RESEARCH ARTICLE Bhartiya Krishi Anusandhan Patrika, Volume 40 Issue 3-4: 326-334 (September and December 2025)

Supply Chain Management Practices among Apple Growers of Shimla District in Himachal Pradesh

Ankush Kumar[1], Jai Singh Parmar[1]

10.18805/BKAP867

ABSTRACT

Background: Apple fruit is the major horticultural crop cultivated in the state of Himachal Pradesh. Shimla district is the largest apple producer among all districts of Himachal Pradesh. Though significant studies related to Apple fruit marketing and understanding of Apple's supply chain management have been conducted in the past of the state. However, there is a discernible gap in understanding the supply chain management practices adopted by apple growers in Himachal Pradesh. This highlights the need for the present study to provide a comprehensive analysis of the key determinants influencing apple farmers' supply chain management practices, as well as the impact of supplier selection criteria and institutional support on SCM practices in the Shimla District of Himachal Pradesh.

Methods: In order to meet the objectives of the study well-structured questionnaire was administered among the respondents to collect the required information. For the selection of the respondents, the non-probability sampling method, *i.e.*, convenience sampling, was used in the study. The data thus collected was analysed through, descriptive and advanced statistical techniques such as Cronbach's alpha for reliability analysis, descriptive statistics and advanced statistical techniques such as multiple regression.

Result: The findings of the study revealed that there is strong internal consistency across all constructs, ensuring the reliability of the instruments used. The regression analysis revealed that there is a significant and positive relationship between supplier selection criteria, institutional support and SCM practices.

Key words: Apple farmers, Market dynamics, Supply chain management practices.

INTRODUCTION

Apple crop predominates the horticulture sector of Himachal Pradesh, claiming about 48.92 per cent of the total area under fruit crops and about 82.53 per cent of the total fruit production (Economic Survey, Himachal Pradesh 2022-2023). Within the state, Shimla districts alone contributes more than half of the production and over one third of the cultivated area, underscoring its central role in apple-based livelihoods. Despite its prominence, the apple sector faces persistent challenges related to productivity, marketing and supply chain inefficiencies. Past studies highlight issues such as poor quality seedlings, limited adoption of quality standards, post harvest losses and the dominance of marketing channels where intermediaries capture a large share of consumer expenditure (Sharma and Guleria, 2020; Getahun *et al.*, 2018). While government initiatives such as subsidies, training programs and cold storage facilities have attempted to improve efficiency (Sayin *et al.*, 2009), growers continue to struggle with fragmented linkages, limited coordination and weak value chain integration. These problems show that supply chain management practices (SCMP) need to be improved to make them more efficient, competitive and profitable for growers.

However, the majority of existing research on apple cultivation in Himachal Pradesh has focused on production economics, marketing margins, or consumer perspectives on fruit quality (Chanda, 2018; Djekic *et al.*, 2019). Relatively little attention has been given to a systematic analysis of supply chain management practices-such as supplier selection, information sharing and strategic partnerships-and their influence on the performance of apple growers. This creates a significant research gap in understanding how SCM theory can be applied to the horticulture sector in a regionally specific context.

The present study addresses this gap by evaluating the supply chain management practices of apple growers in Himachal Pradesh using a structured SCMP framework. By linking globally recognized SCM dimensions with field-based evidence from growers, this research not only positions apple cultivation within broader SCM theory but also contributes practical insights for policymakers and stakeholders. The novelty of this study lies in systematically connecting supply chain practices with grower performance outcomes, moving beyond descriptive analyses of marketing channels to a comprehensive assessment of supply chain efficiency.

Amgai *et al.* (2015) conducted a study on the marketing practices of apple farmers from two village development committees (VDC) namely Kobang and Tukuche of Western Nepal. The findings revealed that the pre-harvest contractual

[1]Himachal Pradesh University Business, Summerhill, Shimla-171 005, Himachal Pradesh, India.

Corresponding Author: Ankush Kumar, Himachal Pradesh University Business, Summerhill, Shimla-171 005, Himachal Pradesh, India. Email: ankushvml495@gmail.com

How to cite this article: Kumar, A. and Parmar, J.S. (2025). Supply Chain Management Practices among Apple Growers of Shimla District in Himachal Pradesh. *Bhartiya Krishi Anusandhan Patrika*. **40(3-4):** 326-334. doi: 10.18805/BKAP867.

Submitted: 30-06-2025 **Accepted:** 30-09-2025 **Online:** 20-11-2025

system was the primary selling method for apple crops in the Mustang district of Western Nepal. The major challenges for traders were identified as transportation and market information gaps in the Apple marketing process in the region. Atreya and Kafle, (2016) examined that apple crop in the Jumla district is produced more than other crops due to its higher profitability but challenges like insect pests and market issues hinder optimal production and marketing. Also, limited supply due to storage constraints affects market fulfillment. Khadka and Solberg, (2020) explored that the government of Nepal has supported farmers of apple crops in many ways such as by providing apple processing facilities, well-established wholesale markets, providing technical assistance in production and subsidizing saplings to poor and needy farmers. However, apple farmers have faced some basic issues like proper input supply of saplings from nurseries and, lack of knowledge about pollinating variety for improving yields. Also at the production level farmers have complained about apple disease and pests, no proper irrigation and no storage facility. Shah, (2020) addressed major issues such as a lack of storage facilities, packaging material shortages, malpractices by commission agents, poor road infrastructure, labor shortages and insufficient processing centers**.** Studies in Himachal Pradesh further reveal that amended APMC acts significantly shaped apple business structures and price realization, reinforcing the importance of market institutions in fruit supply chains (Mustfa and Singh, 2017). Somashekhar *et al*. (2014) identified that the development of information access and supply chain coordination could significantly benefit the agriculture sector by reducing post-harvest losses, lowering transaction costs and improving awareness. These two aspects of agriculture supply chain management can help solve food problems not only in India but globally as well. Chanda (2021) reviewed Himachal Pradesh Government Policies, subsidies and their awareness among horticulturists. Various schemes like technological upgradation, manure and fertilizers, Kisan credit cards, training programs for orchardists, horticulture marketing, insurance, marketing intervention schemes, *etc.* for apple growers lack proper implementation which is the cause of ignorance among growers related to these schemes. Also, high time consumption is the major reason among growers for not applying for subsidies like funds for nursery development, subsidy on horticulture equipment, pesticides, fertilizers, land development, irrigation facilities, anti-hail nets, grading machines, *etc*. Kireeti and Sharma, (2017) investigated that at the production level growers face problems like shortage of labour, lack of availability and knowledge of chemical fertilizers, plant protection chemicals and plant material, farm yard manure and irrigation problems. At the marketing level shortage of grading and packing labour, packing material, lack of storage facility, transportation of produce, marketing intelligence, malpractices in the market and market intervention schemes are faced by growers which need to be resolved by matching services with international standards provided by government agencies and private players. Negi and Anand, (2015) investigated the issues and challenges of the supply chain of the fruits and vegetables sector in India. The study found that cold chain facilities, fragmented supply chain, linkages and integration between the partners, infrastructure facilities, farmer's knowledge and awareness; quality and safety standards, transportation facilities, etc are factors that impose serious challenges for fruits and vegetables sectors. More recent estimates of post-harvest losses in Indian fruit chains confirm that systemic inefficiencies persist at the production, wholesale and retail nodes (Pundir *et al*., 2025). Wani and Songara, (2019) examined the production and marketing efficiency of apple farming and various constraints found in these two functions. The findings revealed that shortage of labour, chemical fertilizers, plant protection chemicals, financial problems and lack of irrigation facilities are constraints in the production of apple crop and lack of grading, packing labor and packing material, lack of communication intelligence and storage facility, malpractices in the market, transport problem and market intervention scheme are constraints in the marketing of apple fruit.

Past research has highlighted two key challenges within Apple's supply chain, the first pertains to Apple production and marketing, which needs to be addressed through the study of supplier selection parameters adopted by Apple growers to meet the need for inbound logistics. The selection of the right supplier for inbound logistics helps in the reduction of production-related issues. The second revolves around government policies and their implementation, particularly examining the institutional support offered by governments to apple growers across the supply chain. Understanding these challenges is crucial for improving the effectiveness of Apple's supply chain. Further, this knowledge helped in conceptualizing the core of the study, *i.e.* relationship between supplier selection criteria, institutional support and supply chain management practices.

Fig 1 shows a conceptual research framework projecting two predictor variables such as Supplier selection criteria and institutional support, whose effect on supply chain management practices is proposed to investigate. And the dimensions included under SCM practices are strategic partnership, customer relationship, information sharing, information quality and postponement. Every supply chain begins with the raw material supplier, which highlights the crucial role of inbound logistics in any supply chain, regardless of the industry. Concerning apple crops also, price, quality of raw material, reliability of the supplier, delivery of the raw materials, long-term relationship and confidence towards the supplier and personal relationship with the supplier, etc. highlights the various factors taken under consideration for a long-term relationship with the supplier. Institutional support refers to the different types of aid and facilities provided by Government or Agricultural agencies to apple growers such

as dissemination of market information, fair market environment, regulated market practices, transactional transparency and availability of necessary support, *etc*. Supply chain management practices (adopted from Li *et al.,* 2005) represent the different dimensions of the practices carried out by apple growers.

Need for study

The existing literature highlights the critical challenges within the apple supply chain, particularly concerning production, marketing and the impact of government policies on apple growers. These challenges include issues such as transportation, market information gaps, lack of storage facilities, malpractices by commission agents, shortage of labour, inadequate implementation of government schemes and subsidies, *etc*. These multifaceted challenges necessitate a comprehensive study to delve into the interplay between supplier selection criteria, institutional support and supply chain management practices within the apple industry. The understanding of these dynamics is crucial for addressing inefficiencies, reducing post-harvest losses, enhancing market access and improving overall competitiveness within the apple supply chain in the Shimla district of the state of Himachal Pradesh.

Objectives of the study

The study was undertaken keeping in view the following objectives

1. To assess key determinants influencing apple farmers' SCM practices in Shimla district of the state of Himachal Pradesh.
2. To analyze the impact of supplier selection criteria and institutional support on SCM practice in Shimla district of the state of Himachal Pradesh.

Hypothesis of the study

Based on the objectives of the present study, the following hypothesis has been formed

H_1: There is a significant interaction effect of supplier selection criteria and institutional support on supply chain management practices.

This hypothesis testing will help us to understand the relationship between supplier selection criteria and institutional support having a significant effect on supply chain management practices and to what extent these two predictors can anticipate the variations in the supply chain management practices *i.e*. outcome variable adopted by Apple growers in the Shimla District of Himachal Pradesh.

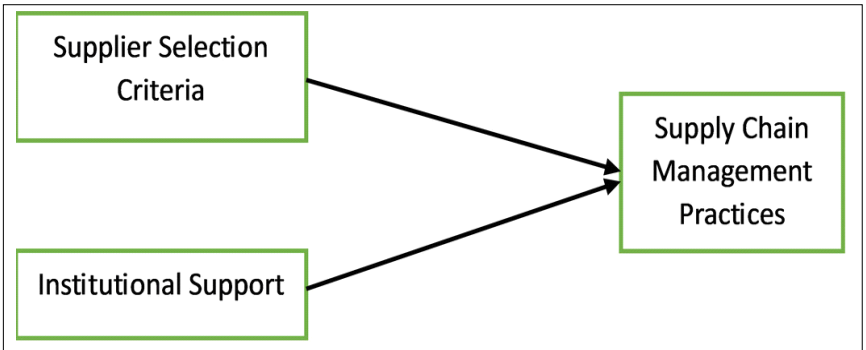
MATERIALS AND METHODS

To acheive the objectives of the study, a well-structured questionnaire was designed and administrated to apple growers residing in different blocks of Shimla District, Himachal Pradesh. The district was selected as the study area for being largest apple producing region in the state, contributing significantly to both cultivated area and overall production. The respondents were selected using a non-probability sampling method, specifically convenience sampling which was considered suitable given the disbursed nature of apple growers and the practical challenges of accessing remote areas. Although this method enabled effective data collection, the results are best interpreted as reflective of the selected sample rather than being representative of the entire population of apple growers in the state. The collected information was analysed with the help of various Statistical tools and techniques such as descriptive statistics, reliability of the scale and constructs in it and multiple linear regression analysis using SPSS statistics.

Reliability analysis

The reliability of a scale that has been used was .933 having 50 items in it. The same reliability analysis has been conducted for each construct of the study and the results are as follows:

Table 1 shows that each construct is reliable for the present study and has a good Cronbach's alpha value. Supplier selection criteria (.848) and postponement (.847) construct have a good level of internal consistency. The construct of customer relationship (.769) and information sharing (.790) suggests acceptable and reasonable internal consistency respectively in measuring the intended concept.



Source: Adopted from Kantharaj (2011) and Singh (2021) studies.

Fig 1: Conceptual framework of supply chain management practices.

Whereas the reliability value of strategic supplier partnership (.806) has been satisfactory. Also, Information quality (.956) and institutional support (.933) have exceptional internal consistency in measuring the intended concept.

RESULTS AND DISCUSSION

Demographic profile of the respondents

The descriptive statistics revealed that the majority of respondents are male, representing 87.7% of the sample. Females only have a notable portion of 12.3% of the sample. The largest age group among respondents is 25 to 34 years, comprising 50.7% of the sample. Whereas below 25 years of age group represents 6.8% of the sample. The presence of respondents below 25 years indicates the importance of youth engagement in agriculture and the potential for innovation and improved farming practices. In terms of educational qualification, the majority of respondents (54.8%) have attained at least a graduation level of education or higher. Secondary school education is the next most prevalent qualification, comprising 30.1% of the sample. Whereas 12.3% of respondents have attained primary school education. Notably, there is a small percentage of participants (1.4%) who either have no schooling or are classified as illiterate.

Table 2 shows the landholding distribution and experience in apple cultivation among apple growers residing in various blocks of Shimla District of the state of Himachal Pradesh. The classification of land holding has been adopted from a common practice exercised by the Department of Agriculture in the state of Himachal Pradesh. The study shows that the majority of respondents (47.9%) fall into the small category with landholding from 1 to 2 hectares. Whereas, the semi-medium category, covered landholdings of 2 to 4 hectares, with 41.1% of respondents falling into this category. A smaller proportion of respondents have landholdings categorised as medium (8.2%) or Large (2.7%). The data indicates a distribution skewed towards smaller and semi-medium landholdings among the respondents. In terms of level of experience in apple cultivation, the majority of

Table 1: Reliability analysis of constructs measuring supply chain management practices among apple growers in Shimla District.

Measures	No. of items	Cronbach's alpha
Supplier selection criteria	13	.848
Strategic supplier partnership	6	.806
Customer relationship	5	.769
Information sharing	6	.790
Information quality	5	.956
Postponement	10	.847
Institutional support	5	.933

Table 2: Profile of respondents based on landholding and experience in apple cultivation.

Landholding		
Land in hectares	Frequency	Percentage
Large-10 hectares and above	2	2.7
Medium 4-10 hectares	6	8.2
Semi-medium 2-4 hectares	30	41.1
Small 1-2 hectares	35	47.9
Total	73	100
Experience in apple cultivation		
Years	Frequency	Percentage
1-5 Years	9	12.3
11-15 Years	25	34.2
6-10 Years	29	39.7
more than 15 years	10	13.7
Total	73	100

Table 3: Sources of labour utilized in horticultural operations of apple cultivation.

Source of labour				
		Responses		Per cent of cases
		N	Per cent	
Sourceoflabour	Contract Workers	58	43.3%	79.5%
	Permanent Workers	24	17.9%	32.9%
	Family Members	52	38.8%	71.2%
Total	134	100.0%	183.6%	

a. Dichotomy group tabulated at value 1.

respondents have intermediate levels of experience in apple cultivation, with 6 to 10 years being the most common range, accounting for 39.7% of respondents. In contrast, the lowest representation is seen in the 1 to 5 years category, which includes 12.3% of respondents.

Table 3 of the multiple response set shows that apple growers mostly hired Contract workers (43.3%) as labour for apple crop cultivation and other activities, followed by Family members (38.8%). It also indicates that permanent workers (17.9%) are another set of labour hired by apple growers in the Shimla district of Himachal Pradesh.

Table 4 indicates the total expenses on labor per season stated by respondents. The majority of respondents (53.4) have reported incurring expenses ranging from 1 to 2 lakhs per season. Also, about 35.6% of respondents out of the given sample have reported less than 1 lakh expense on labour per season for the cultivation of apple crop. Whereas Only 1.4% reported labour expenses exceeding 3 lahks per season out of the given sample.

Table 4: Seasonal labour expenses of respondents residing in Shimla District of Himachal Pradesh.

Total expense on labour per season		
Amount of expense	Frequency	Per cent
1-2 lakhs	39	53.4
2.1-3 lakh	7	9.6
less than 1 lakh	26	35.6
more than 3 lakh	1	1.4
Total	73	100

Table 5 of the multiple response set shows that apple growers mostly prefer commission agents (50.8%), followed by organized retailers (30.0%) to sell their apple produce in the Shimla district of Himachal Pradesh. It also indicates that APMC (14.2%) is approached by the apple growers as an alternative for the sale of the apple crop. Conversely, in the current scenario, direct sales to consumers and processing firms are less favorable alternatives to apple growers for the sale of apple produce in the district of Himachal Pradesh.

Descriptive statistics

Table 6 indicates that supplier selection criteria (SSC) have a mean score of 51.51 with moderate variability (standard deviation of 6.75). Strategic supplier partnership (SSP) has a mean score of 23.07, with a relatively low standard deviation of 3, indicating less variability compared to SSC. Customer relationship (CR) has a mean value of 18.55 and a standard deviation of 2.91, reflecting a relatively narrow range of values. Information sharing (IS) exhibits a mean score of 22.42 and a standard deviation of 3.18, indicating moderate variability around the mean. Information Quality (IQ) has a mean value of 21.92 with a standard deviation of 3.74, indicating moderate variability. Postponement (POS) has a mean of 25.85 and a standard deviation of 4.65. and institutional support (INSTSPPT) has a mean value of 17.73 and a standard deviation of 4.55,

Table 5: Distribution of buyers in the marketing of apple crop.

Buyers of apple crop				
		Responses		Per cent of cases
		N	Per cent	
Apple Buyers	APMC	17	14.2%	23.3%
	Commission Agent	61	50.8%	83.6%
	Directly to Processing Firms	2	1.7%	2.7%
	Directly to Consumers	4	3.3%	5.5%
	To the Organised retailer	36	30.0%	49.3%
Total	120	100.0%	164.4%	

a. Dichotomy group tabulated at value 1.

Table 6: Descriptive statistics of key constructs in supply chain management practices (mean, standard deviation, skewness and kurtosis).

Descriptive statistics							
	N	Mean	Std. deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Std. error	Statistic	Std. error
SSC	73	51.5068	6.74562	-.731	.281	1.187	.555
SSP	73	23.0685	3.37610	-.112	.281	-.301	.555
CR	73	18.5479	2.91090	.373	.281	.955	.555
IS	73	22.4247	3.17507	.311	.281	.713	.555
IQ	73	21.9178	3.74074	-1.027	.281	.155	.555
POS	73	25.8493	4.65078	.920	.281	1.400	.555
INSTSPPT	73	17.7260	4.55296	-.653	.281	.245	.555
Valid N (listwise)	73						

reflecting moderate variability. The values of skewness and kurtosis in the table for all the variables fall within the acceptable range, suggesting that the distributions of the variable are reasonably close to normal distribution. This simply means that most of the data is clustered around the average, with fewer data points farther away from the average. All the variables of the study received somewhat similar responses from the respondents indicating dependable analysis.

Regression analysis

The regression analysis was conducted to examine the relationship between the dependent variable *i.e*. Supply Chain Management Practices (SCMP) and the predictors, namely Supplier selection criteria (SSC) and Institutional support (INSTSPPT). The hypotheses which was framed is as follows:

H_1: There is a significant interaction effect of supplier selection criteria and institutional support on supply chain management practices.

The analysis worked out in Table 7 shows that the model appears to have a moderate level of fit: F(2.70) = 28.130, p<.001, Adj R^2 = .430 and R^2 = 0.446. The correlation coefficient indicates a moderately positive linear relationship (R = 0.668) between the predicted and actual values of the dependent variable based on the predictors included in the model. The coefficient of determination R square is 0.446, which suggests that approximately 44.6% of the variability in the SCMP can be explained by the predictors SSC and INSTSPPT included in the model. The r square value indicates moderate explanatory power pointing towards the role of other unobserved factors which might influence supply chain management practices. Hence, we accept the alternate hypotheses, that there exists a statistically significant and positive relationship between predictors (SSC, INSTSPPT) and outcome variables (SCMP). The r square value suggests that our model has moderate explainatory power pointing towards unobserved factors which might influence supply chain management practices. However, the factors considered for the model is acceptable to explain considereable portion of variance in SCMP. Keeping this in view, the r square = 0.446 and R = 0.668 just indicates that how strong relationship is between our predictos and SCMP. Supplier selection criteria and instutional support doe indeeed play a significant and positive role in shaping supply chain management practices.

The information analyzed in Table 8 indicates that Supplier selection criteria (B = .512, t = 3.776, P<.001) have a moderate positive impact on SCMP after accounting for the scale of the variables. Institutional support (B = .342, t = 5.650, P<.001) has a weaker positive impact on SCMP compared to SSC. For all coefficients, the t-values are statistically significant (t > 2, p<.05), indicating that the coefficients are significantly different from zero. This implies that both SSC and INSTSPPT are important predictors of SCMP in the model.

On the basis of the analysis, it can be stated that the Supplier selection criteria used by apple growers in the state positively influence the supply chain management practices of the apple growers. Whereas, institutional support appears to be comparatively less influential than supplier selection criteria in determining the supply chain management practices of apple growers in the Shimla district of the state of Himachal.

The findings of this study highlight that among various supply chain management practices, supplier selection criteria exerted a stronger influence on the performance of apple growers compared to institutional support mechanisms. This outcome can be attributed to the fact that reliable suppliers ensure timely delivery of high-quality inputs, which directly impacts yield, reduces post-harvest

Table 7: Model summary of multiple regression analysis for supply chain management practices.

Model summary[a]				
Model	R	R square	Adjusted R square	Std. error of the estimate
1	.668[a]	.446	.430	9.81064

a. Predictors: (Constant), SSC, INSTSPPT.

b. Dependent Variable: SCMP.

Table 8: Coefficient estimates of multiple regression analysis for supply chain management practices.

Coefficientsa						
Model		Unstandardized coefficients		Standardized coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	46.237	9.358		4.941	<.001
	INSTSPPT	.977	.259	.342	3.776	<.001
	SSC	.986	.175	.512	5.650	<.001

a. Dependent variable: SCMP.

losses and enhances product quality. Similar results were observed by Kumar *et al.* (2017) in the Indian grape supply chain, where supplier reliability and input quality were identified as critical determinants of farm-level profitability. Likewise, Mango *et al.* (2018) in a study of Kenyan vegetable growers found that supplier partnerships significantly improved productivity and reduced transaction costs, overshadowing the impact of government interventions. Recent research by Abuzaid *et al.* (2024) further supports this view, showing that supplier selection criteria-both traditional and green-directly enhance firm performance in supply chain systems. Similarly, Fang and Ge, (2023) emphasized that supplier performance evaluation, negotiation and improvement remain critical levers for efficiency in agricultural supply chains. Even the dairy industry also demonstrates supply chain practices, including supplier partnerships and cold chain investments significantly improve efficiency and market outcomes (Sinha and Mishra, 2023).

The relatively weaker role of institutional support in this study is consistent with earlier findings. For instance, Verma and Seth, (2016) reported that government subsidies in the apple sector often failed to address the immediate needs of growers due to procedural delays and lack of awareness. Similarly, Shah and Singh, (2019) noted that institutional programs in mango cultivation in Uttar Pradesh had limited effectiveness compared to private supplier networks, which provided quicker and more reliable services. These findings suggest that while institutional interventions remain important, their impact is often constrained unless they are closely aligned with growers' operational requirements. This observation echoes the conclusions of Kumari *et al.* (2022), who found that during the COVID-19 pandemic, institutional mechanisms in emerging economies were often less effective than supplier-driven flexibility and coordination in sustaining agricultural supply chains. Post-Harvest studies in Indian fruit and vegetable chains similarly highlight that unless institutional support is matched by improvements in handling, grading and storage, significant losses continue to occure (Pundir *et al.*, 2025; Sidhu *et al.*, 2024).

Comparative evidence from other horticultural sectors further strengthens the external relevance of these results. Jain *et al.* (2020), in their study on the banana supply chain in Tamil Nadu, emphasized that supplier quality assurance and long-term contracts had a greater effect on grower income than state-sponsored training programs. In a similar vein, Mwangi and Kariuki, (2019) demonstrated that trust and coordination between suppliers and smallholder farmers in East Africa were more influential in improving market access than institutional schemes. More recently, a study of sustainable vegetable production systems in the Northwest Himalayan region (Frontiers, 2025) highlighted that while institutional support through training and extension was important, marketing channel selection and supplier partnerships were more decisive in shaping farm-level performance. Likewise, Kambalapally *et al.* (2025) in the organic grain supply chain found that supplier reliability and certification standards outweighed policy support in determining procurement efficiency. Moreover, Chopra and Meindl, (2021) argue in their broader supply chain management framework that supplier relationships often serve as the backbone of performance outcomes in perishable commodity chains, given the perishability and time-sensitivity of products. Similarly, insights emerge from value chain studies in pulses, where actor linkage and coordination were found to shape commercialisation more strongly than institutional interventions (Sah *et al.*, 2024).

Despite the strengths of this study, several limitations must be acknowledged. The use of convenience sampling and a regional focus on Shimla District may limit the generalizability of the findings to all apple growers in Himachal Pradesh. Furthermore, the moderate explanatory power of the regression model (R^2 = 0.446) indicates that while institutional support and supplier selection criteria significantly affect supply chain management practices, other factors such as climatic variability, infrastructural limitations and volatile market dynamics may also be influential. Future research could adopt probability-based sampling across multiple districts, include additional explanatory variables such as adoption of digital technologies and cold-chain infrastructure and conduct comparative studies across different horticultural crops and regions to build a more holistic understanding.

CONCLUSION

The comprehensive analysis of the study provides meaningful insights regarding apple growers's supply chain management practices in the Shimla district. The reliability analysis of the scale used in the study yielded satisfactory results, with all constructs demonstrating good to exceptional internal consistency as indicated by Cronbach's alpha values ranging from .769 to .956. this ensures that the measurement instruments employed are reliable in capturing the intended concepts such as supplier selection criteria, supply chain management practices and institutional support. Descriptive statistics revealed that the sample of the study comprises male respondents (87.7%), majorly falling within the 25 to 34 years age group (50.7%). This demography profile highlights the importance of younger farmers engaged in apple production activities. Regarding experience in apple cultivation, a considerable portion of respondents (39.7%) reported 6 to 10 years of experience in horticulture practices. In terms of labor utilization, contract workers and family members are the most common sources of labor, representing 47.9% combined use by respondents under study. Financially, the majority of respondents (53.45%) have incurred labour expenses ranging from 1 to 2 lakhs

per season, demonstrating the economic investment required for apple farming.

The regression analysis revealed that both supplier selection criteria and institutional support exert a significant positive influence on supply chain management practices, with supplier selection criteria demonstrating a slightly stronger effect. However, the model accounted for a moderate level of explained variance (R^2 = 0.446), indicating that while these factors are influential, other variables may also play a critical role in shaping supply chain management outcomes which suggests further research could be done to enhance a deeper understanding of various factors affecting supply chain of apple crop.

From a practical perspective, the findings underscore the necessity of developing targeted policies that strengthen supplier selection mechanisms and institutional support systems. Policymakers could focus on enhancing access to reliable suppliers, promoting transparent procurement practices and expanding institutional frameworks that provide financial, technical and infrastructural assistance. Strengthening these areas may improve not only the efficiency of supply chain management but also the overall economic sustainability of apple growers. Future research should aim to capture additional determinants of supply chain management practices, particularly through broader geographical coverage and inclusion of diverse farm sizes, to provide a more comprehensive understanding of this sector.

ACKNOWLEDGEMENT

The authors sincerely acknowledge the support and cooperation of apple growers in Shimla District who participated in the survey and shared valuable insights for this research. The authors also extend gratitude to Himachal Pradesh University Business School for providing academic guidance and research support. Special thanks are due to field investigators and local stakeholders who assisted in data collection during the study.

Disclaimer

The views and interpretations expressed in this article are solely those of the authors and do not necessarily reflect the official policy or position of Himachal Pradesh University or any other affiliated institution.

Informed consent

Informed consent was obtained from all participants prior to data collection. The respondents were assured that their responses would be used solely for academic and research purposes and complete confidentiality and anonymity were maintained throughout the study.

Conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this research article.

REFERENCES

Abuzaid, A.N., Alzoubi, H.M. and Al-Maaitah, N.M. (2024). The effect of suppliers' green and traditional selection criteria in supply chain management on purchasing firms' performance. *Sustainability.* ***16*****(15):** 6276. https://doi.org/10.3390/su16156276.

Amgai, S., Dutta, J.P., Regmi, P.P. and Dangol, D.R. (2015). Analysis of marketing practices of apple in Mustang district of Nepal. *Agriculture Development Journal.* **11:** 2091-2746.

Atreya, P.N. and Kafle, A. (2016). Production Practice, Market and Value Chain Study of Organic Apple of Jumla.

Chanda, K. (2018). Promotional Strategies of Apple Practiced in Himachal Pradesh.

Chanda, K. (2021). Government Policies and Their Awareness: An Analysis of Horticulturists of Himachal Pradesh.

Chopra, S. and Meindl, P. (2021). Supply Chain Management: Strategy, Planning and Operation (8th ed.). Pearson.

Department of Agriculture. HP Agriculture. (n.d.). https://agriculture.hp.gov.in/en/land-use-pattern-english/

Djekic, I., Radivojevic, D. and Milivojevic, J. (2019). Quality perception throughout the apple fruit chain. *Journal of Food Measurement and Characterization*. **13:** 3106-3118.

Economic Survey (2023-24). Economic and Statistics Department, HP, India. (n.d.). https://himachalservices.nic.in/economics/en-IN/economic-survey.html.

Fang, L. and Ge, M. (2023). Research on the selection of agricultural product supply chain supplier. *Academic Journal of Science and Technology.* **9(2):** 1-10. https://doi.org/10.54691/ajst.v9i2.5472.

Frontiers in Sustainable Food Systems. (2025). Market performance and supply chain selection dynamics for vegetables grown through sustainable practices in the Northwest Himalayan region. *Frontiers in Sustainable Food Systems.* **9:** 1558481. https://doi.org/10.3389/fsufs. 2025.1558481.

G.K.D. (2011). Supply chain management in food processing industry: A study with reference to selected food processing units in Karnataka state (Doctoral dissertation, Mangalore University).

Getahun, W., Tesfaye, A., Mamo, T. and Ferede, S. (2018). Apple value chain analysis in the Central Highlands of Ethiopia. *Int J. Agric. Innov. Res*. **7(1):** 2319-1473.

Jain, R., Sharma, R. and Kumar, A. (2020). Supply chain management of banana growers in Tamil Nadu: A study on supplier-farmer linkages. *International Journal of Supply Chain Management.* **9(4):** 118-126.

Kambalapally, V., Singh, J. and Sharma, P. (2025). Supplier selection and procurement gaps in the organic grain supply chain. *International Journal of Extension and Research.* **8(8):** 2307-2316.

Khadka, P. and Solberg, S.Ø. (2020). Apple value chain analysis in two mountainous districts in Nepal. *Journal of Agricultural and Crop Research.* **8(1):** 1-10.

Kireeti, K. and Sharma, L.R. (2017). An inquiry into the problems of apple production and marketing in the perspective of apple growers in Shimla district of Himachal Pradesh. *Int J. Agric. Sci Res*. **7:** 7-14.

Kumar, P., Singh, R. and Yadav, S. (2017). Supply chain management in Indian grape cultivation: A study of supplier-farmer coordination. *Journal of Agribusiness in Developing and Emerging Economies.* **7(3):** 205-219. https://doi.org/10.1108/JADEE-02-2016-0010.

Kumar, S., Singh, R. and Sharma, V. (2017). Supplier relationship management in the Indian grape supply chain. *Journal of Agribusiness in Developing and Emerging Economies*. **7(3):** 245-260.

Kumari, S., Jeble, S., Venkatesh, V. and Choudhary, S. (2022). Antecedents of agriculture supply chain performance during COVID-19: An emerging economy perspective. *Journal of Agribusiness and Rural Development*. **63(2):** 1-15. https://doi.org/10.2478/jard-2022-0008.

Li, S., Rao, S.S., Ragu-Nathan, T.S. and Ragu-Nathan, B. (2005). Development and validation of a measurement instrument for studying supply chain management practices. *Journal of Operations Management*. **23(6):** 618-641. https://doi.org/10.1016/j.jom.2005.01.002.

Mango, N., Makate, C. and Hanyani-Mlambo, B. (2018). Enhancing smallholder vegetable supply chains in Kenya: The role of supplier partnerships. *Food Policy*. **76:** 98-109.

Mango, N., Makate, C. and Lundy, M. (2018). Linking smallholder farmers to markets through supply chain management: A case of vegetable growers in Kenya. *International Food and Agribusiness Management Review*. **21(5):** 589-604. https://doi.org/10.22434/IFAMR2017.0050.

Mustfa, M. and Singh, H. (2017). Impact of amended APMC act on apple business in Himachal Pradesh. *Indian Journal of Agricultural Research*. **51(1):** 38-43. doi: 10.18805/ijare.v51i1.7059.

Mwangi, J. and Kariuki, J. (2019). Trust, coordination and performance in East African horticultural supply chains. *International Journal of Supply Chain Management*. **8(5):** 112-120.

Mwangi, M. and Kariuki, S. (2019). Factors determining supply chain performance of smallholder horticultural farmers in East Africa. *African Journal of Economic and Management Studies*. ***10*(1):** 45-61. https://doi.org/10.1108/AJEMS-05-2018-0156.

Negi, S. and Anand, N. (2015). Supply chain of fruits and vegetables agribusiness in Uttarakhand (India): Major issues and challenges. *Journal of Supply Chain Management Systems*. **4(1):** 43-57.

Pundir, R.S., Sharma, R. and Katoch, V. (2025). Estimation of post-harvest losses in fruits and vegetables supply chains in India. *Agricultural Science Digest*. **45(1):** 56-62.

Sah, R., Yadav, A. and Kumar, P. (2024). Value chain analysis of pulses: Linking smallholders to markets in Eastern India. *Legume Research*. **47(5):** 567-573.

Sayin, C., Karaman, S., Mencet, M.N., Tascioglu, Y. and Karaşahin, I.Y. (2009). Determining the role of cold storage practices for apple marketing in Turkey. In *VI International Postharvest Symposium*. **877:** pp. 979-987.

Shah, A. and Singh, P. (2019). Institutional support and supply chain efficiency in mango cultivation: Evidence from Uttar Pradesh. *Indian Journal of Agricultural Economics*. **74(2):** 233-247.

Shah, I.A. (2020). An analysis on marketing problems of apple fruit growers in Jammu and Kashmir. *Journal of Postharvest Technology*. **8(2):** 43-53.

Shah, P. and Singh, S. (2019). Institutional support and supply chain practices in mango cultivation: Evidence from Uttar Pradesh, India. *Journal of Rural Development*. **38(3):** 421-438.

Sharma, I. and Guleria, A. (2020). Economics of marketing of apple crop and the problems faced by growers in Himachal Pradesh. *Economic Affairs*. **65(2):** 285-293.

Sidhu, J.K., Mohapatra, L. and Singh, D. (2024). Characterization of post-harvest losses along the supply chain of vegetables in Punjab. *Bhartiya Krishi Anusandhan Patrika*. **39(1):** 74-80. doi: 10.18805/BKAP706.

Singh, T. S. (2021). A study on supply chain management practices of food processing industry in Manipur (Doctoral dissertation, North-Eastern Hill University). Department of Management.

Sinha, A. and Mishra, P. (2023). Sustainable dairy supply chain practices and their impact on efficiency and market performance in India. *Asian Journal of Dairy and Food Research*. **42(3):** 245-252.

Somashekhar, I.C., Raju, J.K. and Patil, H. (2014). Agriculture supply chain management: a scenario in India. *Research Journal of Social Science and Management*. **4(07):** 89-99.

Verma, R. and Seth, P. (2016). Effectiveness of government subsidies in apple production: A study of Himachal Pradesh. *Indian Journal of Agricultural Economics*. **71(2):** 195-206.

Verma, S. and Seth, R. (2016). Effectiveness of government support in horticultural value chains: A case of apple growers in Himachal Pradesh. *Indian Journal of Extension Education*. **52(3):** 67-73.

Wani, F.A. and Songara, M. (2019). Production and Marketing Efficiency of Apple Farming- A Study in Shimla and Kullu Districts of Himachal Pradesh.