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Research Article

Socio-economic return analysis of apple farming in Mustang district of Nepal

Bishnu Bahadur Khatri[1], Rajan Binayek Pasa[1*], Chandra Purja[1] and Devendra Adhikari[2]

[1]Tribhuvan University, Central Department of Rural Development, Kathmandu, Nepal
(BBK: bishnu.khatri@cdrd.tu.edu.np, https://orcid.org/0000-0003-4777-1307
CP: chandra.purja564@gmail.com)
[2]School of Education, Kathmandu University, Nepal
(DA: devendra.adhi1984@gmail.com, https://orcid.org/0000-0001-5148-1842)
[*]Correspondence: rajan.pasa@cdrd.tu.edu.np
[*]ORCID: https://orcid.org/0000-0001-8886-7714

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ABSTRACT

Apple farming is commercially done in mountainous regions in Nepal. The aim of this study was to assess social and economic returns of apple farming in Mustang district. The study applied a quantitative approach using multi-site case study methodology. The primary data were collected from 156 respondents by using reliable (Cronbach's alpha 0.70) self-administered questionnaires. The study revealed that the mean age, household size, and ethnicity were 49 years, 6 members, and 80% Janajati, respectively. The mean value of irrigated land, non-irrigated land, and leasehold land was found to be 0.59 ha, 0.11 ha, and 0.18 ha respectively. The majority of households (48.7%) have food sufficiency for 6-9 months. Apple farming has enhanced farmers' living standards and quality of life, with improved access to nutritious food and perceived family well-being while creating 464 self-employment and 758 seasonal jobs. The economic analysis showed that the average initial investment in farm businesses as well as income from agriculture and agro-based entrepreneurship were found US$ 1,864, US$ 5,523 and US$ 6,720 respectively. Likewise, average annual expenses for new seeds, fertilizers/pesticides/vitamins, labor, irrigation, and technician visit fee found US$ 354; 1,089; 1,551; 59, and 64 respectively. The annual income from apple farming is 75% associated with annual expenses for technician's fee, fertilizers/pesticide/vitamin, new seeds, irrigation, and labor. Besides, the variables of expense for fertilizer/pesticide/vitamin ($t= 2.99$, $p<0.05$), irrigation ($t= 0.36$, $p<0.05$), and labor ($t= 5.32$, $p <0.05$) are significantly associated with annual income. Respondents with irrigation facilities had higher annual incomes than those without. Apple farming in Mustang is a key income source, offering significant social and economic benefits. However, issues like inadequate cold storage, poor roads, and retailer monopolies persist. These findings provide valuable insights for policymakers, planners, and technicians advancing apple farming commercialization in Nepal.

Keywords: Apple farming**,** Economic return**, S**ocial returns, Return analysis.

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INTRODUCTION

Apple is one of the valuable cash crops in Nepal because of its demand in the national and international market. In the country, this farming is suitable between 26°22' and 30°27' north latitude and 80°4' and 88°12' east longitude, and it started in Kali Gandaki valley of Mustang District. In 1966, the first small-scaled commercial apple farming in Nepal began at Marpha where the horticultural farm was established and introduced new varieties of apples and production methods (Dhakal, 2023). Gradually, farmers residing in the tropical region and government agencies became interested in high-density apples. Prime Minister Agriculture Modernization Project (PMAMP) provides subsidized seedlings to boost high-density apple plantations. Nepal Government's data shows that fruit production is in increasing rate in terms of area cover and production (Ministry of Agriculture and Livestock Development, 2024). As of the fiscal year 2021/22, 67,200 farmers are directly involved in apple farming in 3100 hectare land, and there exist 460,700 apple trees in Nepal (NSO, 2023). Nepal's national economy is largely contributed by horticulture in which apple farming has a key role especially in uplifting the social-economic standard of marginal farmers (Dhakal, 2023; Khatri & Timsina, 2023).

Apple production of Nepal is around 5.6 MT a year and with average productivity of 7.3 MT/ha (MoALC, 2016/17). In FY 2019/20 Nepal produces 45,205 MT apple (9.5 MT/ha) cultivated in total area 12,910 ha including productive area 5,514 ha (PMAMP, 2021). Regionally, Karnali Province (Jumla, Humla, Mugu, Kalikot) dominates by producing 15,388 MT apples cultivated in 2,331 ha followed by Gandaki Province (Mustang, Manang, Myagdi) producing 7,450 MT cultivated in 632 ha, Koshi Province (Solukhumbu, Terathum, and Khotang) producing 2,116 MT, Bagmati Province (Rasuwa) producing 424.0 MT cultivated in 87 ha and Sudurpachhim Province (Bhajang, Bajura, and Baitadi) producing 1810 MT cultivated in 215 ha in FY 2018/19 (MoALD, 2018/19). For the FY 2018/19, the total apple produced in Mustang, Manang, and Jumla were 5,727.0 MT, 1,312.0 MT, and 6,799.0 MT respectively and yields were 12.9 MT/ha, 12.5 MT/ha, and 6.5MT/ha respectively (MoALD, 2018/19; Thapa, 2022). These evidences signify that apple farming is a suitable cash crop in Nepal due to the country's diverse geographic and climatic contexts.

Despite the increasing significance of apple farming, there is a paucity of empirical research examining the socio-economic returns of apple farming among local farming communities. The socio-economic status of apple growers was carried out by previous researchers in Nepal's Mustang (Dhakal, 2023), Manang (Dhakal, 2024) and Dolpa (Ojha *et al.*, 2021). Mustang district of Nepal, renowned for its distinctive agro-climatic conditions, has emerged as a prominent hub for apple farming, which holds substantial potential for driving economic transformation in the region. This study enriches the ongoing academic contribution by analyzing the socio-economic returns of apple farming in Mustang, and identifies the challenges associated with apple farming practices.

METHODOLOGY

Selection of the study site

This study used quantitative dominant comparative case studies across multiple sites (Yazan, 2015) for analyzing socio-economic returns of apple farming. According to MoAD (2015/16), over 50 districts in Nepal grow apples, and twelve of them including Mustang are

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considered as major producers in the mountain region. This study is focused in the Mustang which is a renowned area for its delicious apples and vibrant tourism, located in Gandaki province. Mustang is situated in the Trans-Himalayan region, bordered by the Annapurna and D*ha*ulagiri ranges to the south and Tibet to the north, making it a significant area for apple production and tourism (Khadka, 2019). The district spans an area of 3,563.21 sq. km, with an altitude ranging from 1,640 to 7,061 meters above sea level. Mustang receives less t*ha*n 260 mm of annual rainfall, with temperatures ranging from -2.7°C in winter to 23.1°C in summer. In 2018/19, the district produced 5,727 metric tons of apples from 445 hectares (MoALD, 2017/18). Mustang was reorganized into five Rural Municipalities in 2017, and this study primarily focused on Thasang and Gharapjhong Rural Municipalities, which are favorable for apple farming.

Sampling size and procedure

In a research, a sample is the representative subset of the population selected for observation and analysis (Best & Khan, 2004). This study used a quantitative approach, identified a sample population of 194, and with 156 respondents selected based on a 95% confidence level and a 5% margin of error. The sample size was calculated using the sample size determination formula (Krejcie & Morgan, 1970). Both purposive and stratified random sampling methods were used for selection.

Selection of apple growers: provide *cha*racteristics, types/nature of farmers selected

The study was conducted in Gharapjhong and Thasang rural municipalities of the Mustang district. The sample population is divided into two main categories: big farmers (or large-scale famers) from apple zones and small farmers (or small- scale famers). The population and sample size distribution are presented below (Table 1).

Table 1: Sample size distribution

Rural municipality	Settlements	Category	Sample Population	Sample Number
Ghoropjong	Marpha Tukche	Big farmers	29	24
		Small farmers	107	84
Thasang R.M	Syang	Big farmers	14	12
		Small farmers	44	36
Total			194	156

Data collection

This study adopted household surveys, observations, and key informant interviews for data collection. Questionnaire survey was employed to gather primary information from 269 respondents, which included structured questions about their personal experiences, knowledge, and opinions regarding apple farming. The questionnaire included private returns and social returns analysis of apple farming (Lekhi, 2008). The research's focus was to explain economic (enhancement of income and employment through skill knowledge and idea) and non-economic (basis of prosperous life, confidence, awareness, improved health indicators, self-esteem) indicators of return analysis.

The study ensured the reliability of the data through Cronbach's alpha test which was >0.7 (Cohen *et al.,* 2018). Regarding validity, the study focused on content, construct, and criterion validity. Content validity ensured careful sampling and the relevance of variables,

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while construct validity involved triangulating data from literature reviews, field data, and statistical methods like factor analysis. Criterion validity affirmed the use of reliable data collection tools throughout the research process.

Statistical analysis

This study used SPSS-27 to analyze data using both descriptive and inferential statistical tools. Descriptive analysis included tools such as frequency tables and measures of central tendency. Inferential statistics was performed statistical analysis such as Likert scale computation and multiple regression (Field, 2009). The study further incorporated description, analysis, and interpretation methods of the data (Yin, 2018). The description method helped to explain the data's meaning, the analysis method identified underlying patterns, and the interpretation method provided insights into the processes and theoretical implications.

RESULTS AND DISCUSSION

The result and discussion is presented into three thematic headings: social return analysis, and economic return analysis, and c*hal*lenges in apple farming, and measurement of association.

Social return analysis

In this analysis, the demographic characteristics of the respondents, educational attainment, access to nutritional fruits and living standard, and community participation have been presented and discussed.

Demographic characteristics

Gayak *et al.*, (2020) found the positive impact of education, ethnicity, economically active household members, and farm experience in raising the apple production. In our research context, majority of people are literate, with high percentage of working population below 60, and more t*han* 80% population belong to indigenous community. These figure could *ha*ve affirmative impact on the growth of apple farming in the study area (Table 2).

Table 2. Demographic characteristics of the respondents

Indicators	Variables	N	%
Age	Up to 40 years	20	12.80
	41 to 60 years	90	57.70
	More than 61 years	46	29.50
Gender	Male	126	80.80
	Female	30	19.20
Marital Status	Unmarried	2	1.30
	Married	147	94.20
	Widow	7	4.50
Caste & Ethnicity	Chettri	2	1.30
	Janjati	127	81.40
	Dalit	27	17.30
Religion	Hindu	30	19.20
	Buddhists	126	80.80
Language	Nepali	36	23.10
	Thakali	120	76.90
Education level	Primary level	47	30.10
	Lower Secondary level	47	30.10

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Indicators	Variables	N	%
	Higher Level	23	14.70
	Illiterate	39	25.00
Land holding	Owned land	146	93.06
	Leasehold land	44	28.02
	Share cropping	31	19.90
Family food sufficiency	6 months	64	41.00
	6-9 months	76	48.70
	9-12 months	13	8.30
	>12 months	3	1.90
Total		156	100.00

The survey revealed that the two-thirds of the total population belong to the age group of 41 - 60 years old. The ratio of the male household head farmer is higher than the female farmer, in which 80.8% were male and 19.2% (<one-fifth) were female. The majority 147(94.2%) were married, 4.5% were widows, and 1.3% were unmarried. Mustang district is dominated by Janjati (indigenous) people. More than 80% of farmers are Janjati who follow Buddhist religion (80.8%), whereas Dalit were 17.3% and 1.3% Chettri following Hindu religion (19.2%). The dominant mother tongue language of the respondents was Thakali (76.9%) and one-third Nepali (23.1%). The high engagement of indigenous communities in the apple farming is helpful to retain indigenous farming technologies in the region.

The status of the farmers with their owned land was 146(93.6%), with leasehold land is 44(28.2%), and sharecropping is 31(19.9%). The mean value of irrigated land, non-irrigated land, and leasehold land was found 0.59 ha, 0.11 ha, and 0.18 ha. Most 76(48.7%) households have food sufficiency for 6-9 months that is followed by 64(41.0%) having six months, 13(8.3%) having 9-12 months. Only 3(1.9%) households have had food sufficiency for >12 months which is critical from access to sufficient, safe, and nutritious food (WFS, 1996).

Child education

The farmers are investing in child education and also playing quality parenting role. A total of 365 children were surveyed, with 109 (29.86%) attending public schools, 69 (18.90%) attending private schools, 58 (15.90%) attending public colleges or universities, and 129 (35.34%) attending private colleges. This distribution highlights the varying preferences for public and private education among the children in the study.

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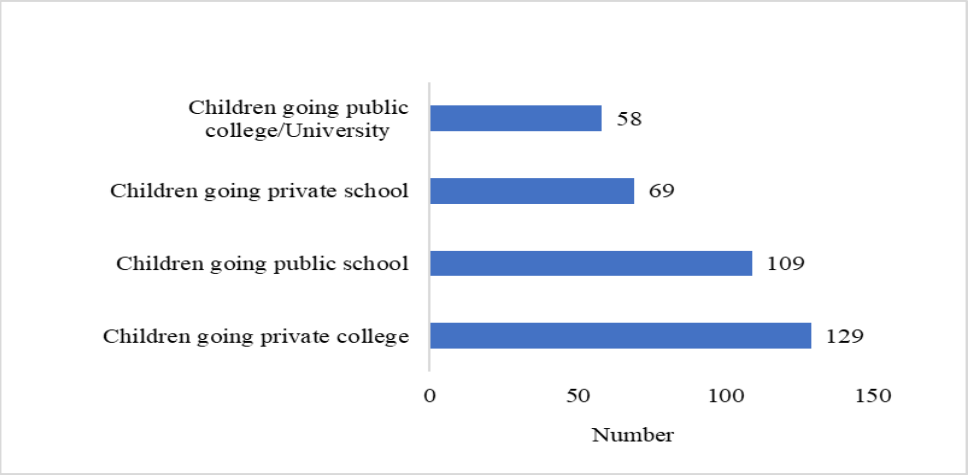

Figure 1: Educational status of the children

Family investment in child education not only en*ha*nces individual opportunities for their children but also strengthens the broader community by fostering economic growth, reducing inequality, and promoting social well-being. Educational attainment of the children ultimately benefits to the community and becomes cornerstone of long-term social returns.

Access to nutritional food and fruits, and living standard

The living standards of the family members of the respondents *ha*ve been improved due to the accessibility of nutritional food (Table 3). It shows that 60.9% of farmers agreed that their family members have good access to nutritious food, while 20.5% strongly agreed. However, 12.2% disagreed, and 6.4% were neutral on the matter. Regarding the improvement in family quality of life from apple farming, 39.1% strongly agreed, 41.0% agreed, 8.3% were neutral, and 11.5% disagreed, indicating a generally positive perception of the impact of apple farming on family well-being.

Table 3: Access to food and living standard

Items	Response	N	%
Family members access to nutritional food and fruits	Strongly agree	32	20.50
	Agree	95	60.90
	neutral	10	6.40
	Disagree	19	12.20
Family quality life improvement	Strongly agree	61	39.10
	Agree	64	41.00
	neutral	13	8.30
	Disagree	18	11.50
Total		156	100.00

Participation in community institution

Since for many generations, there exists a community institution to function community smoothly and effectively (Table 4). It's an individual responsibility to be part of such institution. The table below shows the status of farmer linked with different community institution.

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Table 4: Institutional participation

Category	Response	N	%
Participate in farmer group	Yes	150	96.20
	No	6	3.80
Participate in cooperative group	Yes	67	42.90
	No	89	57.10
Participate in school management community	Yes	41	26.30
	No	115	73.70
Participate in youth club	Yes	42	26.90
	No	114	73.10
Total		156	100.00

The table provides data on farmers' involvement in various community institutions. It reveals that 96.2% of farmers are members of farmer groups, while 42.9% participate in cooperative groups. Additionally, 26.3% are involved in school management committees, and 26.9% take part in youth clubs. The findings from this research support the fact that better socio-economic characteristics of farmers have an immense influence on the local decision making process and making profit on apple enterprise (Nagash *et al.*, 2018)

Economic return analysis

In this section, the employment generation and apple farm development, technical and financial assistance, marketing and financial support, and existing challenges have been presented and discussed.

Employment generation and apple farm development

Apple farming is creating self-employment for the 464 (Min 1 and Max 3) local people including males 227($\bar{x}$ 1.97) and females 237($\bar{x}$1.51) (Table 5). And also creating seasonal employment for the 758 local people (Min 1 and Max 12) including 394 males ($\bar{x}$2.52) and 364 females ($\bar{x}$2.33) including migrant workers. This may be the rationale behind USAID's (2019) claim t*hat* women are increasingly participating in the agricultural and horticulture industries as producers, consumers and daily wage labors. Compost fertilizer is not only used to supplement chemical fertilizer inputs (Preston, 1995) but also improving the efficiency of nutrient cycling when livestock and agricultural systems are integrated (John *et al.*, 2008; Rana & Chopra, 2013). The majority 147(94.9%) of the sample farmers prepared compost fertilizers in 44(29.5%) of them sold their surplus fertilizer to the other farmers.

Using modern technology in apple farming leads to higher production, cost-effectiveness, and time-saving. Owing to that around 131(84%), farmers agreed with the statement that modern technological intervention in apple farming has been increased. Very interestingly some small farmers are not yet using such technologies. They might have been dissuaded by the hefty initial investment required and unwillingness to use contemporary technologies (FDD, 2017). Besides, an increase in the number of apple plants leads to a decrease in the average production cost. Even in the study area, 58(37.8%) of the sample farmers are planning to expand their farms within one year whereas 79(50.6%) farmers do not have an expansion plan. The big farmers who are willing to an extent their farm shared that they need to take the same effort either they plant few or large numbers of apples. The Indian farmers having more than 500 plants in their orchards also had to bear lower cost (Mehta *et al*., 2013). The farmers

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are also facing thunders of challenges in the study area (Table 2). Amgai *et al*. (2015) also reveal that lack of transportation, lack of market knowledge, lack of processing facility, and lack of storage facility were recognized as the primary marketing challenges of apple farming in the Mustang district. Dhakal (2024) also investigated that traditional apple farming system has longer payback period than the High density system. In the traditional system apple trees are planted at distant and in the high density system the trees are planted at closed gaps. Thus Dhakal suggested that farmer need special skills and support to initiate this profitable farm practice and have shorter payback period.

Table 5: Apple farm development

Category	Min	Max	Mean	SD	Skewness
Male member from family involve in farming	1	3	1.45	.52	.48
Female member from family involve in farming	1	3	1.51	.59	.69
Male Labor worked in farm temporarily	1	12	2.52	1.59	2.06
Female labor worked in farm temporarily	1	8	2.33	1.51	1.84

Items	Response	N	%
Preparing compost fertilizer or not?	Yes	148	94.90
	Not yet	7	4.50
	Planning	1	.60
Selling compost fertilizer or not?	Yes	46	29.50
	not yet	95	60.90
	Planning	15	9.60
Planning for expanding apple farming or not?	Yes	59	37.80
	not yet	79	50.60
	may be in future	18	11.50
Total		156	100.00

Family income and expenditure

Apple farming helped to increase income and expenditure of the farmers (Table 6). The majority 156(99.4%) of the sample households adopt agriculture as a primary source of family income. Alongside, the respondents have secondary sources of income from general shop/tourism business (46.8%), remittance (34.6%), private job (14.1%), government job (7.7%) and agro-enterprises (2.56%) respectively. Agro enterprises are producing byproducts of raw apples such as juice, cider, and air-dried apple slices that are getting good market value among domestic consumers (Khanal, 2014). The mean family income from agriculture, local shop and tourism business, remittance, private job, government job and agro-based entrepreneurship found US$ 5,523; 3,728; 5,883; 2,165; 3,007 and 6,720 per annum respectively. Third, average family expenditure on food items, clothing, children's education, traveling and pilgrimage, cultural celebration, medical treatment, and philanthropy was found US$ 1,647; 358; 1,140; 404; 406; 478 and 111 respectively. Fourth, each farmer has different recurring costs for different purposes. Of the total respondents, 99, 36, and 96 farmers have recurring costs for buying land, leased land, and accommodation/houses respectively. The average initial investment while starting commercial farming is US$ 1,864.

Fifth, the major source of investment was owned saving shared by 155(99.4%) followed by individual loans ($\bar{x}$ US$ 3,049) shared by 73 (46.8%), bank loans ($\bar{x}$ US$ 5,020) shared by

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41(26.3%) and cooperative loan (x̄ US$ 3,429) shared by 19(12.8%). Sixth, for the farming purpose, the average annual expenses for new seeds, fertilizers/pesticides/vitamins, labor, irrigation, and technician visit fee found US$ 354; 1,089; 1,551; 59, and 64 respectively. The average expenses for transportation were negligible because retailers or wholesalers managed the transport facilities while harvesting apples from the farm.

Table 6: Family income and expenditure

Family Income			Family Expenditure					
Sources	N	%	Description	Min	Max	Mean	SD	Skewness
Agriculture	156	99.4	Food	40000	2500000	202243	268684	5.95
Agro-entrepreneur	5	3.2	Clothes	50000	750000	43987	61245	10.12
Local business	73	46.8	Children Education	100000	2000000	139967	203690	7.09
Public service	12	7.7	Travelling/pilgrimage	100000	200000	49694	31093	1.99
Private job	22	14.1	Cultural celebration	50000	1000000	49929	82210	10.22
Domestic remittance	29	18.58	Health/medicine	10000	750000	58741	77852	5.55
Foreign remittance	54	34.6	Philanthropy	4000	150000	13660	15737	5.34

Technical and financial assistance

Under the PMAMP Mustang district was introduced as the apple zone in 2018. Since then, the project assisting farmers use through technical, financial assistance, and training (Table 7).

Table 7: Assistances from government and I/NGOs

Category	**Response**	**N**	**%**
Training opportunity	Yes	143	91.70
	No	13	8.30
Tour opportunity	Yes	107	68.60
	No	49	31.40
Rewards opportunity	Yes	20	12.80
	No	136	87.20
Agricultural tools	Yes	57	36.50
	No	99	63.50
All of above	Yes	3	1.90
	No	153	98.1
Subsidy	Yes	111	71.20
	No	45	28.80
Low-interest loan	Yes	61	39.10
	No	95	60.90
Daily allowance	Yes	3	1.90
	No	153	98.10
Cash prize	Yes	30	19.20
	No	126	80.80
Total		156	100.00

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The study also found that the majority of 127(81.4%) of the sample farmers have received such kinds of assistance from the project whereas 29(18.6%) could not be benefitted. This finding resonates with Ojha *et al.* (2021), which identified the positive impacts training to farmers including technical assistance and the land holding in increment of apple production.

The outcomes of commercial farming in general and apple farming, in particular, have brought a positive impact on family well-being. Stringer (2001) also claims that the agricultural sector in emerging countries plays an essential role in social well-being. The majority 115**(**73.71%) of the respondents agreed/strongly agreed that their family members have good access to nutritional food and fruits. Additionally, horticultural crops have the potential to improve human health by diversifying diets and addressing nutritional shortages (USAID, 2019). And the majority, 146(93.6%) of the respondents agreed/strongly agreed with the statement that apple farming supported improving the living standards of the local people.

Farming, marketing and financials supports

Despite both private and social returns, farmers in the study area faced some problems related to farming, marketing and financial support (Table 8).

Table 8: Farming related problems

Probing Questions	**Response**	**N**	**%**
Face farming-related problems like apple diseases	Yes	127	81.40
	No	29	18.60
	No	134	85.90
Shortage of fertilizers/ pesticides/vitamins	Yes	15	9.60
	No	141	90.40
Shortage of agriculture tools	Yes	12	7.70
	No	144	92.30
Faces marketing problems	No	156	100.00
Did your apple get waste	No	140	87.50
	Yes	16	12.50
Did apple price decrease from the previous year?	No	156	100.00
Receive any financial support	Not receive	156	100.00
Possible market for supplying apple product	Inside district	76	48.70
	Myagdi	115	73.70
	Kaski	109	66.90
	Kathmandu	57	36.50
	Other district	32	20.50
Selling produced apples through c*ha*nnel A	Yes	152	97.40
	No	4	2.60
Selling produced apples through c*ha*nnel B	Yes	147	94.20
	No	9	5.80
Total		156	100.00

The majority of the farmers faced the problems like apple diseases and financial compensation-related problems. Nobody witnessed the problem of apple's price reduction as it is a prominent and high-value cash crop which is mentioned in APP (1995) and ADS (2013). Farmers got higher prices compared to the earlier year during the pandemic from 2020- 2021. The majority 115(73.7%) of the respondents supplied their products to the

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Pokhara metropolitan city of Kaski district and the remaining were delivered to Myagdi and Kathmandu. The farmers had two marketing channels: channel A (from the farm gate). Considering Channel A, the marketing margin and producer's shares are 0 and 100% respectively. Similarly, for channel B (producer–traders– consumer) the marketing margin and producer's share were found at 70.56% and 56.63% respectively. The actual farm gate price was (NRs: Min 110, Max 134 Mean 119.68), the retail price was (NRs: Min 85, Max 99 Mean 92.16) and the market price is (NRs: Min 120, Max 190 Mean 162.72) per kg of apples.

Therefore, the economic benefits of the apple farming is encouraging in the study area. Large number of employments has been generated which has increased family income of apple farmers. Their spending and purchasing capacities have been enhanced which has positively supported their living. They have access on financial institutional for loans. Nepal Government has also implemented insurance policy to enhance to confidence and financial security of the apple farmers (MoALD, 2024).

Challenges in apple farming

Despite multiple benefits or private and social returns from apple farming, the farmers are facing various challenges in the study area (Table 9). Amgai *et al.* (2015) also reveal that lack of transportation, lack of market knowledge, lack of processing facility, and lack of storage facility were recognized as the primary marketing challenges of apple farming in the Mustang district. A study by Sapkota et al., (2022) in Jumla explored apple farming is a profitable business the Nepal's hilly region. However, apple production can scale up if there are government operated farms, proper marketing channels through cooperatives, subsidies and credit facilities to farmers, and research based farming and post-harvesting practices. State policies that create favorable political climate for agriculture growth, welcome new enterprise in apple business, and enhancing capacities of farmers can significantly improve apple enterprise (Naqash *et al*., 2018). Similarly farmers have limited knowledge on when or how to efficiently irrigate, fertilized, and trim their apple trees (Subedi *et al.*, 2016) and they have little access to infrastructures such as year-round roads, irrigation, and storage facilities (SNV, 2011). Lack of storage and poor transportation connectivity are major hindrances for apple marketing in Nepal (Ojha *et al*., 2021).

Table 9: Challenges of apple farming

Items	Response	N	%
Shortage of manpower	Strongly agree	1	0.60
	Agree	84	53.80
	Neutral	10	6.40
	Disagree	61	39.10
Shortage of collection center	Strongly agree	132	84.60
	Agree	24	15.40
Insects and diseases problems	Strongly agree	59	37.80
	Agree	94	60.30
	Disagree	1	0.60
	Strongly disagree	2	1.30
Shortages of pesticides, vitamins, and fertilizers	Strongly agree	8	5.10
	Agree	85	54.50

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Items	Response	N	%
	Neutral	24	15.40
	Disagree	38	24.40
	Strongly disagree	1	0.60
Limited knowledge related to apple farming, processing, and marketing	Strongly Agree	11	7.10
	Agree	80	51.30
	Neutral	31	19.90
	Disagree	34	21.80
Climate c*ha*nge impact	Strongly agree	119	76.30
	Agree	35	22.40
	Neutral	1	0.60
	Strongly disagree	1	0.60
Poor infrastructure (cold storage, transportation, and marketing)	Agree	88	56.40
	Neutral	27	17.30
	Disagree	40	25.60
	Strongly disagree	1	0.60
Total		156	100.00

Mustangi apple is highly affected by insects (caterpillar, shoot borer, leafhoppers, apple maggot) and diseases (powdery mildew, apple scab, foot and root diseases, and cedar-apple rust). Majority (100%) respondents express their dissatisfaction with their cooperative leadership efforts that is still failed managing shortages of pesticides, vitamins, and fertilizers and marketing. Even there is no any cold storage facility which could maintain quality of red Fuji apples after harvesting and enhances the economic value of fruits (Peng *et al*., 2020). Tripathy *et al*. (2021) reveal that Kerala's Pimary Agricultural Credit Societies in India abled to improve their productivity and enhanced their capability to produce goods and services due to their competitive process led by good governance. Besides, majority 154(98.71%) of the respondents agreed that the impact of climate change on apple farming is critical. The main climate threats in Mustang district that are causing the apple crop to produce at a lower rate include rising temperatures, drying up of available water, more Northern winds, high-speed winds, less snowfall, and extended periods of drought. Similar to this research's finding, the climatic impact on apple farming was also researched by Khanal (2014). This is the reason that Bai *et al*. (2022) suggested for applying biological control and ecological governance of agricultural pests in a warming climate especially in higher tropics level. There exists multiple challenges in apple farming in Mustang, Nepal. Most of them such as infrastructure development that included road network, storage facilities, collection centers, production of skilled human resources, and climate change impacts need addressed through collaborative efforts of Nepal's local, federal, the central governments, and international communities.

Measurement of association

Multiple regression model (MRM) is developed to predict the outcomes, establish relationship, and support decision making in relation to the apple farming. MRM serves the dependent variable (scale data) through the help of multiple independent variables (binary/scale) at a certain value (Field, 2009). The regression model for the dependent variable average annual income from apple farming concerning 5 independent scale variables (annual expenses for technician's fee, fertilizers/pesticide/vitamin, new seeds, irrigation, and labor) is given below.

Results of the multiple regression model (Table 10) indicated that there was a collective

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significant effect between the independent variables annual expenses for technician's fee, fertilizers/pesticide/vitamin, new seeds, irrigation, and labor with the dependent variable average annual income from apple farming with F (10258392481092.91, 110472400202.88) = 92.85, $p<0.05$, $R^2 = 0.75>0.08$. The independent variables explain 75% of the variability of the dependent variable annual income from apple farming.

Table 10.Coefficients for predictors to describe annual earning ($\bar{x}$) from apple farming

Annual expenses	B	SE	β	T	Sig.	
(Constant)	146825.33**	36597.26		4.01	.00	R-value =.86[a]
New seeds	1.12	.60	.11	1.87	.06	R Square =0.75
Fertilizers/pesticide/Vitamin	.59**	.19	.14	2.99	.00	Adjusted R square = 0.74
Irrigation	30.39**	6.27	.36	4.84	.00	SE of the estimate =
Labor	2.47**	.46	.45	5.32	.00	332373.88
Technician fee	-6.09	6.24	-.08	-.97	.33	

**$p < .01$

All the predictor variables were not found significant. Among them expense for fertilizer/pesticide/vitamin (t= 2.99, $p<0.05$), irrigation (t= 0.36, $p<0.05$), and labor (t= 5.32, $p <0.05$) are the significant predictors in the model. We explored that the dependent variable annual average income from apple farming is largely associated with the independent variable yearly expenses for irrigation purposes and poorly associated with yearly expenses on expertise visits. The respondents having irrigation facilities are on top of annual average income, and their income was significantly higher than the others having without irrigation facilities. So, the expansion of irrigation facilities in apple farms can enhance the productivity of the apple business.

CONCLUSIONS

Apple farming is becoming more profitable product to the farmers. It is becoming prominent source of family earnings in Mustang. It has brought multiple social and economic returns to the local farmers. For the social return, apple farming helped to improved livelihoods and preservation of traditional farming practices. The farmers' investment in their children's education plays a pivotal role in generating long-term social returns by reducing social inequality, and fostering a more resilient and prosperous community. Apple farming has positively influenced the living standards and quality of life for farmers' families, with the majority reporting good access to nutritious food and perceiving improved family well-being. Furthermore, the high level of participation in various community institutions, such as farmer groups, cooperatives, school management committees, and youth clubs, reflects strong social cohesion and collective responsibility, contributing to the smooth functioning of the community. Accordingly, for the economic return, apple farming has generated significant economic returns through job creation, increased efficiency with modern technology, and sustainable farming practices. However, challenges such as inadequate infrastructure, limited market access, and lack of technical knowledge hinder its growth. The Prime Minister Agriculture Modernization project has improved farming practices, family well-being, and living standards, contributing to economic development in Mustang district. However, the farmers are facing pest management, poor cooperative leadership, and impact of climate change related challenges. Therefore, government mechanism need to provide technical

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support related to adaptation, business management and skill training. Infrastructure such as cold storage, transportation, and irrigation, along with affordable access to modern inputs, are essential. Government mechanism also need to manage pricing policies and marketing channels to maximize farmers' profits. Additionally, establishing fruit processing centers in Mustang can boost both agriculture and agro-tourism, contributing to local economic growth.

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Authors' Contributions
Conceptualization and methodology: Bishnu Bahadur Khatri and Rajan Binayek Pasa
Software and validation: Rajan Binayek Pasa and Devendra Adhikari
Formal analysis and investigation: Rajan Binayek Pasa, Chandra Purja, Devendra Adhikari,
Resources: Bishnu Bahadur Khatri
Data curation: Chandra Purja
Writing-original draft preparation: Bishnu Bahadur Khatri, Rajan Binayek Pasa, Devendra Adhikari
Writing revised draft and editing: Bishnu Bahadur Khatri, Rajan Binayek Pasa, Chandra Purja
Supervision: Bishnu Bahadur Khatri.

Conflicts of interest
The authors declare no conflict of interest.

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