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Research Article

POST-HARVEST LOSSES OF MAIZE SUPPLY CHAIN IN PUNJAB, PAKISTAN

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Abstract

Maize holds significant importance in Pakistan's agricultural sector, as it is among the primary cereal crops grown extensively throughout the country. The growing food demand due to the increasing population is a significant issue. Post-harvest losses (PHL) of maize relate to losses that happen laterally in the whole grain logistics network, after harvest to final consumption. The study was conducted in the district Vehari to assess the different types of post-harvest losses and identify the underlying factors responsible for such losses in the maize supply chain. For this purpose, data were collected from 210 respondents by using purposive sampling technique. The sample size includes 120 growers, 30 village traders, 30 commission agents cum wholesaler and 30 retailers. Structured questionnaires were used to gather data from major supply chain actors. The study findings revealed that the average losses at the grower's level, village traders, commission agent cum wholesaler and retailer were 12.21, 2.36, 3.21 and 1.01 percent of the total production respectively. It is recommended that the implementation of modern storage facilities, drying using advanced technologies, training programs for the supply chain actors, financial innovations, and efficient transportation systems will result in significant reduction of post-harvest losses (PHL) in maize production and thus contribute to food security.

Keywords: Post-harvest losses, Maize, Food loss, Supply chain, Punjab.
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1. INTRODUCTION

Corn or maize (Zea mays) is considered as the main grain crops worldwide, after wheat and rice. The nutritional composition of the maize endosperm includes 66.2% carbohydrates, 11.1% protein, 3.6% lipids, 3.6% vitamins and minerals, and 2.7% fiber. The main component of maize kernel oil, the seed, ranges in percentage from 3 to 18 percent, with a calorie weight of 365 kcal/100 g (Kaushal et al., 2023). According to the most commonly reported statistic, up to 30% of food produced worldwide is wasted or discarded during the food supply chain. The losses after harvesting corn declined from 32 percent in 2011 to 16.4 percent in 2019 (Benimana et al., 2021). Food losses and wastage are extensive across the whole food chain of supply occurring on several stages, including farming, processing, wholesaling, and consumption, in both developed and developing nations. In the perspective of developing nations, losses throughout the entire food product value chain are approximated to range from 30% to 50%, with 40% of these losses revealed at the postharvest and processing stages (Shukla and Jharkharia, 2013). The world's food supply might hypothetically improve significantly by reducing postharvest losses, which would reduce the need to increase output in the long term (Kiaya, 2014). One of the goals of the United Nations (UN) Food and Agriculture Organization (FAO), established in 1945, is to decrease food waste. Losses after harvest were acknowledged like a contributor to world hunger at the first global conference on food in 1974. Thus, the FAO started the Special Programme for Preventing Food Loss (Parfitt et al., 2010). Consequently,

scholars have suggested several approaches to measure the quantity of food waste that transpires across several phases of the food chain and in different regions, with a focus on diverse agricultural commodities (Redlingshofer et al., 2017). Numerous investigations have demonstrated ecological effects of food loss throughout the supply network (Cattaneo et al., 2021).

The maize supply chain involves a variety of participants, including growers, input suppliers, merchants, processors, distributors, and retailers. Each of these actors plays a crucial role in ensuring that maize is produced, processed, and distributed efficiently and effectively. However, post-harvest losses can occur from harvesting to distribution. Many major reasons why maize post-harvest losses occur at supply chain include poor harvesting practices, inadequate storage facilities, pest and disease infestation, and poor transportation infrastructure (Chari et al., 2023).

1.1. Harvesting

Harvesting is the initial stage in the kernel distribution network and is a vital process in determining produce quality. Crop harvesting is mostly completed by hand in underdeveloped countries, utilizing apparatus like sickles, blades, cutters, and scythes. In industrialized countries, combine threshers are used to harvest practically all of the crop (Kumar and Kalita, 2017). Harvesting schedule and method are significant elements influencing the losses throughout the reaping activities. Losses can be substantial if crops are not harvested at the optimal stage of development and levels of moisture. Harvesting crops with high moisture content increases drying costs, makes them prone to the formation of mold and pest infestation, and results in a large volume shattered cereals and poor milling yields (Khan and Khan, 2010). Leaving the mature crop unharvested, leads in significant smash losses, contact to bird and rodent assault, and losses due to calamity (Baloch, 1999). To reduce shattering loss in the fields, grains are often harvested with high amounts of moisture. Yet, the harmless humidity content for long-lived storage for the majority of crops is less than 13% (Baloch, 1999).

1.2. Drying

After harvesting, the crucial process of drying is essential to preserve crop standard decrease losses from storage and minimize costs associated with transportation. The moisture content in the grain must be achieved through natural methods, such as sun or shadow, or through mechanical means using dryers. In least developed countries sun drying also known as natural drying stands out as the prevailing and cost-efficient approach for drying harvested crops. In some instances, the entire produce is intentionally leave unthreshed in the farm field solely for the purpose of drying (Kumar and Kalita, 2017).

1.3. Shelling

To avoid damage due to spillages and contaminants, shelling should never be done on bare ground. Hand shelling, while arduous, generates less grain damage than stick pounding. Instead, a manual Sheller or a power Sheller can be used. Shelled grain should be placed in clean spill-proof containers or, ideally, bags (Paulsen et al., 2015). Delays in threshing following crop harvesting result in considerable losses in terms of quality as well as quantity because the produce is unprotected to the environment and vulnerable to rodent, bird, and pest assault (Alavi, 2011).

1.4. Cleaning and grading

Thorough cleaning provides good storage quality of grain and reduced storage losses by removing all foreign matter, superfluous matter, insect damage, and other contaminants. Cleaning can be accomplished by hand sorting or through the use of screens. Correct sifting and grading assists farmers in attracting customers and capturing higher prices (Paulsen et al., 2015).

1.5. Storage

Storage is critical in the distribution network of grain, and various investigation

have found that the greatest losses occur throughout this activity (Majumder et al., 2016). After ninety days of crop preserve in typical storage facility (Granary/Polypropylene bags), maize grain losses were predicted to be as high as 59.48% (Costa, 2014).

1.6. Transportation

An inadequate transportation system, combined with incorrect and badly sustained forms of road, leads to significant spillage and contamination. Another key cause of large transportation losses is crop moving. In nations like India and Pakistan, the wheat bag is usually loaded and unloaded from vehicles up to ten times before milling. (Baloch, 1999).

Maize has become increasingly crucial among cereal crops worldwide, particularly in nations like Pakistan, where a quickly growing community has exceeded available food production. As the highest yielding cereal crop globally, maize plays a significant role, contributing 3.0 percent to agriculture's value added and 0.7 percent to the country's GDP (GOP, 2023). In Pakistan, maize is utilized for diverse purposes such as food, feed and starch production. While in countries like India, Indonesia, and Nepal, maize's primary use was initially for food, its significance in this regard has diminished over time, except in the case of Pakistan (Prasanna and Vivek, 2014). In Pakistan, maize primarily serves as a food source for humans, poultry, and livestock (Waris et al.,2023).

The existence of losses after harvest in the agriculture sector had detrimental effects on both the GDP contribution and farmers' income. The losses after harvest in the maize distribution network within the district of Vehari, Punjab, Pakistan have significant implications for food security, economic sustainability, and market efficiency. Maize is widely cultivated in Sub-Saharan Africa and is essential for achieving food security (Tesfaye et al., 2015). The high losses in maize production can have a direct effect on food security in communities that rely on maize as a food. However, there is a lack of comprehensive research focusing specifically on estimating these losses and analyzing the factors contributing to them. Previous studies have not specifically examined the losses after harvest confronted by the four key actors in the supply chain, namely growers, village traders, Commission Agent's cum Wholesalers, and retailers. Furthermore, the changing weather patterns, particularly heavy rainfall during certain seasons, have a profound impact on losses after harvest of the maize distribution network. However, to the best of our knowledge, no study was undertaken to study the losses after harvest of maize crop in Punjab, Pakistan, so the present research fills the gap by quantifying losses after harvest at different phases of the maize distribution network and to suggest strategies to reduce losses of maize distribution chain in Punjab, Pakistan.

2. REVIEW OF LITERATURE

The losses after harvest are characterized as quantifiable losses occurring within the distribution network (Hodges et al., 2011). Food loss transpires when food is removed from the distribution chain at every phase in its journey (Bellemare et al., 2017). The distribution system is a series of interconnected operations that begin at the time of harvest and conclude when the food is finally delivered to the final consumer.

The measurement of nutrition losses can be approached either quantitatively or qualitative, depending on the available data and the specific nature of the study. Quantitative estimation of food loss can be achieved through two primary methods. The first method involves assessing losses caused by poor post harvest managing procedures, encompassing various stages such as reaping, threshing, drying, wrapping, and carrying (Tefera, 2012) The second approach focuses on the biological deterioration of food caused by living things that cause problems, such as rats, birds, fungus, molds, and insects. In this method, the loss is estimated by comparing the weightiness of unspoiled grains with that of spoiled grains (Hodges et al., 2013).

In Eastern and Southern African countries, losses after harvest of grains contribute to greater than 40% of all losses incurred after harvest in Sub-Saharan African nations (Suleiman and Rosentrater, 2015). According to Meronuck (1987) post harvest losses of Maize were from 15 % to 25 % due to inadequate storage infrastuructre in Least Developed Countries (LDCs). About 60 % to 74 % post-harvest losses occur in maize (Abass et al., 2014). In Tanzania, maize emerged as the cereal through the most pronounced losses after harvest, reaching a staggering 40%. The study also unveiled a concerning statistic: on average, each farm household loses about one ton of their harvested maize annually due to pest-related infestations.

One of the significant impediment to nutritious food security in Africa is through post-harvest management, it results in 20 % to 30 % losses. These losses carry a predictable economic worth of over US $4 billion yearly (Gustafsson et al., 2013). In the latter case, the most substantial share of food losses occurs after harvesting, whereas in the previously, losses are primarily concentrated at the retail and consumer levels (FAO 2011). This study estimated the post-harvest losses (PHL) of maize using response of 420 maize growers located in a rural district of Tanzania. The results of the study showed that 11.7 percent losses of maize farmers occur at the post-harvest level. Statistics showed that 2.9% losses occur before storage, 7.8% during storage, and 1.0% during marketing. According to Markets-PAN (2013), the post-harvest losses (PHL) in maize accounted for 15.5% of total production from 2003 to 2007. Alliance for a Green Revolution in Africa (2013) showed a significant difference in maize losses between small and larger farmers. The study showed that 6% of losses occurred for large farmers and 11% for small farmers. However, a lack of comprehensive and accurate information makes it difficult to evaluate food losses in less developed countries (LDCs), which presents serious challenges. To address this issue, the researcher proposes an alternative approach involving the use of questionnaires to gather subjective estimates of losses from individuals directly involved in the food supply chain (Amentae et al., 2016).

3. MATERIALS AND METHODS

This study was quantitative in nature. The current study aims to investigate the post-harvest losses of the fresh maize supply chain and determine the factors which are responsible for these losses. Structured questionnaires were used to gather data from major supply chain actors. The data were collected from district Vehari Punjab, Pakistan, the district of Vehari in Punjab was chosen as it is the major growing area and having the highest production of maize in Punjab, Pakistan (GOP, 2023). This study is based on primary data collected from various supply chain actors i.e. growers, Village Trader's, Commission agent's cum wholesaler, and retailers. In this study, purposive sampling techniques was used to choose the respondents from population (Darfour and Rosentrater, 2022). The simple random sampling technique was utilized to select tehsils from the districts of Vehari. Burewala and Vehari tehsils were chosen for the study to select the data from these tehsils. The sample size of the present study is imitated from the literature (Alabi et al., 2020; Emana et al., 2017; Marchant, 2006). A total of 210 respondent's data were collected by purposive sampling technique including 120 growers, 30 village traders, 30 commission agent's cum wholesaler and 30 retailers. The study employs descriptive analysis by conducting the use of frequency and percentage terms, as well as data presented in table and figure form.

4. RESULTS AND DISCUSSION

The outcomes of the present study reveal that the most significant loss occurs during the drying and threshing stage i.e. 41.44% of the total losses. This can be attributed to factors such as grain spillage and grain breakage during the process. The raining days led to substantial losses in the

traditional methods of drying crops in the fields or under the sun. Drying a specific farm product in the open sun can take a long time, leading to postharvest losses of up to 30% (Hii et al., 2012). The majority of small-scale growers in developing nations depend on sun drying to make sure their products are thoroughly dried before they are stored. However, poor weather conditions hinder produce from drying out, results in significant losses. The most significant postharvest losses can be reduced by using proper techniques to dry and store grains. On-field drying and conventional preservation in East and Southern Africa yielded losses of 5% to 17% and 5% to 12%, respectively (Rembold et al., 2011). Big farms in North America and Australia typically keep their grain on the farm in large bins. These bins have fans that move the air to dry the corn, either with or without using heat (Groote et al., 2020). A review paper gives a summary of the storage methods in Canada, including various types of dryers, some using heat and some without, but all having air circulation (Jayas and White, 2003). Maize grain breakage occurs due to mechanical stress during harvesting processes. If the maize sheller used is not appropriately adjusted or if the handling procedures are too harsh, it can lead to increased breakage of maize grains.

Cleaning and grading losses, which account for 10.09%, may be influenced by inadequate sorting infrastructure and poor handling practices. Storage losses (12.16%) can be attributed by the issues related to moisture content, pest and rodent infestation, and temperature and humidity control. One of the primary reasons for storage loss is insect-pests. One major pest of stored maize is the maize weevil, Sitophilus zeamais Motschulsky. According to reports, during the conventional field drying process, S. zeamais contaminated 63.6% of corn fields (Tigar et al., 1994).

On-farm PHLs account for about 5 % (Gc and Ghimire, 2019) and storage losses account for 6-10 % (Chegere, 2018). Storage account for the highest PHLs in developing countries (Shisiali, 2018). In some places, storage can account for more than 10 % lost. In Ethiopia, 31 % loss was reported in maize (Garbaba et al., 2018).

Transportation losses are influenced by inefficient transportation infrastructure. The present research's findings demonstrated that 6.03 % losses occurred during the transportation. On average, farmers incurred 2.9 % loss of corn from the point of reaping to storage, encompassing losses that occurred during transportation from the farm to their homesteads (Chegere, 2018). It is estimated that the loss of corn from farm to warehouse is approximately 0.38% (Basappa et al., 2010). The loss rate during maize transportation ranges from 2% to 3.5% (Lisa et al., 2019). Tangible resources refer to the physical and financial assets that enterprises possess, playing an essential part in attaining sustainability (Tran et al., 2020). The presence of financial resources prompts substantial investments in storage facilities, drying materials, road networks, new technologies, and other essential elements crucial for the transportation and processing of maize (Seddon, 2014).

The lack of staff knowledge might be linked to inexperience and inadequate training. Due to lack of knowledge, the present study showed that 6.30 % losses occurred. A significant majority of farmers (96%) indicated a lack of comprehensive knowledge regarding proper post-harvest management methods, particularly in the domains of crop storage and pest control. Of this group, 55% expressed a keen interest in receiving training from agricultural extension officers, specifically focusing on pest and disease management.

Furthermore, 7.75% of the losses are attributed to a lack of financial resources for implementing better post-harvest practices. The main challenges faced by growers in the study zone included insufficient financial resources, pest invasion, elevated transportation costs, and fluctuations in

prices. These outcomes are aligned with the result of the literature (Folayan, 2013). Lastly, 16.22% of losses fall into the "Accident/Other losses" category, which may include spoilage due to inadequate packaging (see table 1).

Table 1: Post-Harvest Losses at the Grower's level

PHLs at Grower's Level	Average Losses in Percentage
Drying & Threshing	41.44
Cleaning & Grading	10.09
Storage	12.16
Transportation	6.03
Staff knowledge	6.30
Lack of financial resources	7.75
Accident/Other losses	16.22
Total Losses	**100.0**

The table 2 provides details about losses after harvest at the village trader level, various factors contribute to overall losses in the corn distribution chain. Transportation losses are about 22.66%, these losses happen because of poor infrastructure. Storage losses indicate exposures in storage, influenced by packaging, storage structure, and climate control issues. The village trader report that 30.17 % losses occur during the storage. The USAID's Feed the Future (FtF) program approximated that up to 40% of each produce in Tanzania is lost due to insufficient storage facilities, along with deficiencies in processing and transportation systems (Abass et al., 2014). Assemblers engaged in maize storage mentioned that storing a 100 kg bag of maize for 6 months would result in a weight reduction to 97 kgs. Using the disparity in weight as a rough gauge for storage losses, it amounts to 3 percent (Kirimi et al., 2011). Drying losses (8.92%) highlight inefficiencies in the drying process. Cleaning and grading losses (16.29%) suggest challenges in these processes, tied to inexperienced handling and outdated technologies. Maize frequently go through incomplete drying at the farm, and fumigation is often neglected, necessitating additional drying and occasional fumigation by traders (Lisa et al., 2019). The utilization of polypropylene bags for maize packaging in Nigeria is associated with inadequate protection during storage, leading to significant postharvest losses. Conversely, proper drying techniques and the implementation of hermetic packaging systems have been identified as effective measures, ensuring commendable storage quality even after a year under ambient storage conditions (Alam et al., 2018). Staff knowledge losses (7.65%) show the impact of inadequate training. Lack of financial resources (14.31%) contributes to losses, emphasizing the need for investments. Addressing these factors is crucial for enhancing the sustainability and efficiency of the maize supply chain at the Village Trader level.

Wholesalers, operating in district towns, play a pivotal role in the maize value chain. They act as crucial intermediaries by procuring maize from primary assemblers. While their primary source is from these assemblers, wholesalers also engage directly with farmers and maize importers to secure their maize supply. In typical or favorable agricultural seasons, the primary domestic supply of maize comes from both small- and large-scale farmers. Smallholder maize sales are predominantly directed to modest assemblers or traders, who consolidate and distribute the produce to larger wholesalers. Subsequently, large-scale millers show a significant part in the corn value chain by procuring grain primarily from major wholesalers and, to

Table 2: Post-Harvest Average Losses at Village Trader's level

PHLs at Village Trader's level	Average Loss in Percentage
Transportation losses	22.66
Storage losses	30.17
Drying Losses	8.92
Cleaning and Grading Losses	16.29
Staff knowledge losses	7.65
Lack of financial resources	14.31
Total	**100.0**

some extent, from smaller traders. The post-harvest losses (PHLs) at the Commission Agent's Cum Wholesaler level are shown in table 3. The transportation losses at commission agent cum wholesaler is 15.60%, unveil challenges during transit, potentially linked to inadequate packaging and transportation infrastructure. Storage losses at 25.10% expose vulnerabilities influenced by poor handling, long-distance transportation, inadequate storage structures, and issues related to temperature and humidity. Drying losses at 10.00% underscore challenges in the drying process, potentially due to inadequate facilities. Cleaning and grading losses at 12.1% suggest inefficiencies, emphasizing the need for improved sorting infrastructure. Staff knowledge losses at 4.80% signify the impact of insufficient training. Lack of financial resources at 10.42% contributes to losses, highlighting the importance of financial investments. Market fluctuations and delay losses at 21.98% underscore the impact of external factors. These losses, coupled with factors like inadequate packaging, inefficient transportation, poor handling, moisture content, pest infestation, and spoilage, emphasize the complexity of addressing PHLs in the maize supply chain at this stage.

Table 3: Post-Harvest Losses at Commission agents cum wholesaler

PHLs at Commission agent cum wholesaler	**Average Loss in Percentage**
Transportation losses	15.60
Storage losses	25.10
Drying Losses	10.00
Cleaning and Grading Losses	12.1
Staff knowledge losses	4.80
Lack of financial resources	10.42
Market Fluctuations and delay Losses	21.98
Total	**100.0**

Furthermore, approximated calculated kernel losses (before processing) are suggested to be within the range of 10 to 20%. However, other investigations have reported more substantial losses exceeding 50% in cereals and up to 100% in pulses (Subramanyam et al., 2011). In Cameroon, it is not uncommon to observe 100% grain damage due to various insect pests in grain stored within unmanaged traditional storage facilities (Mikolo et al., 2007).

At the retail stage, sorting was absent. The aggregation of Post-Harvest Losses (PHLs) throughout these phases of the value chain is not straightforward because of the extensive variability in losses measured in each sample. Table 4 outlines the post-harvest losses (PHLs) experienced at the Retailer's level in the maize supply chain. Transportation losses account for 28.57%, indicating challenges during transit that may be influenced by inefficient transportation infrastructure and poor handling practices.

Table 4: Average Post-Harvest Losses at Retail level

PHLs at Retail level	**Average Losses in Percentage**
Transportation losses	28.57
Storage losses	39.29
Market Fluctuations and delay Losses	32.14.
Total	**100.0**

The overall cumulative losses after harvest in the corn distribution network in Punjab, Pakistan, were recorded at 18.78%. This figure includes losses of 12.2% at the grower level, 2.36% at the village trader level, 3.21% at the commission agents cum wholesaler level, and 1.01% at the retailer level. About 15 % losses occur if we add the minimum stages i.e. farms, preservation, wholesaler, and retail sites. It was found that the total kernel losses in Australia, New Zealand, and North America were 10% from processing and packaging, 2% from handling and storage, and 2% from production. Furthermore, it was estimated that losses were 27% for consumer's level and 2% for retailer's level (Gunders, 2012). In developing nations, grains could experience a storage loss of up to 10% (Hodges et al., 2011).

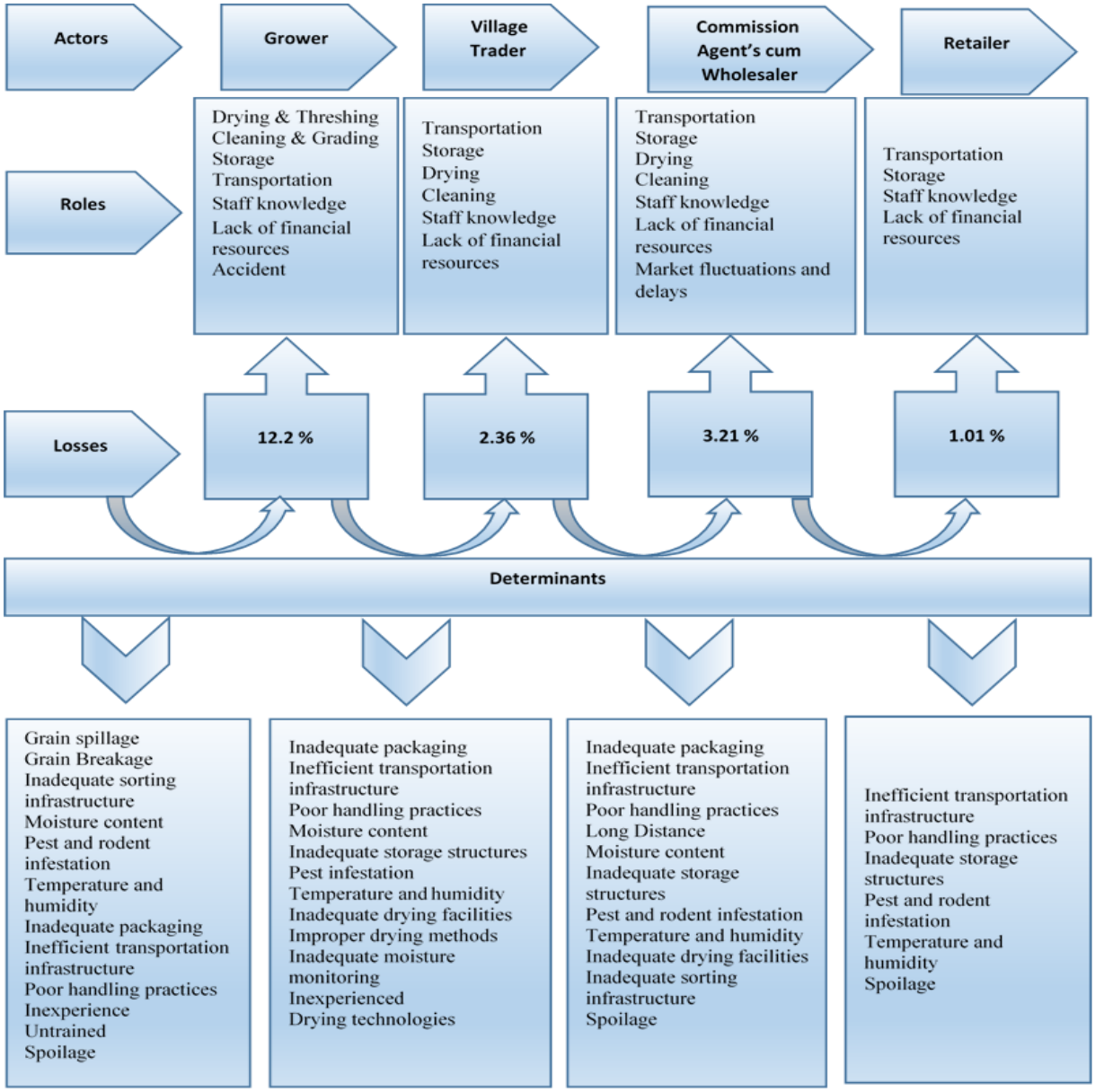

Figure 1: Post-Harvest Losses of Maize Supply Chain

5. CONCLUSION

Maize, a vital crop in Pakistan's agricultural landscape, holds significant importance as one of the primary cereal crops cultivated extensively across the country. Recognized globally as a major cereal, maize (Zea mays) ranks after wheat and rice. Its nutritional composition of the endosperm includes 66.2% carbohydrates, 11.1% protein, 3.6% lipids, 3.6% vitamins and minerals, and 2.7% fiber. The germ, constituting the principal source of maize kernel oil, varies from 3 to 18 percent, providing an energy density of 365 kcal/100 g. In the maize supply chain, the identified key actor's growers, village traders, commission agents cum wholesalers, and retailers play distinct roles encompassing drying, threshing, cleaning, grading, storage, transportation, staff knowledge, financial resources, market fluctuations, and delays and accidents/others losses. The losses at different levels indicate the grower level facing 12.2%, village trader level with 2.36%, commission agents cum wholesaler level at 3.21%, and retailer level at 1.01%. The determinants affecting each actor, such as grain spillage, inadequate sorting infrastructure, moisture content, pest infestation, and inefficient transportation,

highlight the complexity of post-harvest challenges.

5.1. Policies and Strategies

Firstly, to start with use effective threshing and drying methods to address the important 41.44% losses. Producers should be using drying yards or cribs as alternate drying techniques during harvest. The goal of these techniques is to keep moisture levels below 13–15% and reduce damage to the grains, both of which are essential for controlling the growth of mold while in storage. To assist farmers in lowering post-harvest losses, the government should put comprehensive regulations. The government should implement focused training initiatives to improve farmers' understanding of effective threshing, drying, and storing methods.

Secondly, to decrease the 10.09% losses, enhance the cleaning and grading procedures. Improve storage structures to reduce the losses by 12.16%. In terms of storing maize, growers can choose to keep the grain for several months on the cob with or without the sheathing leaves.

Farmers can choose to remove the shells (kernels) from the cobs before storing them. Special machines called maize shellers should be used even on small farms. To minimize losses during transport (around 6%), reliable and affordable transportation options are needed. The government can help by providing these modes of transportation to farmers. Training programs can help farmers reduce losses due to lack of knowledge (about 6%). Financial constraints can lead to losses (around 8%). The government can offer subsidies or low-interest loans to ease this burden. Upgrading infrastructure and implementing safety measures can bring down losses from accidents and other unexpected events (around 16%).

Village traders can benefit from better cleaning, grading, drying, storage, and employee training. These practices can minimize losses throughout the supply chain. The government can assist village traders by supplying better storage options, like metal silos or specially designed hermetic bags that keep moisture out. By avoiding overstocking and making wise decisions, traders can lower their financial losses by accessing reliable market information. Losses can be considerably decreased using effective transportation with few delays and appropriate handling. Corn quality may be preserved and storage losses can be reduced by investing in appropriate storage facilities with temperature and humidity control.

To minimize the losses during the processing of the corn, the Government should conduct a training program for commission agents cum wholesalers. To maintain the quality of the maize and reduce grain damage the government should provide regulations on packaging to ensure proper storage of the maize. Improved logistics with proper monitoring, route planning, and vehicle maintenance can minimize damage during transport.

Better storage techniques, such as product rotation, humidity and temperature control, and inventory management, can help retailers. Retailers can avoid losses from price variations and delays by making well-informed decisions with the support of up-to-date market information. The government should implement packaging regulations to prevent the maize from spoiling and maintain the quality standard at retailer’s level.

The current study mostly focuses on post-harvest losses of the maize crop, leaving out other important cereal crops including wheat, rice, and barley. Additionally, these crops are vital to the nation's economic and food security. Future research needs to focus on these crops' post-harvest losses.

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