

A comprehensive analysis of the value chain dynamics of Dashehari mango in Uttar Pradesh, India

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Abstract

The study looked into the dynamics of Dashehari mango value chain in Lucknow, Uttar Pradesh. A survey of 120 farmers from the Malihabad and Mall blocks of Lucknow was used to collect data. The total cultivation cost per hectare was determined to be Rs. 1,79,469, with variable costs accounting for 53%. Farmers reported an average yield of 11.3 tons per hectare, which falls short of Uttar Pradesh's state productivity for mango. The net return over variable costs was calculated to be Rs. 1,57,050 per hectare. A thorough mapping of the mango value chain in the study area was carried out, followed by a constraint analysis. Harvesting and postharvest losses totaled 13.2%, with retailers bearing the brunt. Pre-harvest contracts were the most common method of mango marketing, with 60-65% of farmers using them. Producers' shares of the consumer rupee varied, ranging from 24% in pre-harvest contract channels to 87% and 62.5%, respectively, in direct marketing and marketing through Farmer Producer Organizations (FPOs). Farmers in the mango value chain faced challenges such as pest management, low shelf life, senile orchards, poor price realization, a lack of processing facilities, and a lack of crop insurance schemes. The study emphasizes the importance of long-term interventions to improve the orchard ecosystem and nutrient management, thereby improving farmers' livelihoods. To address these challenges, promoting the widespread adoption of good agricultural practices, canopy management, integrated pest, disease, nutrient management and advanced harvesting techniques is necessary. Furthermore, the study emphasizes FPOs' critical role in establishing a strong and interconnected network within the agricultural community. By implementing these strategies, the mango-producing region of Uttar Pradesh has the potential to foster a sustainable and thriving industry, contributing to farmer prosperity and the community's overall economic growth.

Key words: Mango, value chain, supply chain, marketing efficiency, price spread, cost and returns and constraints

Introduction

India stands as the global hub for fruits and vegetables, boasting a diverse range and holding a prominent position in production (Kusuma and Basavaraja, 2014). The country is rich in mango varieties, each distinguished by its unique taste, flavour, texture, and size. Mango (*Mangifera indica* L.), hailed as the "King of fruits," is a key fruit crop in tropical and subtropical regions worldwide. Mango is recognized for its nutritional value, exquisite taste, and fragrant qualities, it is esteemed as a nutritional powerhouse (Dadhich, 2012). This fruit is a valuable source of essential nutrients such as potassium, phosphorous, and magnesium while also being an excellent reservoir of vitamin A and Vitamin C (Rajan, 2021).

Mango is grown in an area of 5.58 million hectares of area in the world. India is the largest producer of mangoes, with 46.02 % and 45.88 % of the total world area and production, respectively (Ravi *et al.*, 2021). In 2020-21, India cultivated mangoes across 2.33 million hectares, yielding 20.82 million tonnes. Key mango-producing states include Andhra Pradesh, Uttar Pradesh, Karnataka, Orissa, Maharashtra, and Telangana. With a rich history of cultivation, India boasts approximately a thousand mango cultivars. Notable varieties like Dasher, Langra, and Chausa thrive in the northern regions, while Alphonso and Kesar are popular in the Deccan Plateau and Western regions.

South India is known for Totapuri, Neelam, Mallika, Amrapali, and Benishan varieties.

Mango cultivation is a significant income source for smallholder farming households, particularly in subtropical regions. The mango fruit, known for its substantial market value and income-generating potential (Sarada, 2013), contributes significantly to the agricultural landscape of Uttar Pradesh (UP). In the 2020-21 year, Uttar Pradesh emerged as one of the foremost states in mango production, cultivating over 0.28 million hectares and yielding a total production of 4.80 million tons. Predominant varieties in UP include Dashehari, Langra, and Chausa. Dashehari mangoes exhibit distinctive characteristics, featuring small to medium-sized fruit, oblong to oblong-oblique shape and a vibrant yellow hue. The firm, fiber-free pulp makes it well-suited for direct consumption. Despite its culinary appeal and historically strong market presence, recent trends indicate a diminishing economic potential for mango cultivation (Mishra *et al.*, 2019). Recognizing mango cultivation as a pivotal aspect of farmers' livelihoods, this study delves into the entire value chain, aiming to comprehend constraints and enhance the economic performance and competitiveness of the Dashehari mango value chain. Central research inquiries involve the profitability of mango cultivation, challenges encountered by stakeholders in the mango value chain, and the efficiency of existing supply chains. Through a comprehensive examination of these aspects, this study

provides insights and recommendations to enhance the efficiency, sustainability, and inclusivity of the Dashehari mango value chain.

Materials and methods

Data collection involved surveying 120 farmers selected from Malihabad and Mall block in Lucknow district using a random sampling approach. A structured questionnaire, administered through personal interviews, information on socio-economic status, land holdings, costs and returns, and constraints associated with mango cultivation was gathered. The respondents relied on their memory to provide accurate data. Additionally, data was obtained from 10 pre-harvest contractors, five local aggregators, commission agents, wholesalers, retailers, and two Farmer Producer Organizations (FPOs). Time series data on mango area, production, and productivity were sourced from the Indiatat.com website.

To assess the trend in area, production and productivity of mango crop in the in Uttar Pradesh and India, the compound growth rate analysis was employed.

$$Y_t = ab^t u_t \quad (1)$$

The compound growth rate (g) in percentage was computed as $g = (\text{Antilog of } \ln b - 1) * 100$.

Where,

Y_t : Dependent variable for which growth rate was estimated (area/production/yield/export)

a: Intercept (constant). b: Regression coefficient. t: Years which take values, 1, 2, ..., n. u_t : Disturbance term for the year t

Further, the coefficient of variation (CV) was used as a consistency index to study the variability in area, production and productivity. A linear trend was fitted to the original time series data on area, production and productivity. The formula suggested by Cuddy and Della (1978) was used to calculate the degree of variation around the trend, means coefficient of variation was multiplied by the square root of the difference between the unity and coefficient of determination (R^2). The Cuddy Della Valle Index de-trends the annual price and shows the exact direction of the instability (Cuddy and Della, 1978). A low value of this index indicates low instability and vice-versa.

$$\text{Cuddy - Della Valle Instability Index} = CV \times \sqrt{1 - R^2}$$

Where,

R^2 = Coefficient of determination adjusted to degrees of freedom and CV is coefficient of variation.

Marketing efficiency: Marketing efficiency was calculated by using the formula suggested by Acharya and Agarwal (2007):

$$\text{Marketing efficiency} = \frac{\text{Net selling price of grower}}{\text{Total marketing cost} + \text{Total market margin}}$$

Results

Trend and instability in the area, production, and productivity of mango in UP and India: The Compound Annual Growth Rate (CAGR) was employed to analyze and project the trends in mango cultivation in both Uttar Pradesh (UP) and India (Table 1). Over the period from 1991 to 2020, mango production and productivity

in UP exhibited significant annual growth rates of 3.89 % and 3.64 %, respectively. Surprisingly, the growth in the cultivated area was comparatively modest, registering a rate of only 0.23 % per annum. In contrast, on a national scale, India experienced a growth rate of 2.88 % in mango cultivation area and 3.23 % in production, indicating a slightly slower pace than UP.

Notably, the instability in mango production in UP, indicated by a rate of 14.40 %, is largely attributed to the instability in productivity, which stands at 13.21 %. This suggests that the fluctuations in productivity significantly contribute to the overall variability in mango production within the state. Moreover, at the broader level of India, the instability in mango yield was notably high, recording a percentage of 15.48. This underscores a considerable level of variability in mango productivity across the country as a whole.

Table 1. Trend and instability analysis of the area, production, productivity of mango in Uttar Pradesh and India (1991 to 2020)

Region	Particulars	Trend (%)	Instability (%)
Uttar Pradesh	Area	0.23**	3.35
	Production	3.89**	14.40
	Yield	3.64**	13.21
India	Area	2.88**	10.03
	Production	3.23**	8.02
	Yield	0.35 ^{NS}	15.48

Note: ** indicates significant at 1 % and NS- Non significant

Economics of Dashehari mango cultivation: The cultivation expenses for the Dashehari variety of mango in Lucknow District, Uttar Pradesh, amounted to Rs. 1,79,469 ha⁻¹ (Table 2). Notably, the cost of cultivation remained relatively consistent for mango orchards aged between 21 to 30 years and 31 to 45 years. Variable costs constituted 53 % of the total cultivation cost, with Rs. 90,685 and Rs. 97,916 ha⁻¹ for orchards aged 21 to 30 and 31 to 45 years, respectively. The rise in costs is attributed to increased input requirements, pest and disease control challenges, and harvesting difficulties due to canopy overcrowding.

Within the variable costs (Fig. 1), pest and disease control accounted for the majority at 43 %, followed by human labour (20 %) and irrigation (12 %). Notably, many farmers refrained from using fertilizers but opted for farmyard manure. Fixed costs encompassed the amortization of initial orchard establishment cost, land rental, interest on fixed capital, and depreciation of fixed assets, constituting 47 % of the total cultivation cost.

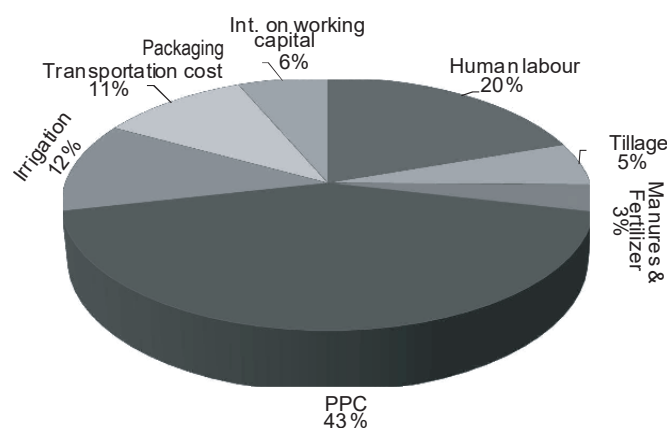


Fig. 1. Share of different components of variable costs in mango

Table 2. Economics of Dashehari mango cultivation (per ha) in UP

Particulars	21-30 years	31-45 years	Average (21-45 years)
Total variable cost (Rs ha ⁻¹)	90685	97916	94301
Total fixed cost (Rs ha ⁻¹)	84771	85566	85169
Total Cost of cultivation (Rs ha ⁻¹)	175456	183482	179469
Yield (Q ha ⁻¹)	116	110	113
Gross returns (Rs. ha ⁻¹)	255200	247500	251350
Net returns over variable cost (Rs ha ⁻¹)	164515	149584	157050
Net returns over total cost (Rs ha ⁻¹)	79744	64018	71881
Cost of Production (Rs kg ⁻¹)	15.13	16.68	15.91

The average yield was 11.3 tons ha⁻¹, with a decrease observed in orchards aged 31 to 45 years due to inadequate sunlight penetration, resulting in lower yields. Gross returns from mango cultivation averaged Rs. 2,51,350 ha⁻¹, while net returns over variable costs were Rs. 1,57,050 ha⁻¹. The average cost of producing Dashehari mango was Rs. 15.91 kg⁻¹.

Dashehari mango value chain in Uttar Pradesh: The mango value chain, along with value chain activities, actors, enablers and constraints, are represented in Fig. 2. The activities include input supply, production, harvesting, processing, and marketing at domestic as well as export markets.

Production activities: Major actors in input supply activity include private nurseries, NHB-accredited nurseries, Government nurseries, ICAR-CISH nursery, manure and fertilizer suppliers, and plant protection chemical suppliers. Though credit suppliers are also part of the mango value chain, their presence was very low as farmers did not avail of loan for cultivation purpose. Various enablers such as ICAR-Central Institute for Subtropical Horticulture, Lucknow, State Horticulture department, FPOs, and State Agriculture Universities facilitate in mango production activity through various research and extension activities. A comprehensive overview of harvest and postharvest losses at various stages of the supply chain is presented in Table 3. The data indicates that during harvesting a loss of 2.8 % was noticed subsequently, packaging and handling contributed a 2.5 % loss, transportation (including loading, unloading, and enroute) resulted in a loss of 4 %, and retail introduced a 4.9 % loss. The total harvest and postharvest loss accounted for 14.2 %.

Table 3. Harvest and postharvest losses in different stages of the supply chain

Sl. No.	Stage	Loss (%)
1	Harvest	2.8
2	Packaging and Handling	2.5
3	Transportation (loading/unloading/enroute)	4.0
4	Retail	4.9

Processing activity: Concerning processing activities, Uttar Pradesh (UP) lacks significant large-scale processing industries. The predominant mode of mango processing occurs at the household level, where raw fruits are utilized to produce pickles, dried mango powder, aam panna, and chutney. While there are limited small-scale industries dedicated to processing mangoes, primarily focusing on pickles, mango powder, and mango pulp, the overall scale of such processing ventures remains relatively minimal in the region.

Supply chain management of mango: Farmers employ various channels for selling their mango produce, price spread and efficiency in each marketing channel is presented in Table 4. Five different marketing channels were identified in the study area.

Channel I: Producer - Consumer

Channel II: Producer – FPO – Retailer – Consumer

Channel III: Producer – Pre -harvest contractor – Commission agent - Wholesaler – Retailer – Consumer

Channel IV: Producer – Local aggregators - Commission agent - Wholesaler – Retailer – Consumer

Channel V: Producer - Commission agent - Wholesaler – Retailer – Consumer

The primary channel was through pre-harvest lease contractors, constituting 65-70 %. Alternatively, 25-30% of farmers sell to local aggregators, managing all production aspects and postharvest tasks followed by sale at local mandi (commission agents) followed by about 20-25% of the farmers. Some farmers market their produce through Farmers Producer Organizations (FPOs), and a few explore international markets. A limited

Table 4. Price spread and efficiency of various marketing channels (Rs./t)

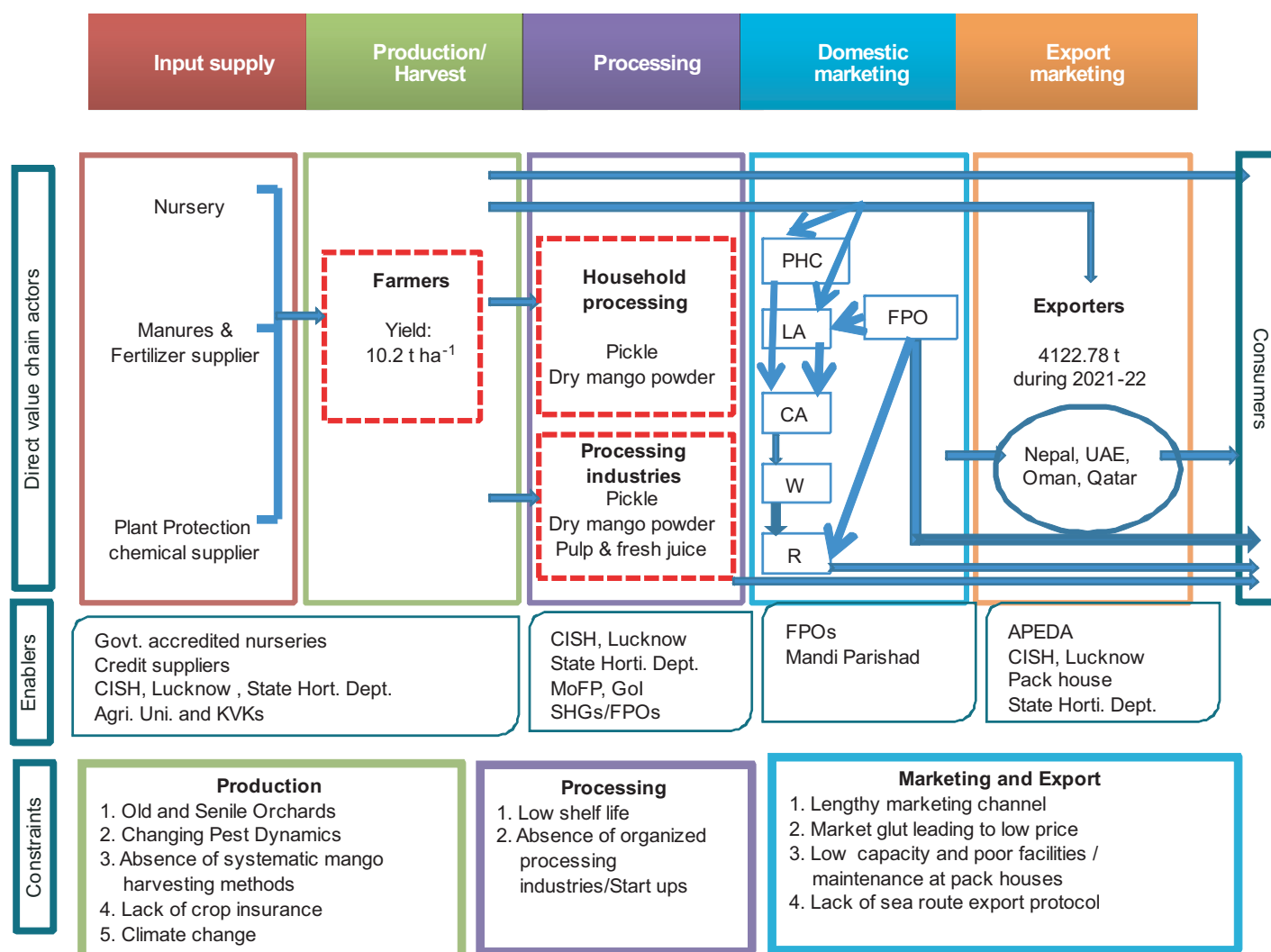
S No.	Particulars	Channels				
		I	II	III	IV	V
1	Farmers/Producers					
	a) Price received	52500	37500	11000	22000	22000
	b) Marketing cost	12000	0	0	3000	3000
	c) Net priced received	40500	37500	11000	19000	19000
2	Preharvest contractor					
	a) Purchase price	0	0	11000	0	0
	b) Marketing cost	0	0	5500	0	0
	c) Market margin	0	0	4500	0	0
	d) Price received	0	0	21000	0	0
3	Locale aggregates					
	a) Purchase price	0	0	0	19000	0
	b) Marketing cost	0	0	0	3000	0
	c) Market margin	0	0	0	1575	0
	d) Price received	0	0	0	24000	0
4	Commission agent					
	a) Purchase price	0	0	21000	24000	19000
	b) Marketing cost	0	0	2000	2500	4000
	c) Market margin	0	0	3000	3000	3000
	d) Price received	0	0	26000	29500	26000
5	FPO/CBBO					
	a) Purchase price	0	37500	0	0	0
	b) Marketing cost	0	11000	0	0	0
	c) Market margin	0	2500	0	0	0
	d) Price received	0	51000	0	0	0
6	Wholesaler					
	a) Purchase price	0	0	26000	29500	26000
	b) Marketing cost	0	0	4000	3000	4000
	c) Market margin	0	0	3500	3500	3000
	d) Price received	0	0	33500	36000	33000
7	Retailer					
	a) Purchase price	0	51000	33500	36000	33000
	b) Marketing cost	0	4000	5000	4500	4500
	c) Market margin	0	2500	6500	5000	5000
	d) Price received	0	57500	45000	45500	42500
8	Total marketing cost	12000	15000	16500	16000	15500
9	Total market margin	0	5000	17500	13075	11000
10	Price paid by consumer	46500	60000	45000	45000	42500
11	Price spread	6000	22500	34000	26000	23500
12	Producer's share in consumers rupee	87.10	62.50	24.44	42.22	44.71
13	Efficiency	3.38	1.88	0.32	0.65	0.72
14	% of farmers	<1	2-5	65-70	25-30	20-25

number of farmers follows direct sales to consumers and exports of A-grade produce. Producers' share in consumers' rupee was highest in direct marketing to consumers (87 %) followed by marketing collectively through farmer-producer organizations (62.5 %). Producers realized the lowest share of consumers' rupee in the marketing channel where pre-harvest contractors were involved. Efficiency was high in Chanel I (3.38), followed by Chanel II (1.88) and Channel V (0.72).

Export Scenario: During the 2021-22 year, 4122 tonnes of mango were exported from UP, which is less than even one percent of the total production. The major export destinations of UP mangoes are Nepal, United Arab Emirates, Qatar and Oman. Very low number and capacity of pack house, poor maintenance of pack house, and lack of sea route export protocol were the constraints faced by the exporters.

Constraints faced by the farmers in the mango value chain: The constraints faced by the farmers are presented in Table 5. All surveyed farmers reported facing challenges in effectively managing pests and diseases. This indicates a universal concern among mango growers, highlighting the pervasive nature of this

issue. A significant majority (85 %) identified low shelf life as a constraint. This suggests that a substantial portion of mango farmers grapple with issues related to the sale of mangoes immediately after harvest, leading to distressed sales during a market glut. About 80 % of farmers reported having old and senile orchards. This point to a widespread challenge among mango cultivators related to aging their orchards, significantly impacting overall productivity and fruit quality. A substantial 75 % of farmers expressed poor price realization as a constraint due to the lengthy marketing channel. A similar percent of farmers highlighted the absence of processing facilities as a constraint. Farmers expressed the need to process the mangoes for better price realization during a glut in the market. Sixty-five percent of farmers reported the absence of crop insurance schemes as a constraint. This indicates a substantial gap in risk mitigation strategies for farmers, particularly concerning potential losses and unforeseen events. Around 58 % of farmers faced difficulties in the harvesting process. This includes challenges related to labour availability and orchard conditions, emphasizing the need for improvements in the harvesting aspect of mango cultivation.



PHC-Pre Harvest Contractor ; LA- Local aggregators ; CA-Commission agents ; W- Wholesalers ; R- Retailers ; FPO-Farmer Producer Organization ; CISH-Central Institute for Subtropical Horticulture ; MoFP- Ministry of Food Processing ; APEDA - Agricultural and Processed Food Products Export Development Authority

Fig. 2. Mapped mango value chain of Dashehari mango in UP

Table 5. Constraints expressed by mango farmers

Constraints	Percent of the farmers
Difficulty in managing pests and diseases	100
Low shelf life	85
Old and senile orchards	80
Poor price realization	75
Absence of processing facilities	75
Absence of crop insurance schemes	65
Difficulty in harvesting	58

Discussion

Uttar Pradesh is one of the leading producers of mangoes in the country. The state's sub-tropical climate and fertile soil provide an ideal environment for mango cultivation. Among the various mango varieties grown in Uttar Pradesh, Dashehari, Chausa and Langra are particularly famous for their unique taste and aroma. Dashehari mango has its roots in Lucknow.

According to an analysis of the Dashehari mango value chain in Lucknow, most orchards have reached the end of their economic life (45 years). Old and senile orchards in the region make it extremely difficult to control pests and diseases, as the huge height of the trees necessitates the use of more pesticides and acts as an obstruction for the penetration of sunlight to every branch of the trees resulting in decreased yield. Yadav *et al.* (2018a) reported an average yield of 17.8 tonnes ha⁻¹ which has now reduced to an average yield of 11.3 tonnes ha⁻¹, indicating the need for interventions for sustainable orchard ecosystem and livelihood of the farmers. Various problems such as difficulty in managing pests, particularly hoppers and thrips, lack of canopy management, non-adoption of good agriculture practices, and improper nutrient management are thriving in the mango industry of the region.

Farmers harvest mangoes mainly by shaking branches and use local harvesters; thus, the fruit falls on the ground, causing internal injury to the fruits. The injured fruits have a very little shelf life. The fruits often develop cracks due to falling from higher heights, resulting in a harvesting loss of around 2.8%. As a climacteric fruit, mango is readily perishable after harvesting due to ripening, environmental conditions, and incorrect postharvest handling, resulting in severe quality losses and economic losses along the supply chain (Le *et al.*, 2022). A total of 13% harvest and Postharvest loss was noticed in the study area. Nanda *et al.* (2010) reported a total postharvest loss of 12.74% in mango. Improper harvesting in the study area resulted in a loss of 2.8%. Sab *et al.* (2017) documented a harvest loss rate of 1.85% in their study. The retail level experienced a bigger loss of 4.9%. Murthy *et al.* (2002) reported a physical postharvest loss of 5.25% at the retail level. The absence of a large-scale processing industry in the region is a significant gap in the value chain. During peak season, the market price of mango reaches very low, forcing farmers to sell their produce at lower rates to prevent losses. The processing industry under an FPO allows farmers to process their produce and market it at a higher price. The major activity in the value chain is supply chain management. In the study area, pre-harvest

contract was the most common practice followed in the marketing of mango (Sudha and Kruijssen, 2008; Sarada, 2013; Gurjar *et al.*, 2017; Murthy *et al.*, 2009; Saripalle, 2019). The channel's widespread adoption is mainly because farmers typically borrow money from these pre-harvest contractors to meet their production or personal expenses. Because the farmer-agent/pre-harvest contractor relationship was credit-based, they were forced to choose an inefficient marketing channel or yielded a lower price for their produce. The channel's widespread adoption is mainly because farmers typically borrow money from these pre-harvest contractors to meet their production or personal expenses. Because the farmer-agent/pre-harvest contractor relationship was credit-based, they were forced to choose an inefficient marketing channel or yield a lower price for their produce. Saripalle (2019) studied the mango value chain in the Kolar district of Karnataka and reported that farmers were locked in a credit cycle with the agents. Though the producers' share in direct marketing's consumer rupee is high, a negligible percent of the producers preferred this channel. Datarkar *et al.* (2014) noticed 93.59% of producers share in the consumer's rupee in direct marketing. Sarada (2013) reported that producers do not prefer to be involved in the marketing system because of lack of knowledge on marketing and to avoid the price risk, farmers preferred the pre-harvest marketing method. Lack of efficiency in marketing channels significantly impacts price realization and is reported as a constraint by many farmers (Kumar *et al.*, 2018). The presence of many intermediaries has resulted in low producer shares in consumers' rupees (Yadav *et al.*, 2018b; Gopalakrishnan, 2013). As the length of the marketing channel increases, producers' share in the consumer rupee increases. Besides, because of the seasonal nature, there is a vast price fluctuation because of the market glut, and the farmers are not ready to bear this price risk. Matin *et al.* (2008) reported that, because of glut in the market, the farmers are not getting due returns for their produce and the country's potential resources are deprived.

Establishing a sustainable mango value chain in Uttar Pradesh is crucial amid challenges like aging orchards, pest issues, and suboptimal practices. A key aspect of this initiative involves the widespread adoption of good agricultural practices, encompassing canopy management, integrated pest, disease, and nutrient management, and the implementation of advanced harvesting techniques. These practices address the current issues faced by mango orchards and contribute to the overall resilience and health of the ecosystem. Enhancing farmers' marketing and managerial skills is vital for navigating market complexities securing sustainable futures. Farmer Producer Organizations (FPOs) play a crucial role, offering collective bargaining power and economies of scale. Diversifying export markets is essential for long-term mango industry growth. Opening up new avenues for international trade not only expands the reach of the exporters/farmers but also minimizes dependence on a single market, thus mitigating the impact of market fluctuations. A holistic approach involving agricultural practices, farmer empowerment, FPO strength, and global market expansion is pivotal for a sustainable and thriving mango industry, contributing to community economic growth.

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