Journal of Innovative Agriculture and Social Development

journal homepage: https://rdpublishers.com/journals/index.php/jiasd

Article

# Deciphering Value Chain Dynamics and Assessing Strategies to Reduce Pre- & Post-Harvest Losses for Mangoes in Sindh and Punjab provinces of Pakistan

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ARTICLE INFORMATION

*Article history:*
Received on 12 June, 2025
Received in revised form on 08 November, 2025
Accepted on 12 November, 2025
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ABSTRACT

Mango is the second largest fruit crop after citrus that makes a significant socio-economic contribution to the Pakistan's economy. However, the performance of mango VC is regarded to be suboptimal and caused mango losses needs upgrading to achieve full potential. The starting point for any upgrading strategy should be deciphering the dynamics of the industry's value chains (VCs). The present study aimed to qualitative examine the dynamics of mango value chains (VCs) in term of types, financial and information flows, and to assess pre- and post- harvest losses and its causes. Data collected through interviews and online surveys of industry actors from retailers including importers backwards to suppliers of inputs. The mango-growers targeted in Punjab and Sindh provinces, and importers from foreign markets. Thematic content analysis identified three types of VCs operating simultaneously in the industry that could be termed traditional, modern, and export mango VCs. These chains, however, differed in their dynamics, such as product, financial, and information flows and chain governance. Traditional chains carried the major mango flows of all quality grades to consumers belonging to all income classes. They were relatively long, unorganized, and governed by spot market transactions. Modern chains were found supplying better quality mangoes to middle and high-income consumers. Export chains mainly targeted foreign consumers. The findings indicate that pre-harvest losses (08%) are primarily caused by factors including climate change, numerous diseases, pests, and fruit fly infestations whereas, post-harvest losses (35-40%) are incurred due to traditional harvesting practices, packaging material, and logistics causing mechanical damages. Pre- and post-harvest losses can be reduced by adopting modern and best production, post-harvest practices and chain performance can be improved by better information flows and more effective chain governance through building collaborative relationships among actors doing business at various stages of mango VCs.

**Keywords:** *Value chain Dynamics; Pre- & Post-Harvest Losses; Performance; Climate Change; Pakistan*

## 1. Introduction

In the horticultural sector of Pakistan, mango (Mangifera Indica L.), popularly known as the "King of fruits," is the second most important fruit crop produced in the country in terms of its area under cultivation (159 thousand hectares) and production (2091 thousand tones) in Punjab and Sindh provinces (Government of Pakistan, 2025; Badar *et al*., 2015; Ghafoor *et al*., 2010; Malik *et al*., 2010). Pakistani mangoes are famous for their sweet taste, juiciness, nutrition, and flavour around the globe (Collins *et al*. 2007; Rathore *et al*., 2007; Hussain *et al*., 2010).

During the summer season, domestic demand for mango is very high, and it is popularly consumed both raw and in processed form as jams, juices, nectars, squashes, milkshakes, and jellies. Although a wide variety of mangoes are grown in Pakistan, Sindhri, Chaunsa (SB & White & late), and Dusehri are the most prominent varieties (Badar *et al*., 2015; Ghafoor *et al*., 2010; Collins & Iqbal 2011; Sun *et al*., 2011). Pakistan is one of the leading mango-producing and exporting countries of the world. It stands in 5th position with an annual production of 2.0 million tones after India, Indonesia, China, and Mexico. In


DOI: https://doi.org/10.57095/jiasd20254174

terms of its exports, Pakistan holds the 6th position after Mexico, Thailand, Brazil, Netherlands, and Peru but Pakistan is facing competitiveness issues and fetching the lowest export prices (818 USD/ton) as compared to other exporting countries of the world (FAO, 2025). Domestic and export trade of mango is handled by the private sector (Aujla et al. 2007). The role of public sector is limited only to facilitating mango exports through its various research, development, and extension institutions. In terms of structure, the mango industry is heterogeneous and diversified in size (PHDEB, 2005; SDPI, 2004).

The main industry actors are orchard owners/growers, pre-harvest contractors, commission agents, wholesalers, retailers (street vendors & modern superstores), and exporters (Badar *et al*., 2019; Badar *et al.*, 2015; Khushk & Smith, 1996). Little is known about how the value chain participants are linked each other, how the products, money and information flows within chains and how chains participants are performing as chain performance is linked to industry performance (Kannegiesser *et al*., 2008). Therefore, the first objective of this study is to examine mango value chain dynamics in Pakistan.

A significant proportion of food produced for human consumption is lost or wasted; globally almost one- third of the total food grown (1.3 billion tons/year) for human consumption is lost or wasted annually (Gustavsson et al., 2011; Parfitt et al., 2010; Gazsó & Greßler 2007). Approximately 30-35% of fruits go to waste during postharvest handling, storage, and ripening (Kiran et al., 2023; Ravi et al., 2023; Lashley, 1999). Besides, these perishable characteristics of the horticultural produce, inadequate arrangements for post-harvest management, like storage, processing, preservation, and marketing facilities, lead to the problem of post-harvest losses (Viet Nguyen, 2022; Mitrannavar, 2012). The postharvest losses of fruits and vegetables in developing countries have been reported to vary between 20% and 40% at different stages of marketing (Msogoya et al., 2011). Studies on the extent of losses of mangoes during postharvest handling are inadequate, especially in Pakistan.

The mango value chain is plagued by significant pre- and post-harvest losses. Pre-harvest losses are primarily attributed to adverse weather conditions, pest and disease infestations, and suboptimal agricultural practices (Kumar et al., 2021). Post-harvest losses, on the other hand, are largely caused by mechanical damage, physiological disorders, pathogenic infections, improper storage, and inadequate packaging (Khan *et al.,* 2025; Gutema & Anteneh, 2022; Tarekegn & Kelem, 2022; Sivakumar et al., 2011). In developing countries, around 40 per cent of losses are at the retail and consumption level, 10-20 per cent are post-harvest losses, and the rest 40-50 per cent of losses reported in other stages of chains, such as pre-harvest or field losses (Gutema & Anteneh, 2022; Roy *et al*., 2019; Gomez et al., 2011; Gustavsson et al., 2011; Godfray et al., 2010). This is inevitably linked to the wastage of natural resources such as water, land, energy, and other inputs to food production (Gustavsson et al., 2011).

The aim of this research study is to examine the types and dynamics of mango industry value chains and assess the pre- and post-harvest losses hindering the mango value chains' efficiency so that upgrading measures can be suggested for improving the performance of chains and ultimately the performance of the mango industry as a whole. The research objectives of study are i) to analyze the mango value chain dynamics in Pakistan, ii) to assess pre- and post-harvest losses of mangoes, and iii) to identify factors contributing to losses and suggest recommendation for improvements.

## 2. Materials and Method

The study is qualitative and uses a case study approach to explore the mango value chain, involving participants from input suppliers to retailers in Punjab and Sindh, where most mangoes are produced (Government of Pakistan, 2025).

The study is qualitative in nature, adopting a case study methodology to address its objective. To examine the value chain dynamics, and mango losses and its causes, participants for study represented mango value chain from input suppliers to growers to traders e.g. commission agents, wholesalers and retailers, exporters were taken from Sindh and Punjab where > 90 % mango produced (Government of Pakistan, 2025). Study participants were identified through snowball sampling, starting with one respondent who helped find others (Saunders et al., 2009). A total of 140 value chain actors were (130) in-depth interviewed and (10) online surveyed, and detailed information about the sample is presented in Figure 1.

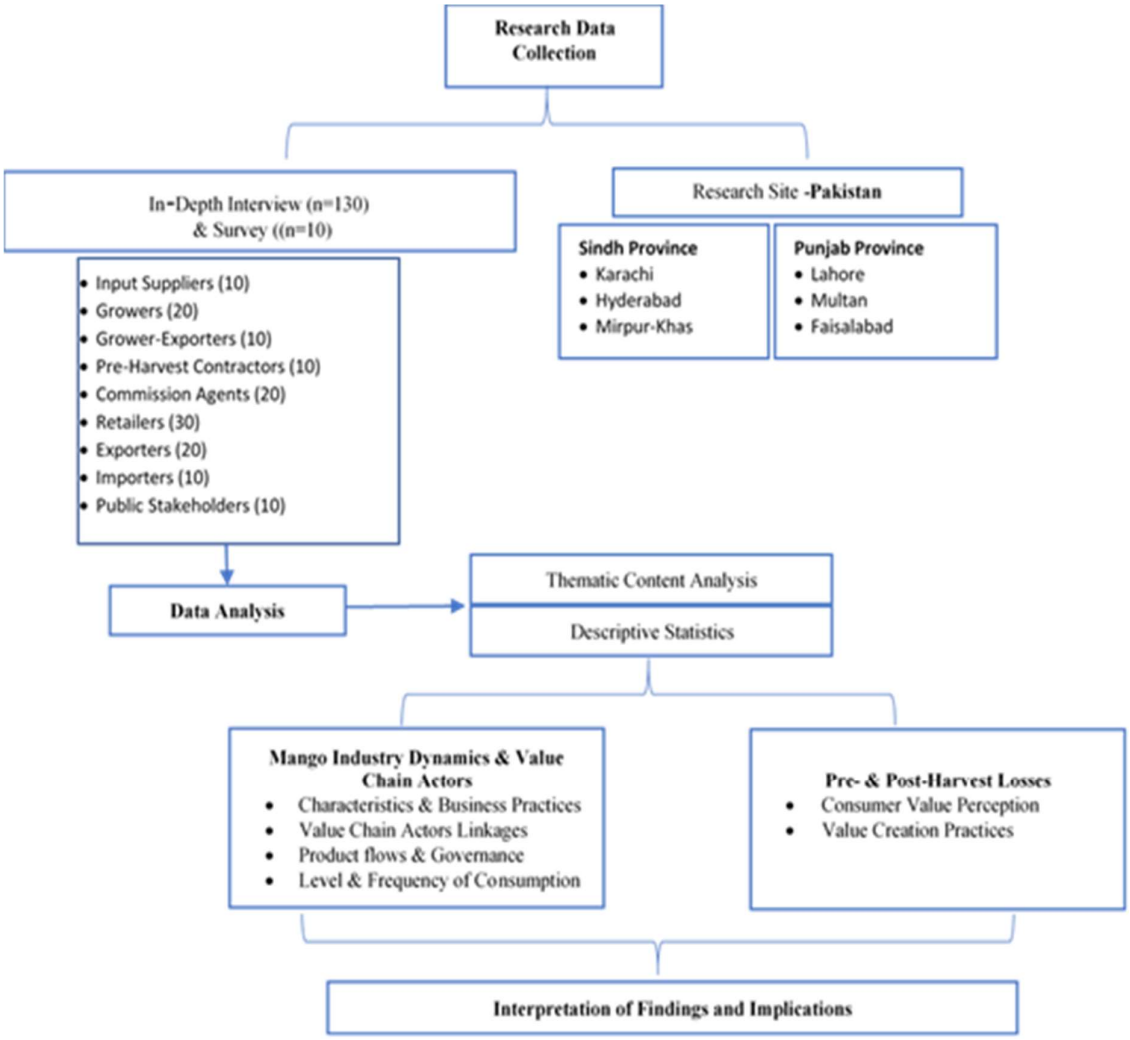


Figure 1. Summary Distribution and Composition of Sample of Research Participants

Topic guides for semi-structured interviews were created after reviewing relevant literature and were tested before the study. In-depth interviews were held with retailers and others in major markets and regions known for mango production. Online surveys were conducted with mango importers from major importing markets for Pakistani mangoes. Detail of targeted participants, data collection and methods and number of participants is given Table 1. All interviews were recorded in local languages and then translated into English. Thematic content analysis was used, employing NVivo 10 software to organize and analyze the data while maintaining participant confidentiality. All the in-depth interviews with mango value chain actors and public stakeholders were transcribed verbatim; this process made the researcher well acquainted with their content. The data was analyzed using thematic content analysis through Nvivo software and 15-points checklist as given in Table 2, was used to ensure the results validity. This involved data coding, which is "a way of tagging text with codes" to help retrieve information later (Jackson & Bazeley, 2019). Themes relating to value chain dynamics, pre- & post-harvest losses and causes of these losses extracted. The transcribed data were carefully reviewed multiple times to understand their meanings and extract important concepts. These concepts were coded into primary nodes, then related concepts were combined into sub-themes and coded at secondary nodes. This process continued until major themes were identified and coded at tertiary nodes, forming a hierarchy to illustrate patterns and relationships in the qualitative data.

Table 1. VC Participants, Type of tools and Method of Data Collection

| VC Participants | Data Collection Tool | Data Collection Method | # of Participants |
|---|---|---|---|
| Input Suppliers | Semi-Structure Questionnaire | In-depth Interview | 10 |
| Growers | Semi-Structure Questionnaire | In-depth Interview | 20 |
| Growers-cum-Exporters | Semi-Structure Questionnaire | In-depth Interview | 10 |
| Pre-Harvest Contractor | Semi-Structure Questionnaire | In-depth Interview | 10 |
| Commission Agents | Semi-Structure Questionnaire | In-depth Interview | 10 |
| Wholesalers | Semi-Structure Questionnaire | In-depth Interview | 10 |
| Retailers | Semi-Structure Questionnaire | In-depth Interview | 30 |
| Exporters | Semi-Structure Questionnaire | In-depth Interview | 20 |
| Importers | Survey Questionnaire | Online Survey | 10 |
| Public Stakeholders | Semi-Structure Questionnaire | In-depth Interview | 10 |
| | Total | | 140 |

Table 2. 15-point checklist for a good thematic analysis *(Braun & Clarke, 2006, p. 96)*

| *Process* | *No* | *Criteria* |
|---|---|---|
| Coding | 1 | The data have been transcribed to an appropriate level of detail, and the transcripts have been checked against the tapes for 'accuracy' |
| | 2 | Each data item has been given equal attention in the coding process |
| | 3 | Themes have not been generated from a few vivid examples (an anecdotal approach), but instead the coding process has been thorough, inclusive, and comprehensive |
| | 4 | All relevant extracts for each theme have been collated |
| | 5 | Themes have been checked against each other and back to the original dataset |
| | 6 | Themes are internally coherent, consistent, and distinctive |
| Analysis | 7 | Data have been analyzed interpreter, made sense of rather than just paraphrased or described |
| | 8 | Analysis and data match each other – the extracts illustrate the analytic claims |
| | 9 | Analysis tells a convincing and well-organized story about the data and topic |
| | 10 | A good balance between analytic narrative and illustrative extracts is provided |
| Overall | 11 | Enough time has been allocated to complete all phases of the analysis adequately, without rushing a phase or giving it a once-over-lightly |
| Written Report | 12 | The assumptions about, and specific approach to, thematic analysis is clearly explicated |
| | 13 | There is a good fit between what you claim you do, and what you show you have done- i.e., described method and reported analysis are consistent |
| | 14 | The language and concepts used in the report are consistent with the epistemological position of the analysis |
| | 15 | The researcher is positioned as active in the research process; themes do not just 'emerge' |

## 3. Results & Discussion

### 3.1. Dynamics of Mango Value Chains in Pakistan

The value chain describes the activities required to bring a product or service from conception to final delivery and final disposal after use (Kaplinsky & Morris, 2000). Mango value chains and value chain actors do not exist in isolation but are interconnected (Badar et al., 2015; Forsman-Hugg et al., 2013; Zúñiga-Arias et al., 2009). All actors create consumer values individually by transforming an input into product output, which is then forwarded to the next actor for more value creation (Hobley & Batt, 2010). These actors are supported by a range of technical, business, and financial service providers, and marketing and trade development and regulatory organizations. Value chain structure influences the dynamics of agri-enterprise behaviors, and these dynamics influence value chain performance. A number of activities along the mango value chains are performed by actors to create consumer value (Figure 2). The business practices, and characteristics of these value chains actors are now described:

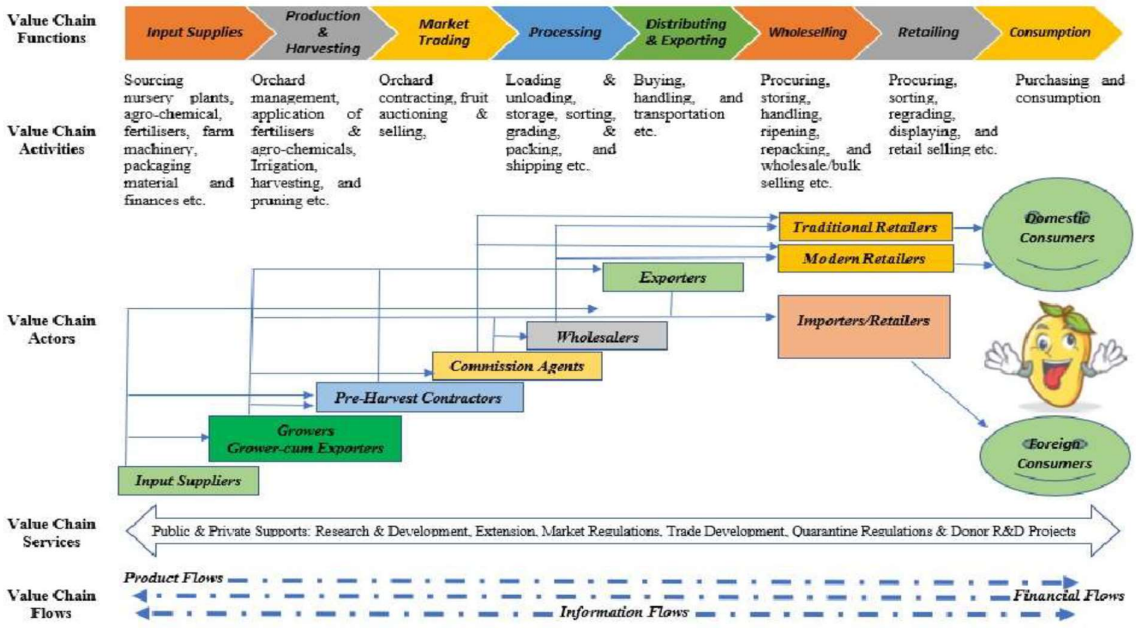


Figure 2. Mango Value Chains Dynamics (Actors, Functions, Activities, Services, and Flows)

### *3.1.1. Agricultural Input Suppliers*

Most growers and grower-exporters produced their own mango seedlings, with some sourcing from commercial nurseries. Interviewed nursery owners used waste mango stones from juice factories for seedlings. One owner noted that climate and limited potting materials affected their clean nursery operation. Fertilizer and pesticides are essential for mango production to meet nutrient needs and control various pests and diseases (Anwar et al., 201; Malik et al., 2010). Most growers obtained these from local dealers, while larger enterprises bought directly from companies. Wooden crates were commonly used for domestic packaging due to their low cost, while exporters preferred cardboard boxes.

Mango Growers' landholdings varied from less than 2 to more than 300 hectares. Among 20 interviewees, thirteen were small (<2 ha) and medium (>2<5 ha) growers without enough resources for modern practices, serving only domestic markets. In contrast, seven large growers (>5 ha) used modern practices for retail and export. Most small growers sold to contractors under varied terms, while large growers sold directly to agents and consumers. Profits were higher for those managing more of their value chain and had low losses from adapting improved farm practices. *Mango growers-cum-exporters* had large landholdings and are considered progressive. The ten interviewees adopted modern orchard practices and had infrastructure for processing and hot water treatment. This allowed them to harvest, sort, grade, process, pack, and sell their produce. Eight were awarded export-related certification and orchard registration from the Department of Plant Protection, enabling exports to high-end markets, but they also sold in domestic markets.

Pre-harvest contractors are called "Bekhar or Beopari." They purchased mango crops to supply commission agents and exporters. The ten contractors interviewed had different business methods, with some handling less than 50 ha and others more. Small contractors sold mostly through commission agents, while larger ones sold to exporters as well. They assessed harvest volume, costs, and consulted with commission agents before finalizing contracts. *Commission agents*, known as "Arhti," connect growers and pre-harvest contractors with wholesalers, retailers, exporters, and processors. Some have the resources to be exporters and operate in fruit and vegetable wholesale markets, owning shops and storage facilities. Eight interviewed agents sold mangoes via auction, charging a regulated commission and providing loans to pre-harvest contractors to secure mango orchards on the condition they sell through the agents. *Wholesalers*, called "Pharia" in Punjab and "Mashakhaur" in Sindh, buy large lots of mangoes

to sell to retailers and processors. After auctioning, the fruit is ripened using local wrapping methods before being sold. *Retailers:* Of the 30 interviewed retailers, 23 sold mangoes traditionally. Most lacked storage, causing losses with unsold mangoes. Quality depended on sales location and customer income.

Retailers handled all aspects of mango sales. They purchased through wholesalers or agents, hired vehicles for transport, and regraded fruit for customers. Most customers negotiated prices due to high competition. The seven modern retailers had transportation, refrigeration and storage, and a facility for displaying their fruit. They procured un-ripened mangoes directly from growers, commission agents, and wholesalers. The fruit was first sorted, graded, and cleaned, and then ripened before display. Specialty fruit retailers had designated a section for mangoes. Exporters: all 20 interviewed exporters sourced mangoes from growers, pre-harvest contractors, and commission agents, and used air or sea freight as needed. Six large exporters had advanced facilities, while 14 small-to medium sized exporters relied on shared resources. Sorting, grading, ripening, and packing were done by seasonal workers. Only two exporters used sea freight. *Importers*, from foreign markets mostly sourced mangoes from Pakistan.

There had been an increasing trend to import directly from growers. They preferred high-quality and medium-sized mangoes, as these bests served most retail outlets. In Pakistan, *public and private stakeholders* play important roles for sustainable mango production and provide a range of support services, most of the interviewed stakeholders included the Trade Development Authority (TDAP), Pakistan Horticulture Development & Export Company (PHDEC), Department of Plant Protection (DPP), Mango Research Station (MRS), Mango Research Institute (MRI), Sindh Horticultural Research Institute (SHRI), Directorate of Economics and Marketing, Directorate of Agricultural Extension, University of Agriculture, Faisalabad, MNS University of Agriculture, Multan, Sindh Agricultural University, Tandojam and International donor agencies.

### 3.2. Product, Information and Financial Flows along the Value Chain

Understanding how product information flows in both directions, and how actors are interconnected and create and deliver value to final consumers, is critical for value chain improvement (Neven, 2014; Hotegni et al., 2014). Actors and stakeholders must be interconnected and work collectively (Forsman-Hogg et al., 2013; Hobley & Batt, 2010; Zúñiga-Arias et al., 2009). The interviews found that the flow of mangoes along the chain was enabled by institutions in both the exporting and importing countries (Figure 2**)**. The features of product, information, and financial flows along mango value chains are as follows.

#### *3.2.1. Product flows*

The product (fresh mangoes) flowed in different ways to end consumers. The mango orchard is the starting point in the value chain. The growers planted purchased or self-raised seedlings. Other inputs were sourced from private companies. Most growers irrigated their orchards from canal water and had a tube well at their orchards. Apart from a small number, most growers sold their crop to a pre-harvest contractor at the flowering and early fruiting stages. The contractor subsequently managed all tasks through transporting and marketing the fruit. Harvested fruit was sorted into different grades (VIP, Super, and Special) and transported to commission agents, where it was sold to wholesalers by auction. Some produce was sold by growers directly to supermarkets if their production practices matched those of grower-exporters.

Based on product flows, the traditional, modern, and export mango value chains in Pakistan are like those in other developing countries (Gómez and Ricketts, 2013; Triennkens, 2011; Ruben et al., 2006; Woods, 2004). Most fruit still flows through "*Traditional Value Chains,"* which serve the needs of consumers from the low-medium income classes. A smaller quantity now flows through "*Modern Value Chains"* associated with the emergence of supermarkets and specialty shops (Badar, 2019; Shah et al., 2007); these serve the needs and requirements of middle- to high-income classes and are associated with better food quality, safety standards, and selling practices. "*Export Value Chains"* have evolved and are mainly driven by demand from foreign consumers and an ability to meet the quarantine requirements of importing countries.

*3.2.2. Financial flows*

Financial flows move backwards along value chains and end at input suppliers. These flows are spot payments, monetary advances, and credit; spot payments are made by consumers to retailers. In the traditional value chains, after deducting profit, retailers transfer consumer money back to wholesalers, and then through credit or cash spot payments to commission agents from wholesalers. After reimbursement of advance payments and deducting government-regulated commissions, the commission agents pass money to pre-harvest contractors and growers, including grower-exporters. Pre-harvest contractors make payments to mango growers in three agreed contractual instalments of payments. Mango growers then purchase input supplies. All value chain actors also make payments to labour. In modern value chains, supermarkets make credit payments through bank account transfer to growers, and commission agents. In export value chains, exporters make cash payments to growers and commission agents and credit payments to pre-harvest contractors .

*3.2.3. Information flows*

Information flows are an important connection for all actors and play a vital role in improving value chain performance (Hilary, et al., 2017; Ariyawardana & Collins et al., 2013). Information flows along the traditional mango value chain were found to be unbalanced and weak, particularly between domestic consumers and traditional retailers. The retailers were reluctant to respond to consumer concerns. In the lower parts of the chain, the central point for information flow between commission agents, wholesalers, and traditional retailers is the wholesale market. The weak flow of information was because of poor standardisation and lack of proper mechanisms to pass information among value chain actors. In wholesale markets, commission agents organised auctions. The fruit was presented in opened crates of mangoes, which were considered insufficient by buyers for assessing mango quality. Commission agents, who have strong forward and backward value chain linkages and strong information flows with pre-harvest contractors, estimated price based on market demand and supply. In contrast, there was limited flow of information between growers and pre-harvest contractors and commission agents; consequently, growers were generally ignorant of market prices, which weakened their bargaining power. As a result, growers were highly dependent on commission agents and pre-harvest contractors for pricing (Shah et al., 2007).

In the modern value chain, there was strong information flow between the retail outlets and commission agents and wholesalers. Supermarkets arranged prior training for mango growers on their fruit specifications. In the export mango value chain, there was strong forward and backward information flow between all value chain actors. In the domestic value chain, the directorates of economics and marketing of the provincial agriculture department played an important role in maintaining market intelligence and its distribution among value chain actors. Market committees prepared and disseminated daily commodity price lists based on average prices in wholesale markets, though few retailers displayed or responded to these lists. Few interviewees were satisfied with the agricultural extension services. The information provided was considered inadequate. In the export value chain, the TDAP, PHDEC, and DPP played a significant role in regulating exports and collecting and disseminating market and quarantine information. They also provided training to value chain actors about good agricultural practices and export requirements.

**3.3. Pre- and Post-Harvest Losses of Mangoes**

Data collected from actors operating along the mango value chains indicated that because of poor orchard management, pre- and post-harvest technical practices, and lack of skilled and trained labour, around 36-41 per cent of mango fruit was lost at different stages of mango value chains before it reached end consumers. Similar causes for mango wastage and losses were also reported by Sivakumar (2011) in developing countries.

Different research studies have recognized that the agricultural sector is highly vulnerable to the impacts of climate change, particularly at the farm stage, with flow-on implications to broad social and economic systems (Porter et al., 2014; Bollinger et al., 2014; Lim-Camacho et al., 2014). However, there is no adequate research study available on the impacts of climate change on post-harvest and food value activities (Lim-Camacho et al., 2014; Porter et al., 2014; Vermeulen et al., 2012).

Table 3. Major Causes and Mango Losses at Different Stages of Value Chain

| Value Chain Stages | Major Causes | Pre-Harvest Losses | Post-Harvest Losses |
|---|---|---|---|
| Orchard Stage | Weather Extremities<br>Temperature variation<br>Windstorm<br>Frostbites<br>Harvesting practices<br>Handling practices<br>Packaging practices<br>Transportation practices | 8 % | 15-20 % |
| F&V Wholesale Market Stage | Handling practices<br>Repacking practices<br>Ripening practices | 0% | < 5 % |
| Retail Market Stage | Handling practices<br>Packaging practices<br>Transportation practices<br>Ripening practices | 0% | 10-15 % |
| Export Stage | Disease infestation<br>Fruit fly infestation | 0 % | < 5 % |
| Total (domestic VCs) | | 08 % | 35-40 % |
| Total (export VC) | | 08 % | 25 % |

This study has found that the most common effects on mango growers, grower-cum-exporters, and pre-harvest contractors involved the changes to mango growing seasons, severe temperature and rainfall variations, productivity, and quality of fruits. At the mango orchard stage, 8% and 15-20% of pre-harvest and post-harvest mango losses respectively were reported by mango growers and pre-harvest contractors as depicted in table 3.

Most mango growers reported severe weather conditions such as windstorms, high temperature variation, rainfalls, and frostbite as the leading causes of pre-harvest mango losses. However, traditional harvesting and poor mango handling, packing, loading, unloading, and transportation practices caused major postharvest damage and loss of the mangoes.

Most of the growers, grower-exporters, and pre-harvest contractors reported severe impacts of climate change on production and fruit quality. The most significant was temperature effects producing low productivity and quality of mangoes. They also reported a shift in mango harvesting seasons because of prolonged summers and unexpected extreme rainfall events causing losses from damage, leading to lower productivity. One grower reported that.

"*There has been much climate change since the last two decades. The spread of winters has been shortened, and the feeling of gradual global warming has been noticed. Almost 35-40 % of the fruit set till the end is wasted due to extremities of weather. Even at the final mangoes harvesting stage, dust storms hail, and hot weather makes more losses*". (Mango Grower 02 – Multan)

Most commission agents and wholesalers reported early availability of mangoes in markets at the wholesale markets stage from early harvesting. Most traditional and modern retailers reported quality issues due to unexpected weather extremes during mango harvesting season. However, they also complained of losses due to inappropriate mango harvesting, packing, and handling.

At the wholesale markets stage, most commission agents did not report significant mango wastage, and wholesalers indicated less than 5% mango losses, mainly due to ripening and repacking. This research study found a low level of mango losses at this stage of value chains because commission agents deal in packed crates of mango fruit, whilst wholesalers bear losses from rough handling during ripening, repacking, loading, unloading, and transportation. However, poor handling practices of fruit and vegetables at wholesale markets cause damage to mango fruit that causes further losses at the retail markets stage.

At the retail markets stage, most of the traditional retailers reported 10-15% of mango losses because of inadequate handling, transportation, and belly packing of mangoes in wooden crates. In contrast to traditional retailers, modern retailers reported that they procure good-quality mangoes and have proper facilities for ripening, storage, and refrigeration; therefore, they only faced around 5 per cent losses.

At the export markets stage, mango exporters indicated less than 5% mango losses. Most of them reported that, to meet the foreign countries' requirements, they mostly procure high-quality mangoes from registered orchards and employ skilled and trained labourers to perform various functions necessary for export. Because of shortened winter seasons and early harvesting of mangoes in Pakistan, exporters reported that they faced competition with other early available mangoes from imported Indian mangoes. Most grower-exporters also reported that climatic changes, temperature variation, and unexpected rainfalls were affecting the quality of the produce they were marketing. Exporters also faced the issues of shortage of skilled labour and of inadequate packaging material, and therefore potential damage to and wastage of fruit during post-harvest activities. As one of the larger mango exporters commented:

*"We faced around 5% mango losses because of incorrect practices (at the processing facility) even though we trained labour every mango season but could not retain them for the whole season. Every season we need to hire new labour and train them again. To deal with this issue, we need to explore new commodities to process at the same processing facility so that we can keep trained labour around."* (Exporter 17 – Lahore)

The above research findings related to mango losses at different stages of mango value chains reveal that most value chain actors are not creating/maintaining lower prices for the consumer and are destroying economic value to be shared by all the chain actors. One of the public representatives of the Pakistan Horticultural Development and Export Company (PHDEC) also highlighted the impact of mango losses in the following comment:

*"From mango orchard to consumers, around 35% of mangoes are lost because of inadequate value chain practices, negatively impacting our farm production and income. If we control and reduce these postharvest mango losses, then it would help in generating more income with the same resource."*

Food losses are generally a major problem economically and environmentally in the agricultural value chain (Salihoglu et al., 2018; Gustavsson et al., 2011). Agricultural waste is often used to assess the environmental performance of an agricultural food system, as it has the potential to affect the delivery of consumer value (Bourlakis et al., 2014). This research study has found that a number of practices along the mango value chains in Pakistan produce a high level of wastage from damage loss, left-over agrochemicals, and packing material because of inappropriate handling practices and inadequate disposal measures.

*At the mango orchard stage,* damaged and burst mangoes and agrochemical residues and leftover packaging materials are a major source of contamination and loss. The majority of mango growers, grower-exporters, and pre-harvest contractors reported that weather extremities, traditional harvesting methods, and inappropriate handling practices caused substantial losses from these sources. However, they also said that the fallen, damaged, and rotten mangoes are purchased by processing companies to make various value-added by-products such as pulp, juices, pickle, and mango powder, locally known as *"aam chor"*. One of them also shared his concerns on wastage by saying:

*"Waste of agricultural chemicals is very dangerous and poisonous. They should be properly managed and disposed of, but most agricultural workers do not care about it and throw the wrappers and bottles of these chemicals in orchards or open places. These may be harmful and hazardous for themselves and other peoples and animals."* (Mango Grower 04, Kabirwala)

Inadequate sanitation and cleaning measures were observed at different *wholesale markets,* which can potentially cause problems for hygienic working conditions and environmental issues and create health problems for agricultural workers, mango traders, buyers, and consumers. The interviews with commission agents and wholesalers showed that they did not take adequate measures to dispose of the waste in the

form of rotten or damaged mangoes generated by their fruit handling and trading activities, and these wastes had the potential to cause environmental and hygienic problems in the fruit and vegetable wholesale markets themselves. *At the retail markets stage*, most traditional retailers reported that they discard rotten fruits, and ripening agents into the garbage of nearby retail businesses instead of properly disposing of them. By comparison, *the export markets* stage only created a small amount of waste. Most exporters reported that they procured good-quality mangoes and transported them to their processing facilities in plastic bins covered with paper. Therefore, they have a relatively small amount of packaging materials and mango waste.

Based on these findings related to the environmental sub-themes, it can be concluded that the environmental performance of mango value chains in Pakistan is sub-optimal because of inadequate and unregulated usage of agrochemicals, the inefficient management and utilization of natural resources, and poor management of agricultural and mango waste. The business practices of different actors and stakeholders in Pakistan's mango value chains do not demonstrate environmental responsibility

## 4. Conclusions & Recommendation

It can be concluded from the findings of the study that the dynamics of the mango industry focus on the value chain's actors and issues faced in creating consumer values. There was a diversity of stakeholders, and the complexity was typical of an agri-food industry and had a similar range of actors as identified previously. Each group of value chain actors was inter-connected to other groups in all the traditional, modern, and export value chains examined, and these were typical of those commonly operating in developing countries. The major flow of mangoes was still through traditional value chain, however, with the emergence of supermarkets in Pakistan, smaller quantities of fresh mangoes flow through the modern value chain, and the smallest proportion flowed through export value chain to fetch foreign consumers' requirements. It therefore essential that, value chain participants must build coordinated relationships, shared information among chain partners and modernize their practices and adapt them to the evolving demands of their clientele.

It was found that pre-harvest processes and changing weather mainly caused damage, which also causes post-harvest losses. Furthermore, traditional harvesting, poor packaging, transporting and handling practices, mechanical damages, disease attacks and fruit fly infestation significantly contributes to mango losses along the value chain. Therefore, it is necessary that value chain participants adopt improved mango production and postharvest practices including disease management, mechanized harvesting techniques, packaging material and practices, transportation, loading and unloading practices to improve productivity, quality and reduce pre- and post-harvest losses along mango value chains. Moreover, upstream management is very important to loss and improve the value chain performance. Mango losses and agricultural waste generated through various activities at different stages of mango value chains in Pakistan have social, economic, and environmental impacts. Socially, inadequate management and disposal of agricultural wastes and mango losses negatively affect the returns to smallholders and village-level traders in particular, but generally reduce returns for all the chain actors.

## Conflicts of Interest

The authors of this manuscript declare no conflict of interest.

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