nepal, 2018

Problem	Index value	Rank
Price fluctuation due to the Indian market	0.81	1
Lack of mechanization	0.78	2
Incidence of disease and pests	0.73	3
Lack of storage facility	0.69	4
High middlemen margin	0.64	5
Lack of irrigation facility	0.61	6
Limited extension services	0.58	7
Lack of grading and packaging facilities	0.52	8
Loss from wild animals	0.48	9
Lack of quality fertilizers	0.42	10

Note. Problems were ranked based on the Index of Importance/Priority index (I_{imp})

Value Chain Mapping

The agricultural value chain is defined as the complete range of goods and services required for an agricultural product to move from the farm to the final consumer,

involving multiple actors performing distinct functions (Wang & Gu, 2022). In this study, the value chain map is presented in a conventional format, with the key stages of the value chain shown on the left side of the map and the associated enterprises at each stage illustrated to the right (Figure 2). In the map, functions are listed vertically along the left-hand side, while the final markets are shown across the top, and the participants or actors in the value chain are represented by boxes. In the potato value chain, the channels were identified based on core business units, including input supply, production, collection, wholesaling, and retailing, which together facilitate the physical flow of products from suppliers to end users. In general, longer marketing chains are associated with a greater increase in the final consumer price.

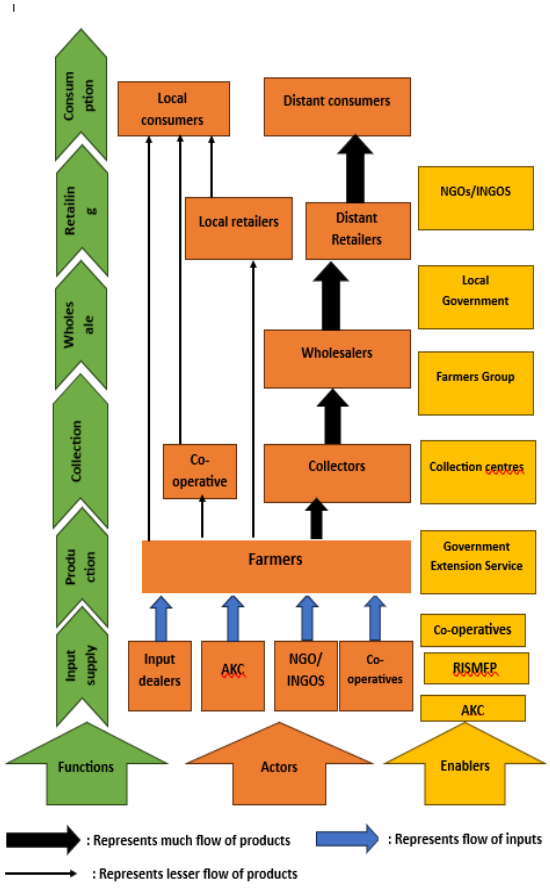

Figure 2: Major and minor potato marketing channels and value chain actors in Dadeldhura district, Nepal, 2018
Note: Arrows indicate the flow of potatoes from producers to final consumers through different market actors

Discussion

Socio-Demographic Characteristics and Farming Behavior

Male-headed households dominated potato production in the study area, which reflects the traditional gender roles in household leadership and agricultural decision-making. Literacy among respondents was 60%, which aligns closely with the district literacy rate of 53.43% (CBS, 2011). Education facilitates better interaction with extension services and enhances the adoption of improved agricultural practices (Tarar, 1983). The dominance of Brahmin and Chhetri households indicates the prevailing social composition of farming communities in the study area. Agriculture remained the primary occupation for the majority of respondents, highlighting the dependence of rural households on farming-based livelihoods. The predominance of sole cropping practices suggests the commercial orientation of potato cultivation in the district. Furthermore, the high proportion of trained farmers indicates the contribution of agricultural extension and PMAMP-related interventions in promoting improved production practices. Access to institutional information and extension support has also been reported to positively influence farmer decision-making and agricultural participation in Nepal (Thapa *et al.,* 2026).

The average age of household heads indicates that potato farming is largely managed by economically active individuals. Age has been shown to influence income-generating capacity and the adoption of agricultural technologies (Ahmad *et al.,* 2007). Similarly, the average household size suggests the availability of family labor for farm operations. Previous studies have highlighted the positive contribution of family labor in horticultural production and household income generation (Bezabih & Hadera, 2007). The average landholding size further indicates the dominance of smallholder farming systems in the district.

Economics and Profitability of Potato Production

The average potato productivity observed in the study area was higher than the national average productivity. Better road access and a higher proportion of trained farmers in Amargadhi Municipality may have contributed to relatively higher productivity. Similar findings regarding the positive influence of farmer training on productivity have been reported by Kangogo *et al.* (2024). Agricultural production fluctuations are often influenced by climatic variability, market demand, and production management practices (Sanwa *et al.,* 2026).

Human labor constituted the largest share of production cost, indicating the labor-intensive nature of potato cultivation in the study area. Labor requirements for land preparation, manuring, irrigation, weeding, and harvesting substantially increase production costs. The limited adoption of mechanized technologies further increases dependence on manual labor. Similar findings were reported by Sapkota and Bajracharya (2018) and Khadka *et al.* (2023), who highlighted that potato cultivation remains highly labor-intensive in Nepal. The present findings are also consistent with Sapkota *et al.* (2019), which reported that labor cost constituted the highest share of total production cost, followed by seed tuber cost.

The observed B/C ratio of 2.12 indicates that potato

cultivation is economically profitable in the study area. Favorable agro-climatic conditions and commercial production potential may have contributed to higher profitability. Similar findings were reported in Nuwakot district, where a B/C ratio of 2.02 was observed (Khanal *et al.,* 2024). However, lower B/C ratios have been reported from Okhaldhunga district (1.23) (Phulara *et al.,* 2021), Achham district (1.47) (Sapkota *et al.,* 2019), and Bajhang district (1.37) (Khadka *et al.,* 2023), indicating geographical variation in potato profitability across Nepal.

Marketing Channels and Efficiency

The findings revealed that longer marketing channels were associated with lower producer's share and reduced marketing efficiency. Channel I showed the highest producer's share due to the absence of intermediaries, whereas Channel IV exhibited the lowest producer's share and highest marketing margin because of the involvement of multiple intermediaries. These findings indicate that value addition and market margins increase with channel length, while farmers receive a smaller proportion of the final consumer price.

The declining marketing efficiency with increasing channel length highlights inefficiencies within the potato marketing system of the study area. Similar observations were reported by Shrestha *et al.* (2022), who emphasized the importance of shortening marketing channels to improve farmers' returns and reduce intermediary dominance within agricultural value chains.

Determinants of Potato Production

The Cobb–Douglas production estimates demonstrated positive and statistically significant effects of labor, FYM, and chemical fertilizers on potato output. These findings emphasize the importance of input intensification in increasing productivity (Amrullah *et al.,* 2024; Khan & Ahmad, 2002). The positive elasticity of FYM indicates that organic manure contributes to soil fertility improvement and complements chemical fertilizer use.

Chemical fertilizer exhibited the highest elasticity among all inputs, suggesting that nutrient management plays a crucial role in increasing potato productivity. Similar findings were reported by Takeshima *et al.* (2017), who emphasized the importance of balanced fertilizer application in improving agricultural productivity. The labor elasticity further reflects the labor-intensive nature of potato cultivation in the study area.

The negative elasticity of cultivated land indicates declining marginal productivity of land under existing management practices. This unexpected negative coefficient may also reflect possible multicollinearity among production inputs, fragmentation of landholdings, and management inefficiencies associated with larger cultivated areas. In smallholder farming systems, expansion of cultivated land without proportional increases in labor, fertilizer, irrigation, and technical management may reduce productivity per unit area. Furthermore, fragmented plots and limitations in supervision and resource allocation can negatively influence production efficiency. This may be associated with limitations in management capacity and inadequate allocation of complementary inputs as cultivated area expands (Chen *et al.,* 2017). The estimated returns to scale of 0.82 indicate decreasing returns to scale, suggesting that productivity improvement is more likely to be achieved through efficient input management rather than proportional expansion of cultivated area.

Production and Marketing Constraints

The study identified several interlinked production and marketing constraints affecting the sustainability of potato cultivation in Dadeldhura district. Price fluctuation associated with the Indian market emerged as the most severe constraint, indicating strong market dependency and income instability among farmers. Such fluctuations discourage long-term investment in potato farming and increase production risk.

The lack of mechanization was another major challenge, reflecting the limited adoption of modern agricultural technologies in the mid-hill regions of Nepal. Similar findings were reported by Gairhe *et al.* (2017). Pest and disease incidence, including late blight and aphid infestation, also significantly affected potato production and increased production costs (Chakrabarti *et al.,* 2022). Improper pesticide management and excessive agrochemical use may further create environmental, health, and socio-economic challenges for farming households (Thapa *et al.,* 2024).

Post-harvest and institutional constraints further limited profitability and marketing efficiency. Inadequate storage facilities forced farmers to sell potatoes immediately after harvest at lower prices, thereby increasing post-harvest losses (Shrestha *et al.,* 2022). Similar postharvest and handling challenges in Nepalese horticultural systems have also been reported by Dhami *et al.* (2023). High middlemen margins reflected inefficiencies within the value chain and reduced farm-gate prices received by producers. Similarly, limited irrigation facilities restricted off-season production opportunities, while inadequate extension services constrained the adoption of improved technologies. Other challenges, including poor grading and packaging facilities, crop losses from wild animals, and lack of quality fertilizers, also affected productivity and profitability (Karki *et al.,* 2022; Magar *et al.,* 2024).

Value Chain Implications

The value chain analysis demonstrated the involvement of multiple actors, including input suppliers, producers, collectors, wholesalers, retailers, and consumers, in facilitating the movement of potatoes from production areas to final markets. The conventional value chain structure indicated that longer market chains contribute to increased consumer prices and reduced producer's share.

The findings suggest the need for improved coordination among value chain actors, strengthening of producer organizations and cooperatives, improved storage

and transportation facilities, and promotion of direct marketing systems to enhance marketing efficiency and increase farmers' returns.

CONCLUSION

Potato cultivation in Dadeldhura district is an economically viable livelihood option for farming households. The average productivity of 19.63 t ha-1 exceeds the national average, and a benefit–cost ratio of 2.12 confirms strong profitability despite the labor-intensive nature of production. Total production cost was NRs 311,859.53 per hectare, dominated by labor (32.95%) and seed tubers (23.51%), while gross returns reached NRs 661,142.20 per hectare.

Value chain analysis identified four marketing channels, with the longest channel (Producers–Collectors–Wholesalers–Retailers–Consumers) handling the largest share of produce (59.74%) but yielding the lowest producer's share (74.8%) and the highest market margin (NRs 11.32/kg). Direct sales provided a 100% producer's share but contributed a smaller share of total sales. Key constraints include high middlemen margins, price fluctuations, limited mechanization, pest and disease incidence, and inadequate storage and irrigation facilities. Strengthening value chain linkages, reducing unnecessary intermediaries, and improving technical and institutional support are essential to enhance farm incomes and ensure the long-term sustainability of potato production in Dadeldhura district.

The Indian market has a strong influence on potato production and marketing in the study area; therefore, proper policies and regulations are needed to manage cross-border market activities and improve producers' income. Farmers also require additional training and technical support on improved production practices, integrated pest and disease management, grading, and post-harvest handling through government agencies and partner institutions. The study further revealed weak coordination among value chain actors, indicating the need to strengthen linkages among producers, traders, collectors, retailers, and other stakeholders to improve market efficiency. Although producers receive a relatively higher share of profit than other actors, the involvement of many middlemen contributes to higher market prices. Thus, the establishment of community-based and cooperative collection centers is recommended to reduce unnecessary intermediaries and improve the marketing system. In addition, affordable farm mechanization and labor-saving technologies should be promoted to reduce the high labor costs of potato production. Finally, effective measures such as fencing systems and community-based protection practices should be implemented with the support of local governments and related institutions to minimize crop losses caused by wild animals.

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