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Investigating Supply Chain Practices of Agro-Food Processing Units of Hilly Region: A Comparative Analysis

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Abstract: This study investigates and compares the supply chain practices of Agro-food processing units in the hilly regions of Himachal Pradesh and Uttarakhand. With both states sharing similar geographical and climatic conditions, the research aims to explore whether these similarities translate into comparable Supply Chain Orientation (SCO), Performance (SCP), and Sustainable Competitive Advantages (SCA). The analysis focuses on critical dimensions of supply chain management, including integration practices, sustainability initiatives, market accessibility, and competitive advantage. Primary data were collected from Agro-food processing units operating in both regions and were analysed using statistical tools to identify significant differences or similarities in their supply chain practices. The findings reveal that while both states demonstrate similar levels of SCO and SCA, there is a statistically significant difference in their performance. The findings suggest noticeable variations in certain aspects of supply chain management, pointing to underlying differences in strategic and operational approaches. Particular emphasis is placed on how integration practices influence performance outcomes in these challenging terrains. This comparative analysis highlights the need for improved coordination and policy support in Uttarakhand to enhance its Agro-food supply chain efficiency. The study concludes with strategic recommendations for policymakers, Agro-food units, and community stakeholders to strengthen sustainable and resilient supply chain systems in both regions. the comparative framework used here can serve as a reference for future studies aiming to benchmark and improve supply chain practices in geographically similar yet operationally diverse settings.

Key words- Supply Chain Performance • Supply Chain Orientation • Supply Chain Integration • Sustainable Competitive Advantages • Hilly Regions • Agro-Food Processing

Introduction

The Agro-food processing industry is a vital component of India's agricultural economy, contributing significantly to rural development, employment generation, and food security. According to the data provided by Ministry of Food Processing Industries (MoFPI), Government of India, as of 2022–23, the sector's Gross Value Added (GVA) reached ₹1.92 lakh crore, reflecting substantial growth from ₹1.34 lakh crore in 2014–15. The sector also attracted USD 6.793 billion in FDI equity inflow from April 2014 to March 2024. Additionally, the share of processed food exports in agri-food exports increased from 13.7% in 2014–15 to 23.4% in 2023–24. The food processing sector is one of the largest employment providers in the organized manufacturing sector, with 12.41% employment in the total registered/organized sector as per the Annual Survey of Industries (ASI) 2022–23. In hilly regions like Himachal Pradesh and Uttarakhand, Agro-food processing holds strategic importance due to the abundance of horticultural crops, medicinal plants, and organic produce. Himachal Pradesh is renowned for its apple production, with the area under apple

cultivation reaching an all-time high of 115.680 thousand hectares in 2024. However, the 2024 apple harvest faced challenges, with production declining due to adverse weather conditions and new packaging norms, impacting the ₹5,000 crore apple economy (The Tribune, 2024, Ground Report, 2024). Conversely, Uttarakhand's Dehraduni Basmati rice, once a hallmark of the region, has seen a significant decline in cultivation. According to a 2024 report by the Uttarakhand Biodiversity Board, the cultivation area reduced from 410 hectares in 2018 to approximately 158 hectares in 2022, primarily due to urbanization, lack of seed conservation programs, and changing agricultural practices. Despite these natural advantages and similar topographical conditions, both states encounter logistical challenges such as difficult terrain, seasonal accessibility, and fragmented supply chains. These challenges often impact the efficiency and integration of Agro-food processing units operating in such regions.

Table: 1 Comparative Data of GSDP 2022-23 and 2023-24 of Uttarakhand and Himachal Pradesh

Indicator	Uttarakhand (2023–24)	Himachal Pradesh (2023–24)
Gross State Domestic Product (GSDP)	₹2,07,430 crore	₹2,07,430 crore
Per Capita GSDP	₹2,60,000	₹2,34,782
GSDP Growth Rate (%)	13.97%	8.2%
Share of Agriculture in GSDP (%)	11%	14.74%
Share of Industry in GSDP (%)	49%	39.98%
Share of Services in GSDP (%)	40%	45.28%
Unemployment Rate (%)	9.8%	4.0%

Data Source: official website of Uttarakhand and Himachal Pradesh (https://uk.gov.in/, https://himachal.gov.in/), : Ministry of Statistics and Programme Implementation, Ministry of Agriculture, Ministry of Industry and Ministry of Labour and Employment).

According to these figures, agriculture, tourism, and hydropower are the most important sectors in the economies of Uttarakhand and Himachal Pradesh. Both states' industrial sectors are growing, though less developed than the service sector, and the economies of Uttarakhand and Himachal Pradesh are growing faster than the national average. The comparative analysis of key economic indicators for Uttarakhand and Himachal Pradesh reveals notable trends in their economic development over the financial years 2022–23 and 2023–24.

Both the states face similar challenges due to their mountainous terrains and physical characteristics, because of their complex topographies, one of the underlying challenges they both face is limited accessibility and connectivity. This cause hurdle in efficient transportation and the free movement of commodities, raw materials, and people (Kansal and Singh, 2022). Furthermore, due to their economies' reliance on tourism and agriculture, they face the same year-round challenge of managing fluctuations in migration, employment, and economic activity (Hassan et al 2022). As limited industrialization and urbanisation threaten their ecological balance, these governments are also grappling with how to conserve their natural environment in the face of rising development demands (Dutta N et al 2020). In terms of infrastructure, isolated and hilly areas frequently face difficulties in obtaining basic facilities and services (Pandey R et al 2018). While both Uttarakhand and Himachal Pradesh have used their vast water resources to generate hydropower, the endeavour has not been without difficulties, such as the need for environmental safeguards and concerns

(Agarwal and Kansal, 2017) both states are distinguished by their scenic beauty and rich cultural heritage, they face similar challenges due to their mountainous environments, necessitating new approaches to promote sustainable development and improve economic development in all aspects.

In the context of hilly regions such as Uttarakhand and Himachal Pradesh, Agro-food processing units face unique challenges (Saxena and Sawalkar, 2020), including limited accessibility, inadequate cold storage infrastructure, small-scale and scattered production, and high transportation costs (Wilkinson 2002.) due to difficult terrain. These constraints often disrupt timely procurement, processing, and market delivery of perishable agricultural produce, leading to post-harvest losses and reduced profitability for local farmers and processors (Singh and Khanna 2019.). In this scenario, efficient and integrated supply chain management emerges as a crucial enabler for overcoming these operational barriers (Fawcett et al 2008). A well-structured supply chain not only facilitates better coordination between farmers, processors, and distributors but also enhances value addition, reduces wastage, and improves market access for regional Agro-products (Azam and Ponnam, 2024). Consequently, evaluating and improving supply chain practices becomes essential for enhancing the competitiveness and sustainability of the Agro-food sector in these hilly regions (Joshi et al 2023).

This study investigates and compares the supply chain practices of Agro-food processing units in Himachal Pradesh and Uttarakhand, focusing on three critical dimensions: Supply Chain Orientation (SCO), Supply Chain Performance (SCP), and Sustainable Competitive Advantage (SCA). These dimensions help assess the effectiveness and resilience of supply chains in the challenging hilly terrains (Tukamuhabwa, 2023). The research explores integration practices, collaboration mechanisms, sustainability efforts, and market access to understand how each state leverages its strengths and addresses logistical challenges (Gosling et al., 2016). By adopting a comparative approach, the study examines whether geographical similarities lead to operational convergence or whether strategic variations influence supply chain outcomes and competitiveness (Kavouras et al., 2005). The findings aim to enrich academic discourse and inform policy and practice, offering actionable insights for government agencies, Agro-processing units, and local communities. Ultimately, the study promotes robust, inclusive, and sustainable Agro-food supply chains in the Indian Himalayan region.

Literature Review

The agro-food industry in India employs approximately 18% of the nation's industrial workforce and holds the fifth position in terms of production, consumption, exports, and sustained growth (Merchant, 2008). Agro-processing encompasses a range of technology-driven economic activities aimed at preserving agricultural produce and transforming it into processed food, feed, fiber, fuel, or industrial raw materials (R.P. Kachru et al., 2010). This sector adds significant value to horticultural outputs by extending shelf life through various processing techniques. A robust and dynamic food processing industry contributes substantially to national economic development (Palanivelu and Apdhulkathar, 2016). According to Rajneesh Mahajan (2016), a well-developed food processing sector can drive socio-economic growth by converting farm produce into rural income, reducing wastage, enabling value addition, promoting crop diversification, generating employment, and boosting exports.

However, infrastructural and logistical challenges continue to impede growth. Rural areas often lack proper connectivity, reliable marketing networks, and basic amenities such

as water, electricity, and cold chain infrastructure. Notably, cold chain availability is nearly 90% below the required capacity (Surendra P. et al., 2012). Negi and Anand (2015) emphasize that poor cold storage, limited processing infrastructure, and insufficient refrigerated transportation are primary causes of product wastage and financial losses.

The National Institute of Agricultural Extension Management (2021) identifies multiple constraints in India's agri-supply chain: dominance of small and marginal farmers, fragmented supply structures, lack of economies of scale, inadequate value addition, and weak marketing infrastructure. In Uttarakhand, these problems are compounded by small landholdings, low education levels among farmers, poor technological adoption, and an unsustainable supply chain approach (Alam and Verma, 2008).

To address these gaps, supply chain management (SCM) must evolve to enhance the financial and operational performance of the food processing sector. Kumar (2013) underscores SCM's pivotal role in achieving food security and reducing spoilage. Firms must adopt efficient practices (Dora M. et al., 2013), foster reliable supplier collaboration, and implement robust performance measurement systems (Bigliardi and Bottani, 2010). Dimensions of SCM—such as new product development, total quality management, and just-in-time (JIT) capabilities—are increasingly crucial to organizational performance (Hsu et al., 2009; Li et al., 2006; Min and Mentzer, 2004). Yet, empirical research is lacking on how these SCM dimensions relate to supply chain and organizational performance (Anant Deshmukh, 2012), indicating a critical area for further study and strategic intervention.

Research Methodology

This study adopts a descriptive and comparative research design aimed at examining the supply chain practices of Agro-food processing units operating in the hilly terrains of Uttarakhand and Himachal Pradesh, India. The research seeks to identify differences in supply chain performance (SCP), supply chain integration (SCI), supply chain orientation (SCO), and sustainable competitive advantage (SCA) between the two states, despite their geographical similarities. A total of 208 Agro-food processing units were selected as the sample for this investigation, with an equal representation of 104 units from each state. The sample was identified using stratified random sampling, ensuring adequate representation of various categories of food processing enterprises, including fruit and vegetable processors, dairy units, cereal processors, and traditional food-based MSMEs. Primary data were collected through a structured and pre-validated questionnaire, designed based on existing literature (Min and Ladd 2007; kumar et al 1995; Chen and Paulraj 2004; Wong et al 2011; Huang et al 2014; Stank et al 2001; Lie et al 2009; Qrunfleh Tarafdar 2013; Dhaigude and Amol 2016; Chen and Paulraj 2004; Wong et al 2011 and Huang et al 2014.) and expert consultations. The questionnaire items were measured using a seven-point Likert like scale, covering multiple facets of supply chain practices. The data were analysed using the Statistical Package for the Social Sciences (SPSS), Version 26.0. To assess the statistical significance of differences between the two states, an independent samples t-test was employed. This technique is suitable for comparing means across two independent groups and has been used to evaluate the differential impact of supply chain practices on performance outcomes in each state. This methodological framework provides a robust foundation for the comparative analysis, ensuring the validity and reliability of the results while offering empirical insights into the supply chain dynamics of Agro-food processing units in hilly regions.

Comparative Analysis

Given the geographical and demographic similarities between Uttarakhand and Himachal Pradesh, a comparative analysis was conducted to evaluate the Agro-food processing units of both states across four key dimensions: SCO, SCI, SCP, and SCA.

H1: There is a Statistically Significant difference in Supply Chain Orientation between food processing units in Uttarakhand and Himachal Pradesh

Table: 2 Group statistics for SCO

	State Name	N	Mean	Std. Deviation	Std. Error Mean
SCO	HP	104	98.250	11.271	1.105
	UK	104	99.037	9.422	.910

Source: Author's Own (Extracted from SPSS)

Table: 3 Independent Samples Test for SCO

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
SCO	Equal variances assumed	0.063	0.803	-0.551	209	0.582	-0.787	1.428	-3.603	2.029
	Equal variances not assumed			-0.550	200.544	0.583	-0.787	1.432	-3.611	2.036

Source: Author's Own (Extracted from SPSS)

The Levene's Test for Equality of Variances showed a significance value of 0.803, indicating equal variances. The t-test for Equality of Means showed a t-value of -0.551, indicating no statistically significant difference between the two groups.

H2: There is a statistically significant difference in Supply Chain Integration between Uttarakhand and Himachal Pradesh food processing units.

Table: 4 Group statistics for SCI

	State Name	N	Mean	Std. Deviation	Std. Error Mean
SCI	HP	104	79.182	11.037	1.082
	UK	104	82.504	8.267	.799

Source: Author's Own (Extracted from SPSS)

Table: 5 Independent Samples Test for SCI

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
SCI	Equal variances	0.979	0.324	-2.47	209	0.014	-3.321	1.340	-5.963	-0.680

	assumed			9						
	Equal variances not assumed			-2.469	190.824	0.014	-3.321	1.345	-5.975	-0.668

Source: Author's Own (Extracted from SPSS)

A t-test was conducted to compare supply chain integration for food processing units in Uttarakhand and Himachal Pradesh. The results showed a significant difference between the two groups, with a mean difference of -3.32198 and a standard error difference of 1.34001. The 95% confidence interval ranged from -5.96364 to -0.68032, supporting the hypothesis (H2).

H3: There is a statistically significant difference in the Supply Chain Performance between food processing units in Uttarakhand and Himachal Pradesh.

Table: 6 Group statistics for SCP

	State Name	N	Mean	Std. Deviation	Std. Error Mean
SCP	HP	104	60.00	12.692	1.244
	UK	104	64.91	8.934	.863

Source: Author's Own (Extracted from SPSS)

Table: 7 Independent Samples Test for SCP

			Levene's Test for Equality of Variances		t-test for Equality of Means						
			F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
										Lower	Upper
SCP	Equal variances assumed		11.828	0.001	-3.261	209	0.001	-4.915	1.507	-7.888	-1.943
	Equal variances not assumed				-3.245	184.524	0.001	-4.915	1.514	-7.904	-1.927

Source: Author's Own (Extracted from SPSS)

A t-test results showed a significant difference between the two groups, with a mean difference of -4.91589 and a standard error difference of 1.50765. The t-test for Equality of Means yielded a t-value of -3.261, less than the common alpha level of 0.05, indicating that equal variances cannot be assumed for comparison.

H4: There is a statistically significant difference in the Sustainable Competitive Advantages between food processing units in Uttarakhand and Himachal Pradesh.

An independent sample t-test was conducted to compare the sustainable competitive advantage of food processing units in Uttarakhand and Himachal Pradesh. The results indicated that the Levene's Test for Equality of Variances resulted in a significance (Sig.) value of 0.467, which is greater than the standard alpha level of 0.05. This suggests that equal variances can be assumed for comparing the two groups.

Table: 8 Group statistics for SCA

	State Name	N	Mean	Std. Deviation	Std. Error Mean
SCA	HP	104	75.64	10.623	1.041
	UK	104	73.23	10.989	1.062

Source: Author's Own (Extracted from SPSS)

Table: 9 Independent Samples Test for SCA

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SCA	Equal variances assumed	0.532	0.467	1.619	209	0.107	2.410	1.488	-0.524	5.345
	Equal variances not assumed			1.620	208.994	0.107	2.410	1.487	-0.522	5.343

Source: Author's Own (Extracted from SPSS)

The t-test for Equality of Means resulted in a t-value of 1.619 with 209 degrees of freedom (df). The two-tailed significance (Sig. 2-tailed) is 0.107, which is greater than the standard alpha level of 0.05. This suggests that there is no statistically significant difference between the means of Uttarakhand and Himachal Pradesh. The mean difference between the two groups is 2.41059, with a standard error difference of 1.48860. The 95% confidence interval of the difference ranges from -0.52400 (lower) to 5.34517 (upper). **Hence, H4 is not supported**.

Table: 10 Results of Hypotheses Testing

	Hypotheses	**Results**
H1	There is a statistically significant difference in supply chain orientation between Uttarakhand and Himachal Pradesh food processing units.	**Unsupported**
H2	There is a statistically significant difference in the supply chain integration between Uttarakhand and Himachal Pradesh food processing units.	**Supported**
H3	There is a statistically significant difference in supply chain performance between Uttarakhand and Himachal Pradesh food processing units.	**Supported**
H4	There is a statistically significant difference in sustainable competitive advantage between Uttarakhand and Himachal Pradesh food processing units.	**Unsupported**

Source: Author's Own

We can clearly conclude from the results of the comparative analysis that, despite having geographical similarities in both hilly regions, there is a difference in their supply chain practices in terms of supply chain performance. This is due to the integration practises established by them. Because one state (Himachal Pradesh) is more integrated with the collaborated activities, it has an impact on its performance. As a result, there is a statistically significant difference in their SCP, interestingly Agro-Food Processing Units of both the regions has same in terms of SCO. However, there is no statistical difference in terms of SCA, as both states benefit from Himalayan products and have specific product differentiation from the market.

Conclusion

In the exploration of Agro-food processing units in the challenging terrains of Uttarakhand and Himachal Pradesh, this study has uncovered critical insights into the realms of supply chain management, sustainable practices, supply chain integration, sustainable competitive advantages and market

accessibility for local products. The synthesis of findings and the subsequent formulation of recommendations present a comprehensive roadmap for the stakeholders involved – the state government, Agro-food processing units, and local communities. As we conclude, it is imperative to reflect on the pivotal role these recommendations play in shaping a resilient and thriving Agro-food processing sector in these regions.

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