

Enhancing Apple Production and Market Linkages in Mountain Regions: Challenges and Opportunities

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Abstract

This article reviews the current state of apple production in mountain regions, emphasizing the challenges faced by farmers and the opportunities to enhance market linkages. Based on case studies at the municipal level of Jumla district and existing literature, the study identifies key factors influencing production and market access. It proposes strategies for improvement, and highlights the importance of sustainable practices for the development of apple production, market linkage and sustainable agriculture in rural areas. Spatial locations of the study area are relatively safe from different kinds of risks and viable for apple farming at commercial level. Further, the natural, cultural and ecological conditions of these specific locations are suitable to promote organic apple farming with agro-based enterprises development activities. Study clearly evinces that capacity development of apple cultivation farmers needs to enhance for increasing apple production and marketing in wright for livelihood improvement and ecological stability in the mountain region. It is suggested that municipal annual plan needs to prioritize apple production and make link mechanism development for the rapid economic development (growth), social change and environmental balance.

Keywords: Apple production, market linkage, mountain regions, sustainable agriculture, rural development

Introduction

Apple production plays a vital role in the socio-economic development of mountain regions. Here are several key reasons why apple cultivation is crucial for these economies. In many parts of the region, apple farming is a primary source of income for rural households. Due to the limited availability of flat, arable land for crops like grains, apples thrive in the cooler, higher-altitude conditions, offering farmers a reliable crop that can be grown on sloped terrain. Rural communities often rely on apple sales to meet their basic needs, fund education, and access healthcare (Reynolds, 2004).

The apple value chain, from cultivation to harvesting, packaging, and distribution, provides numerous employment opportunities. Seasonal labor is required for tasks like pruning, harvesting, and sorting, creating jobs for local communities. Additionally, activities related to processing and marketing apples further contribute to employment, especially in regions where large-scale agricultural enterprises are limited. Further, apple farming stimulates local economies by generating income and promoting local markets. Apples are often sold in both fresh and processed forms (such as juice, cider, and dried apples), allowing smallholders and cooperatives to capture more value from their produce. This income can then circulate within the community, promoting economic resilience in remote areas (Pokhrel, 2021).

Mountain-grown apples are often prized for their quality and unique flavor, which can be a competitive advantage in domestic and international markets. In regions where transportation infrastructure is developed, apples are exported, bringing in foreign exchange and contributing to the overall economic growth of the region. Exporting apples to neighboring districts and regions can also strengthen trade relations and enhance the profile of the region's agricultural sector. It is evident that from the global level research for mountain farmers, apple cultivation offers a means of agricultural diversification. Unlike many crops that may be highly susceptible to environmental conditions, apples especially when grown with improved varieties and modern practices can provide a reliable harvest even in challenging climates. This helps reduce the risk of income loss due to crop failure, which is important in regions where climate variability is high.

In many geographical settings of mountain region of Nepal apple orchards will have become a part of the agro-tourism economy. Tourists would be attracted by the scenic landscapes, seasonal fruit-picking activities, and local produce markets. This not only promotes tourism-related income but also helps market local apples to a wider audience, creating additional revenue streams for farmers (Koirala and Shrestha, 2015).

While apples are predominantly a cash crop, they also can contribute to local food security by providing a source of nutritious fruit to the local population. Apples are rich in vitamins and fiber, supporting the health and dietary needs of people in remote mountain regions who may have limited access to a diverse range of foods. Scientific research probe that apple orchards in mountainous areas often have positive environmental effects, including soil conservation and prevention of erosion, which is crucial in mountain region of Nepal which is prone to landslides or degradation. The agroforestry approach to apple farming can maintain biodiversity, reduce deforestation, and contribute to more sustainable agricultural practices in fragile mountain ecosystems (Wolfram & Berard (2015).

The mountainous terrain in Jumla limits the availability of arable land, making it difficult to expand apple orchards. Additionally, harsh winters and erratic rainfall can affect both apple quality and yield. It needs to improve irrigation systems and adopt climate-resilient apple varieties to mitigate the impacts of climate change and weather variability. Similarly, Jumna's remote location presents logistical challenges in transporting apples to larger markets. Poor road conditions and a lack of cold storage facilities lead to significant post-harvest losses. So that it seems too necessary to develop improved road networks and establish cold storage facilities in Jumla to reduce post-harvest losses and improve market linkages (Singh,1996). The next issue of apple farmers in Jumla often rely on traditional farming methods and lack access to modern agricultural tools and techniques. This results in lower productivity and inferior quality compared to other apple-producing regions. Thus, provide training and access to modern farming technologies, including improved apple varieties, pest control methods, and sustainable farming practices is necessary. Moreover, it is seemed that farmers in Jumla have limited access to real-time market information, leading to poor bargaining power and exploitation by intermediaries. Apple prices are often volatile, leaving farmers vulnerable to price shocks (Evans, 2013). There is low efforts to establish a market information system that provides real-time updates on prices and demand, empowering farmers to make informed decisions and negotiate better deals. Innovative researches also require to review the local apple processing farmers' ability to add value to their produce that can promote fresh apple sold and reduce to waste by introducing processing facilities to produce dried apples, apple juice, or other products. Apple orchards in Jumla are increasingly vulnerable to pests and diseases, such as apple scab and codling moths (Poudel and Koji, 2013). Farmers often lack the knowledge and resources to manage these issues effectively. Many apple farmers in Jumla operate individually, lacking cooperative structures that would enable them to pool resources, share knowledge, and collectively negotiate with buyers. Sustainable interventions guided by these objectives could uplift the economic status of farmers in Jumla and position the district as a key player of apple farming and marketing in Jumla including mountain region in Nepal (Shrestha, 2012).

Apples are believed to have originated from the wild apple forests of Central Asia, particularly the Tien Shan Mountains. Kalinsky and Morris (2001) traced the evolutionary origins of apples, identifying wild *Malus sieversii* as the ancestor of modern cultivated apples. The spread of apples along the Silk Road helped introduce apple cultivation to various mountainous regions, including the Himalayas and the Caucasus. Koirala and Shrestha (215) had explored that how ancient trade routes facilitated the spread of apples and other fruits. The introduction of cultivated apple varieties to mountain regions through European traders and missionaries is well-documented. European

colonial powers, particularly the British in India, brought new apple varieties to the Himalayas. Shrestha (2012) discussed the role of British settlers in introducing modern apple cultivation practices to the mountain regions of India, especially Himachal Pradesh. In Europe, traditional orchard systems in mountainous regions such as the Alps and the Pyrenees were developed. Reynolds (2004) highlights the adoption of European apple varieties in mountain agroforestry systems, particularly in the Alps. The Green Revolution, with its focus on agricultural modernization, had a significant impact on apple production in regions like the Indian Himalayas and Nepal. Singh and Adhikari (2010) examined the rise of apple farming as a commercial venture in Nepal, particularly in regions like Jumla and Mustang.

The introduction of high-density planting systems and the use of drip irrigation in apple orchards revolutionized productivity in mountain regions. Evans (2013) explained how these modern techniques have been adopted in mountainous regions like the Alps and the Himalayas. The push towards organic farming and sustainability, especially in Europe and parts of Asia, has further transformed apple production. Wolfram & Berard (2015) explored the trend towards organic apple farming in mountain regions and its growing market demand.

The rise of global markets and the availability of cold storage technologies have allowed apples from mountainous regions to enter international markets. Singh (1996) analyzed the impact of global trade on apple farmers in Himalayan regions. The shift towards producing value-added products, such as apple cider and dried apples, has further diversified the apple economy in these areas. Goldstein (2018) documented the evolution of apple-based industries in European and North American mountain regions. Climate change has become a major issue for apple farmers in mountainous regions, with warming temperatures affecting traditional growing cycles. Battista and Naylor (2009) discussed how climate change is altering apple production patterns in high-altitude regions. Despite these challenges, the future of apple production in mountainous areas remains promising, with growing interest in sustainable and organic practices. Pokhrel (2021) has provided insights into how apple farming is adapting to environmental challenges through innovative practices (Reynolds (2004) .

Jones, Edward (2010) noted that modern apple cultivation, particularly in commercial settings, emphasizes increased efficiency, higher yields, and the use of technology to maximize profitability. These practices are often associated with large-scale production in developed mountain regions such as the Alps or the Pacific Northwest. Evans (2013) analyzed the benefits of high-density planting in terms of improved yields and space efficiency, which has become standard practice in commercial apple farming. The use of synthetic fertilizers and pesticides poses environmental risks, such as soil degradation

and water pollution. Goldstein (2018), reviews the environmental consequences of modern apple farming, particularly the over-reliance on chemical inputs.. *Battisti and Rosamond (2009)*, said that many farmers have begun to integrate traditional and modern apple cultivation methods, especially in regions where sustainability and environmental concerns are at the forefront. Hybrid practices focus on optimizing yields while minimizing environmental impact through organic or sustainable farming methods.

Improving market linkages for smallholder farmers, especially in remote or mountainous regions, is crucial for enhancing market access and participation in value chains. Studies in this area examine how farmers can better connect to buyers, processors, and exporters. International Institute for Environment and Development (IIED), London (2009) stated that the business models of market linkage.. *Koirala, and Shrestha (2015)*, examined the role of farmer cooperatives and local market hubs in linking apple and vegetable producers in Nepal to domestic and export markets. They discuss how collective action can help smallholder farmers overcome market barriers and capture more value in the supply chain (*Kaplinsky and Morris 2001*)..

The existing research on market access and value chain analysis provides valuable insights into the challenges faced by smallholder farmers, particularly in remote or mountainous regions, and the opportunities to improve their market participation. Studies by **Barrett (2008)**, **Kaplinsky and Morris (2001)** and **Singh and Adhikari (2010)** offer frameworks and case studies that highlight the importance of infrastructure, market linkages, and value chain upgrading for enhancing farmer incomes and improving livelihoods (*Lima, Peru (2014)* reviewed donor-funded value chain projects focuses on smallholder farmers and how value chain development can increase their market participation. Donovan and Poole assess the outcomes of various projects, discussing both successes and limitations in value chain development in rural areas. They emphasize the need for long-term investments and coordination among stakeholders. *Singh and Adhikari (2010)*, focus on the value chain of apple farming in the Himalayan regions of Nepal. They identify key actors involved in the apple value chain, from farmers to exporters, and analyze how value is distributed along the chain. The study also highlights the challenges apple farmers face in capturing higher value due to market inefficiencies and limited access to global markets. *Similarly, Gary and Karina (2011)*, emphasized on global value chain analysis outlines the key concepts and tools for analyzing agricultural value chains in a global context. They discuss how smallholders in developing regions can integrate into global value chains by upgrading their production methods and linking to higher-value markets.

Methods and Materials

Multidisciplinary study design and integrated approach were employed to investigate out the current situation of apple farming and its marketing to validate the location specific-innovative practices. Both qualitative and quantitative data were collected and analyzed using appropriate qualitative and quantitative research methods and techniques. A participatory process was adopted to collect field based information on apple farming practices, apple production, marketing channel and their link to sustainable livelihoods improvements for mountain rural communities. The field assessment of the study was guided by prevailing theories and principles of the farm-field school (FFS) approach and Life Cycle Assessment (LCA). This approach assisted to incorporate general observations, data collection, literature review and household surveys. Both descriptive and comparative study design were applied to present the comparative scenario of apple production and its market linkage in the mountain ecological region of the Karnali Province. (Wolfram, 2015). The overall study framework is presented in figure 1.

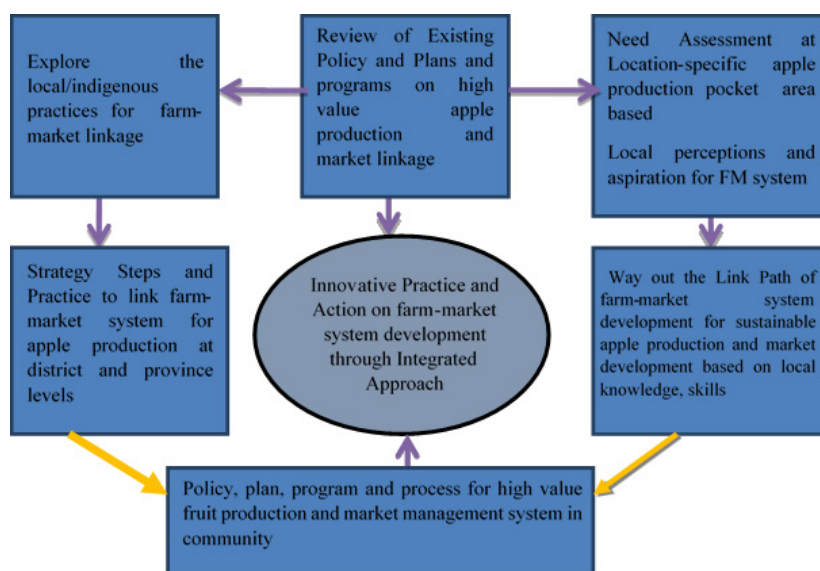


Figure 1: Methodological framework of the study

About 50 respondents were selected from five rural municipalities and one municipality of Jumla district. The location map of the study is presented in fig-2.

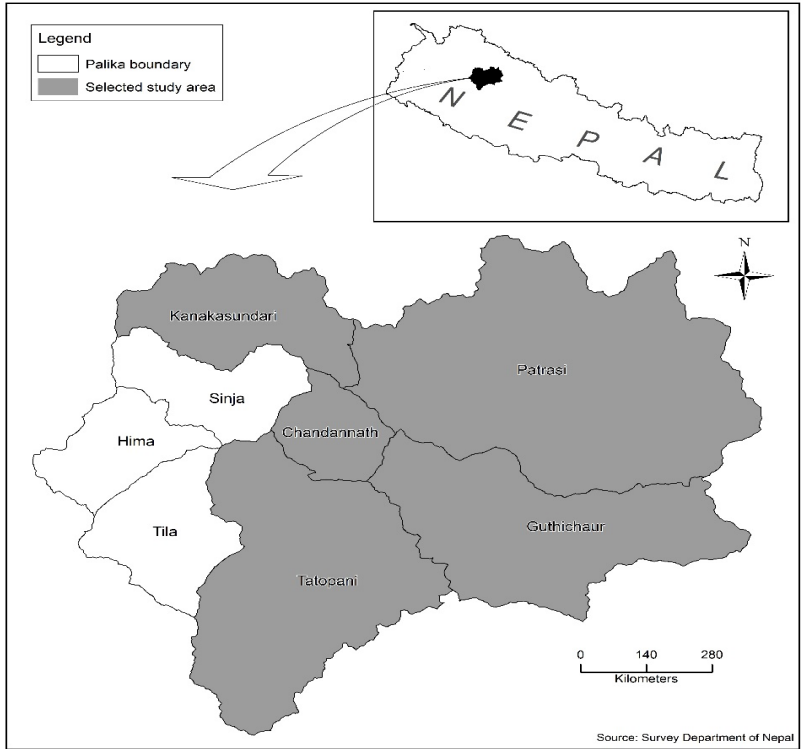


Figure 2: Location map of the study area

Results and Discussion

Apple production

The respondent apple farmers from the selected five municipalities of Jumla district said that their municipalities have been classified as the super zone of apple production. They further stated that approximately 10,000 ropani of land is annually used for apple production in the district. The average apple production reported was 10,000 kg per ropani. However, these basic and average statistics vary based on the with municipality and willingness of farmers to engage in apple farming (table-1).

Table 1 depicts land area used for apple farming in the study area. Approximately 10,000 sq/km land is used for apple farming with an average landholding size of 20sq/km. the table also shows the distribution of landholdings by size and productivity of land which varies based on the municipality. The production of apple has been estimated 10,00,000 Kg with 1000 kg/sq/km. The majority of the apple farmers reported using compost manure with very few chemical fertilizers.

Table 1: depicts land area used for apple farming in the study area

Characteristic	Category	Number of Respondents	Percent
Land Holding Area km	≤ 10,000 sq.km.	36	72
	>10,000 sq.km.	14	28
	Mean S.D = 8178 ± 4943.323 sq.km.	Range = 20500	
Productivity of Land kg/ km	≤ 10,000 kg	32	64
	>10,000 kg	18	36
	Mean S.D = 12104 ± 16143.109 kg	Range =99500	
Fertilizers used	Compost	32	64
	Chemical	18	36

Source: Field Study, 2023

Challenges in apple production

A significant portion of the population in the study area relies on agriculture and related activities for their livelihoods. Apple farming has been traditionally practiced in the region, but it has recently gained importance as a commercial farming activity for improving livelihoods. However, farmers face various challenges that hinder the commercialization and sustainable improvement of their livelihoods through apple farming. Farmers also perceive a weak role and responsibility of local provincial and federal governments in supporting sustainable livelihood improvement through apple farming.

Table 2: Problems and challenges for apple production perceived by apple farmers (n=50)

Faced problems and challenges	No.of respondents	Percent
Unavailability of inputs (fertilizers, pesticides, phytohormones, irrigation, etc.)	27	14.6
Lack of technical knowledge	35	18.9
Shortage of manpower	16	8.6
Climate change Impact	27	14.6
Lack of Farm Insurance, Loan facility	22	11.9
Poor Infrastructure	9	4.9
Shortage of agriculture tools	2	1.1
Disease, insecticides and pest problems	37	20
Lack of quality planting materials	8	4.3
Others	2	1.1

Source: Field Study, 2023

Table-2 shows the problems faced by farmers during apple production. Around 20 percent respondent stated that diseases, insecticides and pest are the main problem, followed by lack of technical knowledge (18.9%), unavailability of inputs (fertilizers, pesticides, phytohormones, irrigation, etc.) (14.6%), effects of climate change (14.6%), lack of farm insurance, loan. At the same time, more than 25 percent respondents perceived poor transportation as the major problems in apple marketing followed by poor marketing infrastructure and storage problem agriculture tool (23.6%), Poor technical knowledge (18.2%), low quality of production(13.5%), lack of packaging materials (8.8%), poor bargaining capacity (6%) and price variation (4.1%).

Market linkage issues

Apple farmers and district level stakeholders reported that apple farming has evolved over the centuries in an often harsh and difficult environment. The lifestyles and beliefs of mountain communities have inspired them to seek sustenance from the farm but also to strengthen market system to boost up their farm production. Stakeholders opined that the market is vital to increase apple production and improve farmer's livelihoods. They stressed on market integration of organic apple farming to change socio-economic status and human values and aspirations for the overall progress of the study area. Market links for apple production are to be vital source of income that can significantly improve the lives of farmers and overall development. They noted that the possible factors and agents for market link promotion are to be commission agents, retailers, farmers, the agriculture development office, the Jumla Apple Super Zone, and social media that play important roles in the marketing of apples in proper way. The suggested linkage of the apple market is presented in figure -3.



Figure 3: Market linkage of apple production

Opportunities for improvement

Apple farming in Jumla, a district which has a great potential for improvement and market linkage enhancement. The geographical setting and climate allow for the production of high-quality apples. The study findings reveal several opportunities for growth and optimization. Among them adoption of modern horticultural practices, such as high-density planting, drip irrigation, integrated pest management, and the use of organic fertilizers could be a game changer to improve yield and quality. For this, investing

in research to develop disease-resistant apple varieties suited to the local climate and training farmers on best practices in pruning, soil management, and tree health can help boost productivity. Similarly, adequate cold storage infrastructure, leading to post-harvest losses can be reduced by establishing modern cold storage systems that will reduce wastage and extend the shelf life of apples. Further, establishing proper sorting, grading, and packaging facilities ensures that apples meet quality standards, which can help attract better market prices. Most of the stakeholders argued that organizing farmers into cooperatives can strengthen their bargaining power, provide better access to inputs, and facilitate collective marketing, reducing the influence of middlemen. Moreover, improving road networks and transportation from remote areas like Jumla to major urban centers could help farmers' access larger markets more efficiently. Furthermore, connecting farmers with retailers, wholesalers, and distributors can enhance market opportunities. Apple farmers perceived that targeting niche export markets, especially organic or high-altitude apple markets, could significantly increase profitability and certification as an organic or specialty product would open access to international consumers willing to pay a premium. Similarly, investing in local processing units for apple juice, dried apples, apple cider, and other by-products can add value and reduce the risk of wastage practices, market trends, and the benefits of cooperatives will help them adapt to changing and creating a unique brand identity for Jumla apples (such as *Himalayan Organic Apples*) would help differentiate the product in both national and international markets. The most important event that needs to address immediately is educating farmers on sustainable agriculture market conditions and technology and providing training on financial management, access to credit, and loans can empower farmers to invest in infrastructure and technology. Government efforts on ensuring access to government grants, subsidies, and low-interest loans for the development of infrastructure like cold storage and transport facilities, increasing the role of local agricultural extension services and research institutions to support farmers with innovative farming methods and market insights, encouraging farmers to adopt agroforestry and organic farming practices can boost long-term sustainability and appeal to environmentally conscious consumers, and with climate change affecting traditional agricultural cycles, introducing climate-resilient apple varieties and water-efficient farming methods is critical. Further, all level governments need to create digital platforms or partnering with e-commerce platforms can help farmers sell directly to consumers or retailers, increasing their income and reducing dependence on traditional markets and providing mobile apps for real-time market price updates, weather forecasts, and access to agricultural advice.

Conclusion

Climatic condition, geographical location and soil nutrient of the study area permit the practice of organic apple farming at small as well as commercial scale effectively. Therefore, a comprehensive development program needs to set up to increase the productivity of the apple farm production. Commercialization of apple farming with sufficient supports of technical know-how, inputs and market facilities for apple production could be a game changer strategic steps for shifting from traditional substance rural life style of rural mountain communities into modern and competitive livelihood through implementation of apple super zone area of the district. It could be an instrumental tool for overall productivity of farm resources. Spatial locations of the study area are relatively safe from different kinds of risks and viable for apple farming at commercial level. Further, the natural, cultural and ecological conditions of these specific locations are suitable to promote organic apple farming with agro-based enterprises development activities. This study clearly evinces that capacity development of apple cultivation farmers needs to enhance for increasing apple production and marketing for livelihood improvement and ecological stability in the mountain region.

By addressing the identified constraints and leveraging available opportunities, for right holders and stakeholders can work together towards enhancing the effective efforts involving policy, technology and ecological sustainability in the development of apple farming in Jumla. Collaborative efforts involving policymakers, agricultural extension services, farmer groups, and market intermediaries are essential for achieving the desired outcomes and improving the livelihoods of apple farmers in Jumla. Regarding the facts and figures of the study some policy recommendations are put forward to address further action oriented activities by academic institutions and government organizations.

- Government initiated agricultural pocket area under the Prime Minister Agriculture Modernization Project, apple production super zone in Jumla needs to be promoted through mix up of modern technology and traditional wisdom. Beside the targeted apple cultivation has to emphasize on ensuring location -specific innovative and novel practices by combining traditional practices and scientific knowledge for taking multifarious benefits from the apple farming.
- Local farmers have to be encouraged by providing necessary technical and financial supports from federal, province and local governments with first priority to use these resources to promote the livelihoods of locals adopting the principles of sustainability.

- Apart from apple production, agro-based, medicinal and aromatic herbal plants and non-timber forest product plant species-based entrepreneurship development has to be encouraged in the study area.
- Municipal annual plan needs to prioritize apple production and market link mechanism development for the rapid economic development (growth), social change and ecological stability.
- Location specific apple farming extension actions need to be implemented by applying local skills and techniques in all viable locations.
- Physical infrastructure developments over time and across the region need to be preserved and good practices in mountain farming are to be designed and execute in such area where the apple farming, its production and marketing can be promoted.
- Simultaneously, inappropriate techniques used in mountain environments can quickly lead to erosion, land degradation and even desertification. Thus, innovative techniques and traditional knowledge need to be carefully integrated into modern technology to increase the productivity and restore resilience, with the promotion of a repository of successful practices at farm level.
- Capacity development of local communities is essential to raise awareness on public responsibility for utilization and conservation of land, forest and water resources by adopting the principles of sustainable development.

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