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**| RESEARCH ARTICLE**

# Post-Harvest Losses, Bargaining Power, and Market Inefficiencies in Jordan's Potato Value Chain

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**| ABSTRACT**

Potato production plays an important role in Jordan's agricultural economy and food supply, while producers face challenges mainly related to post-harvest losses, market volatility, limited storage capacity, and weak market coordination. This study analyzes the potato value chain in Ramtha District, northern Jordan, with a focus on post-harvest losses, market relations, and opportunities for value-chain upgrading. A cross-sectional survey was conducted among 115 actors involved in potato production, marketing, logistics, storage, and consumption. Quantitative data were complemented by a limited number of open-ended responses to capture actors' views on key constraints and potential improvements. The findings indicate that market and post-harvest constraints are important sources of pressure on value-chain performance. Price volatility was identified by 91.2% of respondents as a factor reducing net profit margins, while 88% reported that wholesalers held the greatest bargaining power. Technology adoption was limited, with only 6.1% reporting the use of technologies such as grading, packing, price applications, or tracking systems. Affordable cold-storage facilities, standardized packaging processes, better market regulation, and greater price transparency during the season were among the other areas that respondents identified as needing improvement. The results suggest that upgrading storage and post-harvest handling, improving market transparency, providing better access to information and finance, and supporting better coordination among potato value-chain actors could contribute to reducing losses and improving the resilience of the potato sector in Ramtha. The study provides a field-based assessment of the potato value chain and identifies practical entry points for improving its efficiency and contribution to food security in Jordan.

**| KEYWORDS**

Potato value chain; Food security; Post-harvest losses; Agricultural logistics; Market governance; Jordan.

**| ARTICLE INFORMATION**

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## 1. Introduction

Food security is increasingly affected by climate variability, economic shocks, market volatility, and pressure on natural resources. These challenges are particularly important in the Middle East and North Africa (MENA), where water scarcity increases risks to agricultural production and can contribute to instability across agri-food supply chains. In this context, improving the efficiency and resilience of agricultural value chains is important not only for farmers' livelihoods but also for maintaining food availability and access (FAO et al., 2024; FAO, 2023; World Bank, 2017).

Jordan is known for its limited water resources, which places severe restrictions on agricultural production. In this regard, the development of agricultural value chains for those crops that have the greatest demand in the country is a priority. Potatoes are one of the most widespread vegetables in Jordan; they are in great demand and play a crucial role in the national economy. They

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are grown extensively in the northern part of the country, and Ramtha District in Irbid Governorate is among the largest potato-producing areas in the country. Therefore, an in-depth study of the potato value chain in this district is of particular interest (FAO, 2015; Ministry of Agriculture, 2022; Jordan News Agency [Petra], 2025).

A value-chain perspective allows the performance of an agricultural product to be examined across the different activities and actors involved in its movement from production to the final market. This includes not only farming, but also harvesting, sorting and packing, storage, transportation, wholesale and retail activities. The approach also helps identify how coordination, market relationships, information, and bargaining power influence the distribution of value among actors. In the case of perishable agricultural products such as potatoes, weaknesses in post-harvest handling, storage, and market coordination can result in physical losses and reduced returns for producers (Porter, 1985; Gereffi et al., 2005; Kaplinsky & Morris, 2001; Trienekens, 2011; Gustavsson et al., 2011; FAO, 2015).

Despite the importance of potatoes in Jordan, existing research has largely focused on production-related issues such as yields, diseases, water use, and cultivation practices, while less attention has been given to the complete value chain from farm to market. The literature review revealed gaps in the understanding of post-harvest losses at different levels of the chain, farmers' bargaining position, and the way market governance affects their trading conditions. Therefore, there is a need for field-based analysis, which would consider different actors as a whole, not focusing only on production or marketing (Jaradat et al., 2023; Bani-Hani et al., 2018; Al-Karablieh & Al-Assaf, 2017).

Against this background, this study assesses the potato value chain in Ramtha district, northern Jordan. It focuses on the main links and actors within the chain, with particular emphasis on post-harvest losses, market and price conditions, bargaining power, technology application, and availability of storage and other services. The study explores potential areas of value-chain upgrading, such as improving storage, sorting and packing, logistics, market information and coordination. It uses primary data gathered from value-chain actors in order to contribute to an evidence-based understanding of constraints and opportunities for the upgrade of the Jordanian potato value chain, and thus its increased role in the national food security.

## 2. Literature Review

### *2.1 Agricultural Value Chains and Food Security*

Value-chain analysis provides a framework for examining how value is created, transferred, and distributed across the different activities and actors involved in bringing a product from production to the final market. The approach has evolved from the analysis of firm-level activities to broader global value-chain perspectives that consider governance, coordination, standards, power relations, and the distribution of returns among actors (Porter, 1985; Gereffi et al., 2005; Kaplinsky & Morris, 2001). In agricultural systems, these dimensions are particularly relevant because farmers' outcomes are influenced not only by production practices but also by access to storage, market, transportation, information, and other services (Trienekens, 2011).

Agricultural value-chain studies have therefore been used to examine market access, farmer organization, coordination among actors, and opportunities for upgrading. Previous research has shown that improvements in logistics, post-harvest handling, market coordination, and collective action can influence both farmer returns and food availability. At the same time, the benefits of value-chain upgrading are not necessarily distributed equally among actors. Governance arrangements, market standards, and differences in bargaining power can affect which actors are able to capture greater value within the chain (Hellin et al., 2009; Devaux et al., 2007; Markelova et al., 2009; Trienekens, 2011).

Post-harvest loss is an important aspect of this relationship. Losses may occur at various stages, including harvesting, sorting and packing, storage, transportation, wholesale, and retail. These losses can affect both the quantity and quality of food products for consumers and the income of producers. For perishable agricultural products, inadequate infrastructure and handling can reduce the amount of food and its quality reaching consumers while decreasing the producers' incomes. In water-scarce environments, the minimization of physical losses has an additional importance because resources spent on the production of lost food are also wasted (Gustavsson et al., 2011; FAO, 2015).

### *2.2 Food-System and Potato Value-Chain Challenges in MENA and Jordan*

The MENA region faces persistent constraints related to water scarcity, climate variability, and dependence on food imports. These conditions increase the importance of improving the efficiency and resilience of domestic agricultural value chains. Regional evidence identifies post-harvest loss as a continuing challenge, particularly for fruits and vegetables, where inadequate cold-chain infrastructure, handling practices, and transportation can contribute to losses between harvest and retail. Climate-related pressures can further increase production and market risks, particularly for producers with limited access to finance and risk-management mechanisms (World Bank, 2017; FAO, 2023a; Govind, 2022; FAO, n.d.).

These challenges were particularly acute in Jordan, where agriculture development takes place under very limited water resources. The country's food-security and agricultural policies have focused on improving water productivity, with an emphasis on enhanced agricultural value chains, as well as infrastructure and market development, to strengthen the resilience of its food production system. The National Food Security Strategy (2021–2030) and National Plan for Sustainable Agriculture also explicitly prioritize building agri-food value chains and upgrading agricultural and market infrastructure (FAO, 2015; The Hashemite Kingdom of Jordan, 2022; Ministry of Agriculture, Hashemite Kingdom of Jordan, 2022).

The significance of potatoes as a vegetable crop in this context can be explained by their demand and importance for agricultural livelihood. It should also be noted that potato production is mainly localized in several regions, among which northern Jordan is the most prominent. The district of Ramtha, in particular, is mentioned in the project documents as a key potato-producing area. Research on Jordanian potato production has examined issues such as disease management, water use, planting density, seed quality, and yields. However, these studies generally address production-level issues rather than the broader chain through which potatoes move from farms to markets (Jordan News Agency [Petra], 2025; Jaradat et al., 2023; Bani-Hani et al., 2018; FAOSTAT, 2025).

### *2.3 Potato Value Chains, Market Relations, and Research Gap*

Evidence from potato-producing countries illustrates the importance of post-harvest management and market organization. Studies from countries such as Egypt and India have documented losses associated with inadequate storage and handling, as well as challenges related to price instability and farmer profitability (El-Rahman et al., 2018; Degebasa, 2020). Other studies highlighted the importance of farmer organization and collective action in improving access to inputs, markets, and bargaining opportunities (Hellin et al., 2009; Devaux et al., 2007; Markelova et al., 2009; Trienekens, 2011). However, the effectiveness of such mechanisms depends on the institutional and market context in which they operate (Trienekens, 2011).

In Jordan, the available literature on potatoes remains relatively fragmented. Existing research provides information on production, pests, water use, and other agronomic issues, while comparatively less attention has been given to the complete potato value chain (Jaradat et al., 2023; Bani-Hani et al., 2018; Al-Karablieh & Al-Assaf, 2017). In particular, there is limited field-based evidence that simultaneously examines post-harvest losses, market relationships, bargaining power, and the conditions under which farmers sell their produce. The literature review similarly identifies a limited number of studies that follow potatoes from farm to market or examine how market governance and farmers' terms of trade affect outcomes.

The relevance of such a gap becomes more evident if we consider the situation in the Ramtha district because the potato production there involves various stakeholders like wholesalers, retailers, transport and logistics companies, storage and packing firms, and big buyers. By looking at the agricultural value-chain description from these different perspectives, it may be possible to understand where the losses occur and what changes need to be made to address them. Therefore, the current research will focus on the potato value chain in Ramtha and attempt to assess the sources of post-harvest losses, market situations and prices, bargaining power, use of technologies, and access to storage and other services. It will also consider various options for upgrading the value chain, including improving storage, sorting and packing, logistics, market information, and coordination.

## 3. Methodology

### *3.1 Research Design and Study Area*

This study used a cross-sectional survey to examine the potato value chain in Ramtha District, Irbid Governorate, northern Jordan. The study was mainly quantitative, with a limited number of open-ended questions added to capture respondents' views on key constraints and possible improvements. No key informant interviews or focus group discussions were conducted. Ramtha was selected because of its importance as a seasonal potato production area and the range of actors involved in the local value chain. The study considered the chain beyond farm-level production and included actors involved in marketing, transportation, storage, packing, and final consumption.

### *3.2 Study Population and Sampling*

The target population included six main groups of actors: farmers, wholesalers, retailers, transport and logistics providers, storage and packing operators, and large consumers such as restaurants, hotels, and processors. For farmers, the sampling frame covered the main potato-producing area in Ramtha. For the other groups, respondents were identified through local markets and relevant urban nodes.

The estimated number of potato farmers in the district was approximately 200. An initial sample-size calculation, based on a 95% confidence level, a 6% margin of error, a population proportion of 50%, and an estimated population size of 200 farmers, yielded a target sample of 115 respondents. To capture perspectives from across the potato value chain, the study included six groups of actors: farmers, wholesalers, retailers, transport and logistics providers, storage and packing operators, and large consumers. The planned allocation was 60 farmers, 12 wholesalers, 15 retailers, 10 transport and logistics providers, 10 storage and packing operators, and 8 large consumers. Because population sizes for the other value-chain actor groups were not available, respondents from these groups were included to provide coverage of the different stages of the value chain. The achieved sample differed from the planned allocation, with approximately 77 farmers accounting for 67% of the final sample.

### *3.3 Data Collection Instrument*

Data were collected using a structured questionnaire consisting mainly of close-ended questions, together with a limited number of open-ended questions. The questionnaire covered eight areas: respondent and business characteristics; production inputs and practices; yields and losses; markets and prices; transportation, storage and packaging; risks and constraints; coping strategies and good practices; and respondents' suggestions for improving the value chain.

Before the main data collection, the questionnaire was piloted with 5–8 respondents to check the clarity of the questions and the time required to complete the survey. Minor adjustments were made following the pilot. The research team was also briefed on informed consent, neutral probing, and the definitions of key terms used in the questionnaire. During data collection, completed responses were checked regularly for completeness and consistency.

### *3.4 Data Management and Analysis*

The survey was administered digitally using Kobo and the collected data were exported to Excel/CSV for cleaning and preparation for analysis. The dataset was checked for duplicate records and inconsistent values, while selected outliers were verified through follow-up calls. Units were standardized where necessary, including quantities reported in kilograms or tonnes and monetary values in Jordanian dinars. A codebook was prepared to document the variables and their coding.

The analysis of the data mainly relied on descriptive statistics such as frequencies, percentages, mean, median, and standard deviation depending upon the nature of the variable. The percentages were computed using the valid percentages for each item. In cases where there were multiple response items, each item was separated and analyzed individually. Thus, the percentages may add up to more than 100%. The open-ended questions were analyzed by identifying themes and grouping similar responses and then summarizing the results using percentages and frequencies.

The participants were reminded that they could skip any questions that they do not want to answer or stop the survey at any time. The participants were also assured that no personal information would be collected.

## 4. Results and Findings

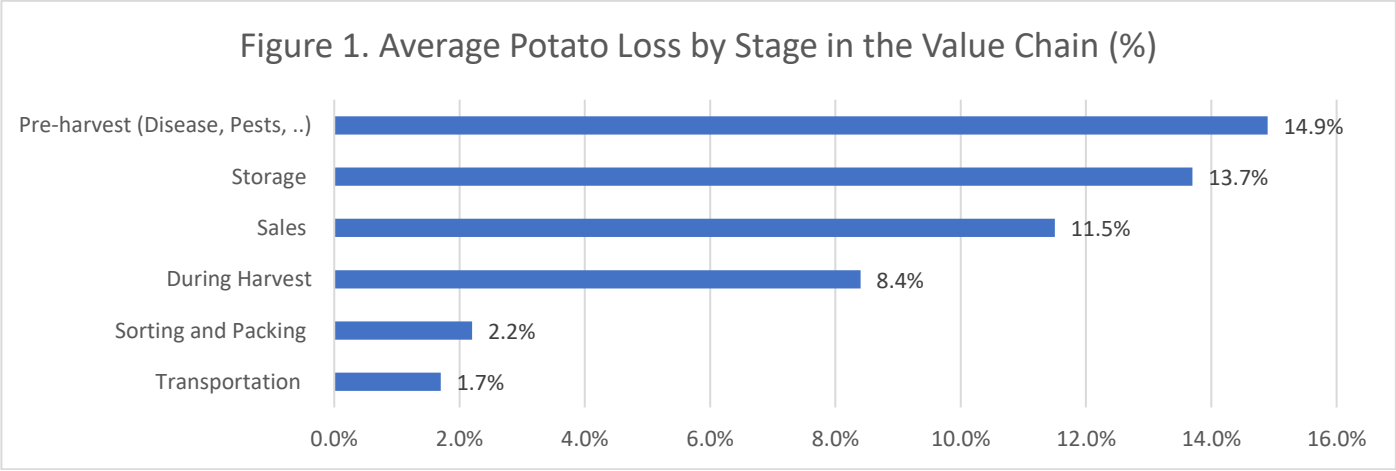
### *4.1 Profile of the Survey Respondents*

A total of 115 respondents participated in the survey, representing different stages of the potato value chain in Ramtha District. Farmers constituted the largest group, accounting for approximately 77 respondents (67%), followed by wholesalers/distributors (9%), retailers (9%), transport and logistics providers (6%), storage and warehouse operators (5%), and large consumers such as restaurants and hotels (4%). The sample was predominantly male, with 113 respondents (98.3%) being men and two (1.7%) women. The composition of the sample provided coverage of the main activities through which potatoes move from production to the market. However, the relatively large proportion of farmers means that the findings should be interpreted primarily as a description of the surveyed value-chain actors rather than as a statistically representative estimate for every actor group in the district.

### *4.2 Production and Losses Along the Value Chain*

Among surveyed farmers, the average planted area for the season was 318 dunums, with a median of 259 dunums. The average reported land-preparation cost was JOD 970 per dunum, compared with a median of JOD 1,000. Seeds were identified as the costliest production input by 50.0% of respondents, followed by water (28.3%) and fertilisers (20.4%). The main production challenges reported were pest control (23.3%), price fluctuations (22.4%), soil health (20.5%), market access (17.1%), and water availability (16.8%). Reported potato losses occurred at several stages of the value chain (Figure 1). The highest average loss was reported during the pre-harvest stage, primarily due to diseases and pests, at 14.9% (median: 15%; n=86). This was followed by storage losses, averaging 13.7% (median: 15%; n=97).

Losses associated with sales, including stagnation and price reductions, averaged 11.5% (median: 10%; n=100). Average losses during harvesting were 8.4% (median: 10%; n=86), while losses during sorting and packing and transportation were lower, at 2.2% and 1.7%, respectively.



The reported causes varied by stage. Before harvest, diseases and pests and climatic conditions were each identified by 71.7% of respondents, followed by seed quality (69.9%) and farming practices (68.1%). During harvesting, inappropriate tools or equipment were identified by 73.6% of respondents as a cause of loss. For sorting and packing, impacts and mishandling were the most frequently reported causes (73.5%), followed by humidity or heat (22.1%) and inadequate packaging (15.0%).

Storage-related losses were associated mainly with pests and fungi (58.6%) and poor ventilation (41.4%). Electricity costs were identified by 87.2% of respondents as a storage constraint, while 83.5% reported the lack of suitable cold-storage facilities. During transportation, improper loading was the most frequently reported source of loss (78.6%), whereas congestion or delays, long distances, and poor road conditions were mentioned less frequently. Most respondents described road conditions as average (66.1%), while 30.4% considered them good and 3.6% considered them poor.

At the sales stage, price volatility was the most frequently reported cause of economic loss (82.3%), followed by oversupply (76.1%) and high-quality requirements (49.6%). In an open-ended question concerning the main reason for potato losses, weather and temperature fluctuations were mentioned most frequently (35.7%), followed by pests and diseases (21.3%) and input or seed quality issues (10.6%).

### *4.3 Market Conditions, Selling Practices, and Bargaining Power*

Most respondents described current potato demand as medium (74.8%), while 12.2% considered it high and 5.2% very high. Potatoes were primarily sold through wholesale markets, which accounted for 66.4% of reported sales channels. Smaller shares were sold through contracts with restaurants or hotels (11.0%), retailers (9.6%), and direct farm sales (8.9%). Only 2.7% reported selling to export markets. The geographical distribution of sales also showed a strong orientation toward markets outside Irbid Governorate.

Respondents generally perceived competition in potato marketing as high or very high, with 33.9% describing competition as high and 49.6% as very high. Price formation was strongly linked to wholesale markets and brokers. In the detailed price-determination question, 87.5% identified the wholesale market and 65.2% brokers as mechanisms influencing price formation; negotiation or contracts were reported by 7.1%, cost-based margins by 6.3%, and large buyers' requirements by 5.4%.

Price conditions were also a major issue. When asked about price changes over the previous three years, 75.7% of respondents reported that prices had decreased, while 5.2% reported a significant decrease. In contrast, 84.3% reported that prices had increased recently, suggesting substantial fluctuations rather than a stable price trend. Price volatility was identified by 91.2% of respondents as a factor reducing net profit margins during the previous season. High commissions were reported by 74.3%, while 72.6% identified high post-harvest losses as a factor affecting profitability.

The distribution of perceived bargaining power was particularly concentrated. Eighty-eight percent of respondents identified wholesalers as the actors with the greatest bargaining power, compared with 5% for retailers, 4% for large consumers, and 3% for farmers. These responses indicate that wholesale markets and intermediary actors play an important role in determining the conditions under which potatoes are sold.

### *4.4* Access to Training, Services, Finance, and Technology

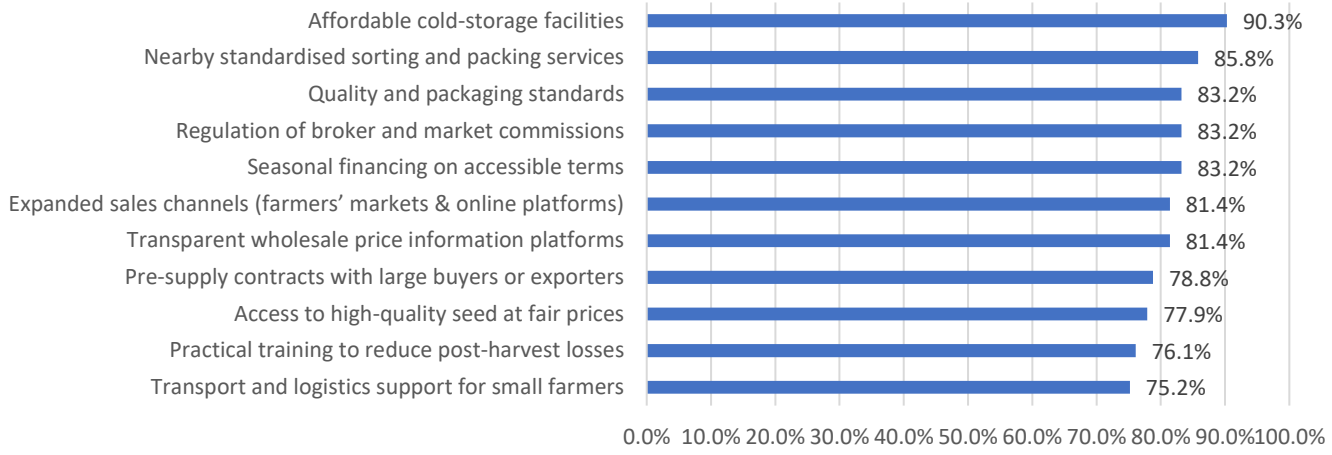
Access to training and support services was limited among the surveyed respondents. Only two respondents reported having attended relevant training, both related to transportation and logistics. Similarly, only three respondents reported benefiting from government services, with the support mainly consisting of market-price information. One transport-sector respondent reported receiving financial support but considered the amount insufficient.

Technology adoption was also limited. Only seven respondents (6.1%) reported using technologies such as grading and packing systems, price applications, or sensor and tracking tools. Approximately 30% of respondents reported using some form of coping strategy during difficult seasons. Storage was the main strategy reported by all respondents in this group, while one respondent specifically mentioned cold storage and another reported exporting surplus production.

### *4.5* Respondents' Suggested Improvements

Respondents identified several potential improvements to the potato value chain. Affordable cold-storage facilities received the highest level of support, selected by 90.3% of respondents, followed by nearby standardised sorting and packing services (85.8%). Seasonal financing on accessible terms and the regulation of broker and market commissions and quality and packaging standards were each selected by 83.2% of respondents. Transparent platforms providing real-time wholesale price information and expanded sales channels, including farmers' markets and online platforms, were each identified by 81.4% of respondents. Figure 2 presents the most frequently suggested improvements to the potato value chain, highlighting priorities related to storage, post-harvest handling, access to finance, market regulation, and price transparency.

Figure 2. Respondents' Suggested Improvements to the Potato Value Chain (%)




Note: Multiple responses were permitted; percentages represent the proportion of respondents selecting each improvement and do not sum to 100%.

Other proposed measures included pre-supply contracts with large buyers or exporters (78.8%), access to high-quality seed at fair prices (77.9%), practical training to reduce post-harvest losses (76.1%), and transport and logistics support for small farmers (75.2%). Because these were multiple-response questions, the percentages represent the proportion of respondents selecting each option and therefore do not sum to 100%.

Among the 29 respondents who provided an open-ended response concerning the single decision that could immediately improve their income, price transparency and market regulation were the most common theme (45%). Training, extension, and mechanisation accounted for 14%, followed by seed access and quality (10%), storage infrastructure and terms (7%), and lower regulatory or energy costs (7%).

### *4.6* Additional Statistical Analysis

The study also examined selected relationships between reported losses, market conditions, and practices. Because storage-loss percentages and net returns were not normally distributed, non-parametric tests were used.

For storage losses, a direct measure of access to cold storage was not available in the dataset. Instead, selection of "inappropriate temperatures" as a cause of storage loss was used as a proxy. Storage-loss percentages did not differ significantly between respondents who selected this factor and those who did not (Mann–Whitney $U = 925.5$, $Z = -0.31$, $p = .759$). The median storage loss was 10% in both groups. This finding was contrary to the expected direction, as inappropriate storage temperatures would be expected to be associated with higher storage losses. The absence of a significant difference may reflect the use of a proxy measure for storage conditions, as well as the relatively small number of observations in some response categories.

Reported transport losses also did not differ significantly according to road-condition categories (Kruskal–Wallis $H(2) = 0.799$, $p = .671$). Median transport loss was approximately 1% among respondents reporting good or average road conditions, compared with approximately 2.6% among the small group reporting poor road conditions ($n = 4$). Although the median loss was higher among respondents reporting poor road conditions, the difference was not statistically significant. This result should be interpreted cautiously given the very small number of observations in the poor-road category, which limits the reliability of the comparison.

Finally, respondents who reported adopting coping or good practices had higher reported total losses than those who did not (Mann–Whitney $U = 697.0$, $Z = -2.553$, $p = .011$). Median total loss was 52% among adopters and 47.5% among non-adopters. This finding was contrary to the original expectation that adoption of good practices would be associated with lower losses. The result should therefore not be interpreted as evidence that the practices themselves increase losses. The relationship may instead reflect reverse causality or other factors, such as actor type, scale, water access, and timing within the season.

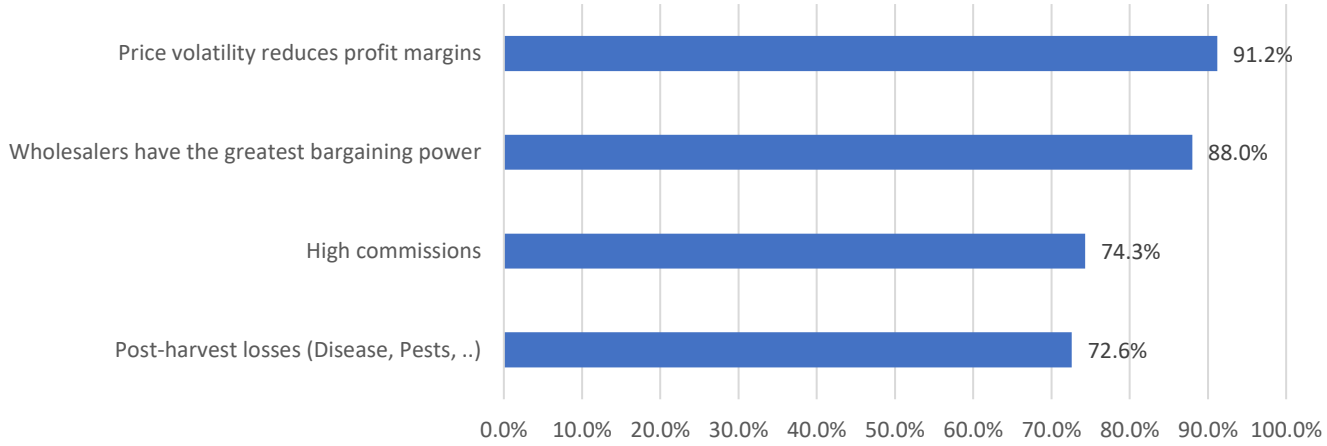
## *5.* Theoretical Implications

reported before harvesting (14.9%) and during storage (13.7%). These findings reinforce the theoretical argument that agricultural value creation depends not only on production efficiency but also on the coordination and effectiveness of

downstream activities. Accordingly, the study highlights the relevance of adopting an integrated, system-wide perspective when examining agricultural value-chain performance in developing economies.

Second, the study contributes to value-chain governance theory by highlighting how market structures, bargaining power, and price dynamics shape the distribution of economic value among supply-chain actors. Gereffi et al. (2005) emphasise that governance arrangements influence coordination and the distribution of economic opportunities within value chains. The findings provide context-specific evidence of these dynamics in the potato value chain in Ramtha District. Wholesalers were identified by 88% of respondents as having the greatest bargaining power, while 91.2% reported that price volatility reduced profit margins. In addition, 74.3% identified high commissions and 72.6% identified post-harvest losses as factors affecting profitability. Together, these findings highlight the perceived influence of market power, price instability, transaction costs, and post-harvest inefficiencies on the profitability of potato production and marketing.

Figure 3. Key Market and Value-Chain Factors Affecting Profitability




Note: Multiple responses were allowed. Percentages indicate the proportion of respondents who identified each factor as affecting profitability.

These findings suggest that market concentration and information asymmetry may constrain producers' ability to capture value, even when production activities are relatively efficient. The study therefore extends the application of value-chain governance theory to local agricultural markets in Jordan, illustrating how perceived power imbalances and market uncertainty can represent important barriers to more equitable value distribution.

Third, the findings contribute to the literature on agricultural value-chain upgrading by emphasizing the potential complementarity between physical infrastructure, technological capabilities, and institutional coordination. Previous research has recognized the importance of logistics improvements, market access, and collective action in strengthening agricultural value chains (Devaux et al., 2007; Markelova et al., 2009; Trienekens, 2011). The present study adds to this discussion by identifying limited technology adoption (6.1%), inadequate access to cold-storage facilities, and insufficient training and support services as simultaneous constraints. These findings suggest that upgrading agricultural value chains should be conceptualized as a multidimensional process encompassing operational, technological, and institutional improvements. Furthermore, the statistically significant association between adopting coping practices and reporting higher total losses ($p = .011$) challenges the assumption that adopting such practices is necessarily associated with better outcomes. Rather than establishing an adverse effect of these practices, this relationship raises the possibility that actors experiencing greater losses are more likely to adopt corrective measures. This observation highlights the importance of considering contextual conditions, adoption timing, and reverse causality when developing theoretical explanations of agricultural value-chain upgrading.

Finally, the study contributes to discussions linking agricultural value-chain efficiency with food security and resilience in resource-constrained environments. The findings indicate that losses, limited storage capacity, and market volatility coexist within a food-production system already affected by water scarcity and climate-related pressures. Building on the arguments of Gustavsson et al. (2011) and FAO (2015), the study reinforces the relevance of examining food security through the combined perspectives of physical losses, market access, and supply-chain coordination. It also identifies potential relationships among these dimensions that warrant further theoretical development and longitudinal testing. Overall, the research provides a context-

specific foundation for examining how governance arrangements, logistics capabilities, and market coordination jointly influence agricultural value-chain performance and resilience.

### *6.* Practical and Managerial Implications

The findings provide several practical implications for farmers, wholesalers, logistics service providers, agricultural cooperatives, and policymakers seeking to improve the efficiency and resilience of the potato value chain in Ramtha District. First, improving post-harvest infrastructure should be considered a priority, particularly given the reported average storage losses of 13.7% and the widespread identification of electricity costs (87.2%) and inadequate cold-storage facilities (83.5%) as major constraints. The Ministry of Agriculture, agricultural cooperatives, and private investors could explore shared cold-storage facilities that provide affordable services to farmers, particularly smaller producers who may lack the financial resources to invest individually. Such facilities could be supported through public–private partnerships, cooperative financing arrangements, or targeted agricultural development programmes. Furthermore, investments in standardized sorting, grading, and packaging services could improve product handling and reduce quality deterioration, although their economic effectiveness should be evaluated through pilot projects and cost–benefit assessments.

Second, the findings highlight the need to improve market transparency and strengthen farmers' bargaining positions. Given that 88% of respondents perceived wholesalers as possessing the greatest bargaining power, while 91.2% associated price volatility with reduced profit margins, policymakers should consider establishing transparent agricultural market-information systems. Digital platforms providing regularly updated wholesale prices, supply conditions, and market-demand information could help farmers make more informed decisions regarding harvest timing, storage, and selling arrangements. Agricultural cooperatives could also facilitate collective marketing, coordinated transportation, and negotiations with wholesalers and institutional buyers. In addition, promoting transparent commission structures and voluntary pre-supply contracts with restaurants, food processors, and large retailers could provide farmers with greater predictability and additional marketing opportunities.

Third, improving technological capabilities and practical training is essential for supporting agricultural value-chain upgrading. The finding that only 6.1% of respondents reported using relevant technologies indicates considerable scope for introducing accessible digital and operational tools. Agricultural extension services and training institutions could provide targeted programmes covering post-harvest handling, pest management, storage practices, grading, packaging, and basic digital market applications. Rather than prioritizing expensive technological solutions, interventions should initially focus on affordable technologies that correspond to farmers' operational needs and financial capacities. Demonstration projects and cooperative technology-sharing initiatives could help evaluate usability, adoption barriers, and potential economic benefits before wider implementation.

Fourth, the findings underline the importance of improving access to agricultural finance and strengthening coordination among value-chain actors. Seasonal financing on accessible terms was identified as a priority by 83.2% of respondents, suggesting that financial constraints may limit producers' capacity to invest in appropriate inputs, storage services, and post-harvest improvements. Financial institutions and agricultural development agencies could therefore explore seasonal credit products with repayment schedules aligned with agricultural production and marketing cycles. Complementary support could include cooperative purchasing arrangements, shared logistics services, and structured coordination mechanisms connecting farmers, wholesalers, transport providers, storage operators, and large buyers. These measures could improve information exchange, reduce operational fragmentation, facilitate more coordinated decisions across the value chain.

Finally, the findings offer important implications for agricultural policy and food-security planning in Jordan. Given the country's water scarcity and the importance of potatoes to domestic food supply, reducing avoidable losses may complement efforts to increase agricultural production. Policymakers should therefore consider integrating post-harvest loss reduction, market transparency, farmer capacity building, and infrastructure development into regional agricultural development programmes. Priority interventions could be evaluated using measurable indicators, including storage-loss percentages, post-harvest handling costs, price variability, farmers' net returns, and technology adoption rates. Such monitoring would allow government agencies and other stakeholders to assess whether proposed interventions improve value-chain performance and generate benefits for different groups of actors. Collectively, these recommendations provide a practical framework for strengthening the potato value chain in Ramtha while supporting broader national objectives related to agricultural sustainability, resilience, and food security.

## 7. Conclusion

This study examined the potato value chain in Ramtha District by considering the different actors involved in production, marketing, transportation, storage, packing, and consumption. The findings show that challenges in the value chain are not concentrated at a single stage. Losses were reported before harvest, during harvesting and handling, in storage, and at the point of sale, while market conditions added further pressure on producers and other actors.

The results particularly point to the importance of post-harvest management and market conditions. Storage losses were relatively high, and respondents identified electricity costs and limited access to cold-storage facilities as major storage constraints. At the market level, price volatility, commissions, and dependence on wholesale markets were frequently associated

with reduced profitability. The concentration of perceived bargaining power among wholesalers also suggests that farmers have limited influence over price and selling conditions.

Yet, the survey also showed limited availability of some of the resources that could help actors in responding to these problems. Training participation and use of modern technology were low, and government services and finances were not easily accessible. Respondents also gave some recommendations for improving the situation in the chosen geographical area by providing affordable storage, standardized sorting and packing, market price information, regulation of commissions and quality, seasonal financing, and broader sales channels.

The findings thus suggest that improvement of the potato value chain in Ramtha requires consideration of both infrastructural and market aspects. Enhancements in storage and post-harvest handling will help to reduce losses, while provision of market information and well-defined market rules may facilitate more informed selling and production decisions on the part of value-chain actors. Capacity building, provision of appropriate technologies, access to finance, and improved coordination will complement these measures.

As with any field-based study, the findings should be considered in light of the study design. The cross-sectional survey provides a snapshot of the potato value chain during the study period, while the use of self-reported data reflects the experiences and perceptions of value-chain actors. The sample covered the main actor groups in the chain, although farmers represented the largest share of respondents, consistent with the study's emphasis on the production side of the value chain. For selected statistical comparisons, some response categories were relatively small and findings should therefore be interpreted with appropriate caution. The analysis of storage conditions also used a proxy measure where a direct measure of access to cold-storage facilities was not available. Accordingly, the statistical findings identify associations within the surveyed data rather than causal effects. Future studies could build on these findings through multi-season data collection, larger actor-specific samples, and the integration of observed loss measurements, transaction prices, and detailed value-chain margins.

Overall, the study provides field-based evidence on the constraints faced by potato value-chain actors in Ramtha and identifies practical areas for further investigation and intervention. Improving post-harvest management, storage, market information, and coordination could support a more efficient and resilient potato value chain and contribute to the broader role of agricultural systems in food security in Jordan.

This study contributes to the agricultural value-chain literature by providing empirical insights into how post-harvest constraints, market governance, bargaining power, and limited technological capabilities shape value-chain performance in an emerging economy characterized by resource scarcity. First, the findings extend the agricultural value-chain perspective by demonstrating the importance of examining production, logistics, storage, and market relationships as interconnected activities rather than isolated operational functions. Consistent with the value-chain frameworks of Porter (1985), Gereffi et al. (2005), and Trienekens (2011), the findings indicate that inefficiencies arise at multiple stages of the potato value chain, with particularly substantial losses

**Ethics and informed consent**: No formal ethics committee approval was obtained or required for this study. Participation in the survey was voluntary, and verbal informed consent was obtained from respondents before data collection. Respondents were informed that they could decline to answer individual questions or withdraw from the survey at any time. Personal identifiers were not retained in the final dataset. The data were collected and used for academic purposes.

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